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Disaster-resilient communication ecosystem in an inclusive society – A case of foreigners in Japan

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ABSTRACT

The number of foreign residents and tourists in Japan has been dramatically increasing in recent years. Despite the fact that Japan is prone to natural disasters, with each climate-related event turning into an emergency such as with record rainfalls, floods and mudslides almost every year, non-Japanese communication infrastructure and everyday disaster drills for foreigners have received little attention. This study aims to understand how a resilient communication ecosystem forms in various disaster contexts involving foreigners. Within a framework of information ecology we try to get an overview of the communication ecosystem in literature and outline its structure and trends in social media use. Our empirical case study uses Twitter API and R programming software to extract and analyze tweets in English during Typhoon 19 (Hagibis) in October 2019. It reveals that many information sources transmit warnings and evacuation orders through social media but do not convey a sense of locality and precise instructions on how to act. For future disaster preparedness, we argue that the municipal government, as a responsible agent, should (1) make available instructional information in foreign languages on social media, (2) transfer such information through collaboration with transmitters, and (3) examine the use of local hashtags in social media to strengthen non-Japanese speaker’s capacity to adapt.

1. Introduction

The geographic characteristics of Japan makes the country highly vulnerable to disasters such as earthquakes, typhoons, volcanic eruptions, flash floods and landslides [1]. Therefore, disaster risk reduction and resilience measures are enshrined in the everyday activities of the Japanese people including school curriculum, building regulations and design, as well as in corporate organization setup [2]. Disaster risk reduction drills often take place in schools, work places, homes, and include the publication of detailed evacuation plans and procedures in all local communities [3]. However, these efforts of building the capacity of residents facing emergencies could be falling short in terms of coverage and results due to the influx of foreigners who may neither be enrolled in schools or engaged with Japanese establishments or are staying only for a short period of time [4].

The population of foreign residents in Japan has been increasing exponentially in recent years according to a report by Mizuho Research Institute [5], with their number reaching a record high of 2.5 million people by January 1, 2018. The report reveals an increase by 170,000 residents from January 1 to December 31 in 2017. Additionally, the Japan National Tourism Organization reports that the number of foreign tourists visiting Japan is rapidly increasing. It recorded 31 million in 2018, which was four times as many as visiting in 2008, and six times over the number visiting in 2003.¹ This trend of increased foreign tourists may partly stem from the influence of numerous sporting and other events across the country which include the Formula 1 Grand Prix, the FIVB Volleyball Women’s championship and the Japan Tennis Open [6].

¹ Last accessed on March 6, 2020. https://www.jnto.go.jp/jpn/statistics/visitor_trends/ .

The Tokyo 2020 Olympic and Paralympic Games, which has been postponed to 2021, as well as the push by government stakeholders to amend bills to relax immigration laws can also be expected to boost the number of foreign residents and tourists in the country [7,8]. Even though some foreigners become permanent residents, the qualification for permanent residence status requires a ten-year continuous stay in Japan including five years of work, but does not necessarily require the acquisition of Japanese language skills [9] although it may matter at some points. Living in Japan briefly or as a permanent resident does not necessarily mean the person speaks Japanese or is accustomed to disaster risk reduction culture and procedures in Japan.
Although the composition and dynamics of the Japanese population is gradually changing in terms of the non-Japanese population, existing infrastructure and systems that support non-Japanese speakers and foreigners as a whole during disasters seem to be inadequate or lacking.\(^2\)

The current Japanese disaster management system is composed of both vertical and horizontal coordination mechanisms and, depending on the scale of the disaster, activities flow vertically from the national level, through the prefectural to the municipal level before getting down to the communities themselves \([10]\). The municipal disaster management council together with other parties are close to disaster victims and responsible for municipal disaster management plans and information \([11]\). When necessary, the municipality is also responsible for the issue of evacuation orders to residents during disasters \([11]\). Again, when it comes to emergency alerts or risk information, there is an existing mechanism where warning messages proceed from the national government (the cabinet, Japan Meteorological Agency (JMA)) to local administrations (prefecture, municipalities) and from there to the people. Messages may also be transmitted directly top-down through base stations and are received on cell phones. However, reports by news outlets suggest that language barriers, coupled with the inexperience of many foreigners with regard to Japanese disaster procedure protocols, create a huge sense of panic and confusion during disasters \([12,13]\). Lack of appropriate risk information and procedural evacuation or alert actions create this confusion amongst the foreigners. Therefore, most foreigners access news outlets in their respective countries or rely on social media for disaster risk particulars, alert instructions, or evacuation information \([14]\).

The use of social media is seen as a significant trend in accessing swift, precise and easy feedback information in critical situations \([15–17]\). Social media has become the most sourced avenue for information during disasters \([18]\). This applies to both Japanese and non-Japanese users. Irrespective of the chaotic nature or confusion that erupts due to limited risk information accessibility and delivery, a certain level of resilience is achieved through instinctive user responses. Thus, in extreme events, a spontaneous system of resilience is often formed within the context of all the actors involved in the situation \([19]\). This process usually develops because the participating actors share a common interest or find themselves in a situation that requires urgent solutions. The characteristics of this phenomenon create a state of ecosystem which becomes unique to the area affected and to the nature of the event; it generates interactions and communication procedures or methods to reduce vulnerabilities to the disaster \([19,20]\). The interactions within this ecosystem could be formal or informal, depending on the situation and different communication structures, modes and tools employed.

The high frequency of disaster occurrences in Japan in conjunction with a booming foreign population up to Covid-19, and an anticipated, fast rising population again thereafter, provides an ideal case for trying with a booming foreign population up to Covid-19, and an anticipated, foreign population.

This paper is divided into the following parts: first, we introduce the information ecology framework as the theoretical premise of a resilient communication ecosystem. A literature review should give us insights into current studies on the topic and their deployment. A key question is how a resilient communication ecosystem is formed in different disaster contexts. To better understand this question, we seek cases amongst the literature which highlight disaster resilience through collaboration, communication and stakeholder participation. Cases with such attributes are selected, reviewed and discussed from the viewpoint of information ecology. Following the case review, we use the Twitter API (Application Programming Interface) application and the R programming language to collect and analyze English language tweets shared on the Twitter platform during Typhoon Hagibis which hit Japan in 2019. This gives us an empirical understanding of a resilient communication ecosystem. It is assumed that information shared on Twitter in English is meant for consumption by non-Japanese. Again, media coverage of the typhoon is also monitored to serve as supplementary information to our analysis. Based on insights from literature review and findings from tweet analysis, we try to describe a structure which guides our understanding of a communication system applicable to foreigners during a disaster. We conclude the paper with observed limitations and future research directions.

2. Overview of theoretical framework

2.1. Information ecology

Information ecology is composed of a framework which is defined as “a system of people, practices, values, and technologies in a particular local environment” \([20]\). Previous research uses the notion of ecosystem to describe the nature of resilience in a societal context \([22]\). Information ecology framework, which is an extended notion of the ecosystem, helps us to examine the capabilities of each element within the system. The framework contains five components, including: system, diversity, coevolution, keystone species and locality. Table 1 summarizes the elements of information ecology. Not shown but also included is the perspective of a technology role which focuses on human activities that are enabled by the given technology implementation.

Given that resilience is defined as a system’s ability to absorb disturbances \([21]\), information ecology believes that this ability emerges through interrelationships or dependencies between system entities \([20]\). These interrelationships exist between a diversity of players equipped with relevant technologies. Keystone species play a central role in creating interrelationships, which, in turn, may lead to new forms of coevolution. The notion of locality reminds us of interrelationships and coevolution emerging in a local setting \([23]\).

The information ecology framework comes down to a set of key elements providing a systematic view of resilience. It enables us to understand who within a network of relationships is a key for realizing resilience, and what relations can be observed within a system and

| Table 1 | Key elements of information ecology [derived from Ref. [20]]. |
|---------|--------------------------------------------------------------|
| Key Elements | Description |
| System | Strong interrelationships and dependencies that develop among different parts and take different forms. |
| Diversity | Different kinds of people, ideas, technologies and tools that work together in a complementary way. |
| Coevolution | Capability of adapting to new constraints and possibilities, which, in turn lead to further change. Information ecologies evolve as new ideas, tools and activities, and new forms of expertise rise up within them. |
| Keystone species | The presence of keystone species is crucial to the survival of the ecology itself, e.g., skilled people/groups whose presence is necessary to support the effective use of technology. |
| Locality | Local settings or attributes that give people the meaning of the ecology. |

\(^2\) “Japan must improve its disaster services for foreigners.” (2018, October 9). Nikkei Asian Review. Last accessed on January 18, 2020. [https://asia.nikkei.com/Opinion/The-Nikkei-View/Japan-must-improve-its-disaster-services-for-foreigners](https://asia.nikkei.com/Opinion/The-Nikkei-View/Japan-must-improve-its-disaster-services-for-foreigners).
under which local contexts. Coevolution is a driving force for forming the resilient ecosystem in times of disaster and is produced by collaboration of systems with diverse species that provide local context or knowledge [19]. To this we need to add the role of technology in helping human activities and support the formation of coevolution.

2.2. Resilient communication ecosystem

We notice a similar framework exists as communication ecology [24]. It refers to individual or socio-demographic group connections that strengthen neighborhood communication infrastructure. It helps identify communication patterns of local communities or groups of people. In a disaster context, communication ecology includes community organizations, local media and disaster-specific communication sources [25]. Such communication fosters community resilience [26], which can be described as the ability of a neighborhood or geographically defined area to collectively optimize their connected interactions for their benefit [27].

Collective ability is required to deal with stressors and resume daily life through cooperation, following unforeseen shocks. Hence, community resilience and its collective ability aim to empower individuals in a given community [28]. Resilience is enhanced through economic development, social capital, information and communication, and community competence [29]. Provision of or ensuring access to vital information through proper communication systems is essential to strengthen community capacity towards the unexpected. In this regard, a resilient communication ecosystem that this paper tries to get an understanding of, encompasses the dynamically evolving processes that empower the collective ability of information gathering and provision, as well as interactions and collective communication structures among individuals, communities, and local organizations.

A literature review in the following section will help us extract the essential elements of a resilient communication ecosystem based on information ecology.

3. Structure of a resilient communication ecosystem

This study follows a systematic mapping approach [30] as it has the flexibility, robustness and ability to chronologically categorize and classify related materials in research contexts. The process was based on papers which applied the same approach, i.e., [30-32]. We set the following research question (RQ);

RQ: How is a resilient communication ecosystem formed in time of a disaster?

We want to understand how resilience mechanisms are able to evolve spontaneously during disasters through communication, collaboration and the roles of different stakeholders affected by them. To accomplish this, this study categorized the process into three main activities [30]. They are (1) search for relevant publications, (2) definition of a classification scheme, and (3) review of relevant journal papers.

3.1. Search for relevant publications

The search for relevant publications was undertaken in two steps. First, an online database search was conducted with the keywords “Collaboration in Disaster”, “Communication in Disaster” and “Institutional Role in Disaster” across a number of journal databases such as ScienceDirect (Elsevier), SpringerLink, and Emerald Management. 1 ScienceDirect (Elsevier) database fetched a total of 1265, 1265 and 1746 papers respectively for each keyword while SpringerLink produced 5858, 13,358, and 7465. On the contrary, there were 123, 73, and 95 papers for the same categories for Emerald Management. Due to the large number of papers, each result was sorted by checking relevancy within the database. A sample of the first two hundred papers was then selected for further review. The next stage was to choose potentially relevant papers by reading the titles, keywords and abstracts from the selected sample. The criteria for this scanning were: (1) a clear statement of research purpose, (2) a geographical context of the research and (3) a full discussion of at least one disaster. This procedure resulted in the selection of 51 papers from all the sampled papers.

3.2. Definition of a classification scheme

The classification used in this research was to read, clearly identify and arrange the contents of the 51 potential papers to extract the following content; 1. Research titles, 2. Source (type of journal database), 3. Research question of the article 4. Purpose (which keyword is dominant), 5. Type of disaster, 6. Country or region of disaster, 7. Identified stakeholders, 8. Communication tools used, and 9. Communication structure of the case. This stage identified the contents relevant to this study.

3.3. Insights from selected cases

The communication ecosystem found to be prevalent within the reviewed cases highlights the presence of institutions, individuals and other actors who become involved in disaster events and perform various tasks or activities aimed at reducing either their own risk or that of the stakeholders. In most cases, a system evolved consisting of actors receiving and sharing information when a disaster or crisis took place [33,34]. Information ecology promotes sharing and learning; particularly about the use of new technologies, and to reduce given levels of confusion, frustration and ambiguities [35]. In this review, social media emerges as a new trend in technology and rather becomes the medium for sharing information with the aim to reduce anxiety about a disaster situation that could negatively affect the people involved [36].

Actors include government agencies, non-government agencies, and other actors who evolve to become part of the resilient structure of the framework, matching the nature of each situation. Actors can be clearly distinguished based on the roles they play within the system. They include (1) remote actors, (2) responsible agents and (3) transmitters, and (4) targets. Remote actors are organizations, agencies and individuals that are tasked to analyze and forecast the magnitude of the impending or expected hazard [37]. They do not have direct every-day contact with affected persons but provide guidance, information and advice through other agencies. In some examples, a weather forecast agency may play the role of remote actor, as in the case of the 2013 floods in Austria [37]. The World Health Organization also supports local communities by giving constant guidance and recommendations as a remote actor during Ebola outbreak in West Africa [38]. Responsible agents have the highest authority and are responsible for issuing needed guidance for people to stay out of risk zones, advising rescue efforts, and providing information on how to reduce risk [39]. They are the national agencies such as at the level of ministry or governmental organization [40], including security agencies and fire brigades [41]. Transmitters convey the relevant information to the population at large [42]. Transmitters are often media agencies, such as the BBC in the Ebola outbreak [43]. Blood donors who volunteered after an appeal issued by the Oslo University Hospital on social media during the terrorist attack in Norway [44] also gave evidence that individuals, too, can become transmitters. Those impacted in vulnerable areas or in regions potentially at risk are the target population. They are affected by disaster characteristics such as location, demographic details, information accessibility and information flow between them and other parties [45].

Keystone species identified in the described disasters represent the group or actors whose presence is crucial for all resilience activities. Although they are usually described as highly skilled actors, evidence from the reviewed cases also proves that their activities would not be
successful without the cooperation and support from other entities [46]. For instance, staff of the Oslo University Hospital can be described as “keystone species” in the case of terrorist attacks in Norway [44]. However, actors such as blood donors to the hospital and patients, news agencies who covered all events, individual volunteers who help spread “blood request” alerts by the hospital on social media, as well as others who sent time situational information on social media to update others can be said to be the auxiliary actors who complemented the “keystone species” effort. They give rise to the notion that resilience efforts are often created by a system of actors or groups who are connected through information sharing and play specific roles in a cohesive and coordinated manner during events or disasters [47].

Furthermore, the key to all these systems are the space or context in which their actions take place [48,49]. In information ecology, it is the “locality” or the setting that initiates all processes. This gives the specification of the context and guides the actions that follow. In some cases, factors such as the geographical location, messaging or information content, characteristics of actors, the medium of information delivery, duration of the event, and the actions taken give the “local identity” of the system [17,41,50]. During the Ebola crises, this meant the names of the affected countries [43], while for earthquakes and disasters such as fires it refers to their exact locations. For the purpose of this study, locality refers to a system of individuals, agencies and local communities that refer to a local information and actions to be taken in order to reduce risk within a given area.

Table 2 summarizes insights from our case review which illustrate the structure of a resilient communication ecosystem.

The quest for information creates a communication space in which all information is exchanged. In all the case studies, social media was the main avenue for such information dissemination and feedback. Although there was evidence of other information sources [52], Twitter and Facebook became the widely used information avenues [55]. Let’s now illustrate the formation of a resilient communication ecosystem during the emergency caused by Typhoon Hagibis.

4. Empirical data collection

4.1. Research context

The use of Twitter continues to gain popularity across different regions of the world with new figures depicting North America, Europe and Asia as the top users [56]. In disaster events, the public becomes more active online [18] with individuals having “average” sized Twitter network connections tweeting most frequently [57]. This study selected Twitter as a suitable medium to solicit resilience-related information shared on the platform when Tokyo was hit by Typhoon 19 (Hagibis).

Table 2

| Characteristics | Descriptions based on information ecology perspective |
|-----------------|-------------------------------------------------------|
| Adaptation (coevolution) | Social media enhances coevolution within the disaster communication setup by exchanging real time information about the event [51]. |
| Heterogeneity (diversity) | Cases exhibit diversity among information and communication tools, i.e., Twitter, Facebook, organizational websites, and mass media [52], and list various actors such as remote actors [37,38], responsible agents [40,41], transmitters [43], and targets [45]. |
| Driving force (keystone species) | Cases show highly skilled, voluntary entities or governmental organizations could be a driving force for adaptation. Examples: women welfare associations [53], hospital staff [44], IT-skilled workers [54], and city officials [19]. |
| Reference point (locality) | Reference to the location of crises or context of a disaster is involves all actors [38]. They become interlinked through reference information [49] and hence are able to contribute to disaster risk reduction. |

Typhoon Hagibis is described as one of the strongest typhoons ever to hit Japan when it made a landfall in the Izu Peninsula, near Tokyo. This storm made its way through the eastern part of the island of Honshu on the night of October 12, 2019 and became a low-pressure, extratropical system in the morning of October 13. The path, intensity and other characteristics of the typhoon were widely covered by many agencies, both locally and nationally. According to the Fire and Disaster Management Agency, by February 12, 2020, 99 people had died, three were missing and 381 had suffered injuries. Three thousand and two hundred eighty eight buildings were totally destroyed and 64,705 houses were partially destroyed. More than 30,000 houses were submerged by flooding. A hundred and thirty-five embankments along more than 70 rivers throughout the country broke as a result of record rain, and flooding occurred at least 271 rivers. The railyard of ten Hokuriku Shinkansen (bullet trains) was flooded and recovery cost was estimated to come to 32.8 billion Japanese yen (around 0.3 billion USD). The typhoon occurred at the same time that Japan was hosting both Volley Ball and Rugby world cups, presenting a test case of tweets particularly for and by non-Japanese, our research target in resilient communication during the Typhoon.

As stated previously, the Japanese governance system is composed of three tiers, national, prefectural, and municipal. Among these, municipal government is closest to people at large and therefore is in charge of issuing evacuation orders, opening and operating evacuation centers, and managing relief efforts [38]. When an evacuation order is issued by a local municipality, residents who live in specific zones are supposed to evacuate. There are, however, five levels of evacuation order. The lowest, level 1, warns of a potential emergency. Level 2 warns of an evacuation. Level 3 requires evacuation of the elderly, and preparation for evacuation by everyone else. Level 4 orders evacuation by all remaining people, and level 5 requires taking action for saving one’s life. The prefectural government coordinates relief efforts stipulated by the national government. From the perspective of a communication ecosystem, these government entities correspond to a responsible agent.

Besides government, there is another keystone species that is responsible for issuing warning alerts, namely, the Japan Meteorological Agency (JMA). JMA issues warning alerts based on weather forecast. Japanese municipalities issue evacuation advisories based on JMA weather warnings. The five levels of evacuation advisories correspond to JMA’s warning levels, also defined along five alarm stages.

4.2. Data collection and analysis

Data collection was done using Twitter API in R package to scout tweets in the English language. To extract the tweets, the following steps were used:

a. Registration with Twitter API to secure API credentials
b. Integrating Twitter CRAN (programming language for R package) into R statistical package
c. Searching by tweets. This was conducted by searching the hashtags “#Hagibis” and “#Typhoon 19”. To restrict tweets to only English language, the code “en” was added. Typhoon Hagibis made a landfall on October 12, 2019. Therefore, the tweet search was restricted to search for information of tweets made on that day. The entire code use for the search was (Hagibis < - searchTwitter

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4 Last accessed on July 20, 2020, https://www.fdma.go.jp/tags/893.html.
5 Last accessed on March 6, 2020, http://www.bousai.go.jp/updates/r1typhoon19/pdf/r1typhoon19_44.pdf.
6 Last accessed on March 6, 2020, https://www.jiji.com/jc/article?k=201902000403sg=soc.
7 Last accessed on March 6, 2020, https://www.japantimes.co.jp/news/2019/10/13/national/ten-trains-used-hokuriku-shinkansen-line-sustain-damage-yard-flooded/#Xj5x1TE2zzyx.
Within our sample framework, @NHKWORLD_News is the most retweets while 13% came from other origins. The results show that @NHKWORLD_News (Fig. 2). @EarthUncutTV covered 16% of total 19,582. Amongst them, 71% were retweets which originated from aggregated number of retweets we found from our time frame was individuals. This was determined based on their handle IDs. The total single account was 50 out of the original 145 tweets. They were sent by Typhoon Hagibis

5. Findings

Among 5000 tweets extracted, the number of original tweets (that is; tweets bearing initial message from a source) is 145. The remainder of 4855 are retweets of the original 145 tweets. Although retweets are counted as one element within the sample tweets and time frame, each retweet also contains attributes of what the aggregated count might be for the particular original tweet, i.e., it counts as one element in our time frame, but could be the nth retweet for that particular tweet.

5.1. Overview of the English language communication ecosystem during Typhoon Hagibis

From our findings, the highest number of original tweets from a single account was 50 out of the original 145 tweets. They were sent by @NHKWORLD_News, a public broadcaster in Japan (Fig. 1). This was followed by 25 tweets created through a Twitter handle name @EarthUncutTV; which is leading online portal, documenting extreme natural events or disasters in the Asia Pacific region and around the world. Around half the tweets within the 145 original tweets were made by individuals. This was determined based on their handle IDs. The total aggregated number of retweets we found from our time frame was 19,582. Amongst them, 71% were retweets which originated from @NHKWORLD_News (Fig. 2). @EarthUncutTV covered 16% of total retweets while 13% came from other origins. The results show that within our sample framework, @NHKWORLD_News is the most dominant tweeter account.

Data analysis was based on the framework of a resilient communication ecosystem. The first aim was to find keystone species supporting the communication ecosystem. Therefore, we focused on the number of tweets and Twitter ID accounts with a high number of retweets. As a result of retweet number analysis, we established the formation of coevolution within the ecosystem. We also aimed to explore the kind of information content exchanged in the ecosystem. Hence we conducted thematic analysis [39] which allowed us to apply key elements of a communication ecosystem. It shows how the communication ecosystem for English language was formed when the typhoon hit Japan. In order to extract a sense of locality, we picked up the name of a region or city, and searched for local information such as evacuation orders or emergency alerts within a certain tweet. Diversity in this case reflects the number of tweets and different account ID information that posted or retweeted with #Hagibis or #Typhoon_19 during the sampled time frame.

The ranking of retweets exceeding one hundred per source is shown in Fig. 3. The most retweeted tweet recorded 1870 retweets. The original tweet was posted by @NHKWORLD_News saying “Hagibis is expected to bring violent winds to some areas. A maximum wind speed of 144 km for the Kanto area, and 126 km for the Tohoku region.” The second most retweeted one was posted by an individual account saying “Ghost town/ Shibuya at 6pm before a typhoon” with a photo taken in Shibuya City. The top ten retweeted tweets are shown in Table 3. Names in italics stand for region or city name.

The 5th and 10th tweets mentioned evacuation orders issued by local municipalities while other tweets shared the event as it happened in different places around Japan, or they reported on its effects. We found only three among 145 original tweets that captured the emergency alert issued by JMA (Fig. 4). Those three were tweeted by individuals and generated only a few retweets. The emergency alert was described in Japanese which is translated as “Special alert at level 5 for heavy rain has been issued to Tokyo area. Level 5 alert means the highest level of warning. Take action for saving your life. Some areas have been newly added under the special alert. Check TV, radio, or local municipalities’ information,” as of October 12, 21:27 p.m. The alert requested people to refer to information from local municipalities but all of it was in Japanese.

5.2. The structure of Typhoon Hagibis’s communication ecosystem

Keystone species, remote actors, heterogeneity of information, responsible agents and locality all played important roles in this ecosystem. Examining the structural elements of the typhoon’s communication ecosystem, our empirical data revealed that @NHKWORLD_News was a keystone species functioning as a forceful transmitter that helped form the ecosystem by providing information to non-Japanese speakers. It generated 13,983 retweets among a total of 19,614, followed by 3075 retweets generated through @EarthUncutTV. Almost half of original tweets – 75 tweets - were generated through these two accounts, with the rest 70 tweets coming from individuals. This communication system therefore gives the impression of few representative agents although many had their messages retweeted.

While remote actors, such as JMA in this case, did not directly appear in the ecosystem, it was referred to seven times within the 145 original sample tweets. One of them is the 7th tweet in Table 3, and others are as follows:

- Japan’s Meteorological Agency says Typhoon Hagibis made landfall near Izu Peninsula in Shizuoka just before 7 p.m. Saturday – tweeted by @NHKWORLD_News.
- The Japan Meteorological Agency has issued heavy rain emergency warnings for Shizuoka Prefecture, Kanagawa Prefecture, Tokyo,
Table 3
Top ten retweeted tweets.

| Original tweet                                                                 | Source                  | Number of retweets |
|--------------------------------------------------------------------------------|-------------------------|--------------------|
| 1. Hagibis is expected to bring violent winds to some areas. A maximum wind speed of 144 km for the Kanto area, and 126 km for the Tohoku region. | NHKWORLD_News           | 1870               |
| 2. Ghost town//Shibuya at 6pm before a typhoon                                    | Individual              | 1517               |
| 3. Typhoon Hagibis is already battering Chiba Prefecture where violent gusts have torn roofs of homes and left some residents with injuries. | NHKWORLD_News           | 1234               |
| 4. Flooding in the Tokyo suburb of Hachioji has overwhelmed the drainage system, causing it to gush out onto the street. Click here for more updates: https://www3.nhk.or.jp/nhkworld/en/news/special/01/1919/ | NHKWORLD_News           | 1206               |
| 5. Authorities have ordered thousands of people in Shizuoka, Tokyo, Gunma, and Wakayama prefectures to evacuate their homes immediately as Typhoon Hagibis barrels toward Japan. | NHKWORLD_News           | 1006               |
| 6. Water levels of rivers in Tokyo are rising.                                    | NHKWORLD_News           | 832                |
| 7. Meteorological Agency officials have classified Typhoon Hagibis as “very strong”. The storm is moving northwards over the Pacific towards Japan’s main island of Honshu. | NHKWORLD_News           | 830                |
| 8. This is a footage taken in Shibuya at a construction site of a condominium. A crane at the highest floor was broken and it’s hanging. | NHKWORLD_News           | 658                |
| 9. The popular sightseeing areas of Hakone and Kamakura in Kanagawa Prefecture are hit by powerful winds and strong waves as the typhoon approaches. | NHKWORLD_News           | 655                |
| 10. At 7 p.m. on Saturday, evacuation orders at level 4 on the 5-level warning scale are issued for 813,000 households in Fukushima, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi, Niigata, Shizuoka and Mie. | NHKWORLD_News           | 596                |

Fig. 3. Number of retweets per source.

Fig. 4. Individual’s tweet with emergency alert picture (source: https://twitter.com/demainlaveille/status/1182997161690058756).
Saitama Prefecture, Gunma Prefecture, Yamanashi Prefecture and Nagano Prefecture. – tweeted by @NHKWORLD_News.

- Japan’s land ministry and meteorological agency say the Tama River, which flows through Tokyo, reached the evacuation warning level at an observation point in Chofu City at around 1:50 p.m. – tweeted by @NHKWORLD_News.

- Officials with Japan’s land ministry and meteorological agency say the Tama River, which flows through Tokyo and neighboring Kanagawa prefecture, reached the flood risk level at an observation point at around 3:40 p.m. on Saturday. – tweeted by @NHKWORLD_News.

- The Japan Meteorological Agency issued the highest-level heavy rain emergency warnings at 3:30 p.m. on Saturday for Tokyo and 6 other prefectures in central and eastern Japan. – tweeted by @NHKWORLD_News.

- The Japan Meteorological Agency (@JMA_kishou) said that the Tropical Cyclone #Hagibis made landfall in Izu Peninsula at around 19:00 JST. – tweeted by @CCMofa_Japan.

Our constant monitoring of the event on the internet also reveals that JMA was giving constant updates of the real-time weather status and alerts on its website. This information was provided in English. However, most of it did not appear in our sample frame as it did not utilize Twitter in English. As the Japanese disaster management system also grants direct access of emergency information from JMA to the population, an emergency alert was sent to people’s cell phones from JMA, but this was written in Japanese (Fig. 4). Hence, people who do not speak Japanese may not have understood this, and the real time information could only be solicited by a few who originally knew about such a website or the information provided.

On the other hand, much evacuation information is issued by municipal government. We found five tweets mentioning evacuation orders. Two of those were the 5th and 10th tweet in Table 3. Another three were also generated by @NHKWORLD_News (italics refers to location), as follows.

- As of 5 p.m. on Saturday, evacuation orders at level 4 on the 5-level warning scale have been issued for 619,000 households in towns and cities in Fukushima, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi, Nagano, Shizuoka and Mie.

- As of 2 p.m. on Saturday, evacuation orders at level 4 on the 5-level warning scale have been issued for 110,000 households in towns and cities in Gunma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi, Shizuoka and Mie.

- Authorities have issued evacuation orders for many parts of central and eastern Japan. As of 5 p.m. on Saturday, evacuation orders at level 4 on the 5-level warning scale have been issued for 619,000 households.

As responsible agents, some Japanese local municipalities use Twitter as additional medium to communicate with their residents. However, these tweets are usually sent only in Japanese, hence, no tweet appeared in our research scheme. After reviewing the 145 original tweets, we found that tweets were reporting certain conditions and the situation of the event. These were bits of general information that did not contain a point of reference or local knowledge to guide people or prompt precise actions on reducing risks. This type of limited locality information within our sampled communication system during the typhoon suggests an information shortfall for non-Japanese community and their expectations. The NHK world reported several cases of non-Japanese having difficulties to find information in English or what action to take [60]. For example, a Dutch man, who had been living in Japan for a half year, received an emergency message but he could not find information where to evacuate. Another American woman was supported by her friend in translating disaster information.

6. Discussion

Emergency situations generate exceptional communication features which contravene the norm [61]. Therefore, a communication ecosystem forms and breaks up every time a disaster occurs. We observed dynamic characteristics of crisis communication structure with the involvement of various organizations [62] and tools [52]. The tools greatly hinge on social media which have become essential for digital crisis communication [55]. However, more research is required to better capture the nature of social media use in crisis communication [63]. Several studies reported that local governments especially in Thailand and the U.S. are reluctant to utilize social media in disaster situations [64,65]. They prefer to use traditional media such as TV and radio though those mass media tend to allow only one-way communication during a crisis [66]. As our study shows, information through mass media becomes limited or challenged to meet specific needs due to its broader audience base [67] compared to the multiple-interaction communication style that characterizes social media [17]. Government, as a responsible agency, needs to understand the characteristics of mass media and social media communication and create an appropriate communication strategy or collaboration scheme when preparing for future catastrophes.

In the recent Covid-19 crisis, the need for more targeted health information within a community and the importance of strong partnerships across authorities and trusted organizations are being discussed [68]. We hold that more consideration should be paid to the provision of targeted information to those who do not share a common context or background of disaster preparedness. On daily-basis practices in Japan, almost all local municipal governments prepare a so-called “hazard map” and distribute it to residents. The map shows vulnerable or areas prone to landslides and flooding (Fig. 5). People living in a given area are supposed to prepare for evacuation in case an evacuation order is issued by local municipalities. This highlights the importance of targeted information delivery which intends to meet certain expectations.

Ordinarily, municipalities only issue evacuation orders and do not provide residents with specific information where to evacuate to. From a regular everyday disaster drill, trained residents are expected to know where the evacuation centers are in their area. As people interpret new information based on previously acquired knowledge [69], a responsible agent should also consider how to provide information to people who hadn’t had any disaster training.

Beside the feature of interactive communication characterizing social media, the pull of multiple information sources and agents creates a sense of assurance and security in coping with or adjusting to events. This was experienced in the 2010 Haiti earthquake, when social media contributed swiftly to creating a common operating picture of the situation through the collection of information from individuals rather than from a hierarchical communication structure [70]. In addition, what is important in crisis communication is who distributes a message and how it is mediated in a population [62]. Our study shows that news sources who already seem to have gained social trust played a role as a keystone species in foreign language communication (Fig. 3) and therefore became a driving force when forming a communication ecosystem. However, other studies suggest that other keystone species perform this role outside of social media such as in the case of Malaysia, where people tend to share information obtained from face-to-face communication, rather than from media sources [71]. A similar discussion can be found in the case of Hurricane Katrina, where minorities prioritize personal information sources over the media [69]. These cases suggest that social media promote effective resilience in communication, and that the delivery of information to foreigners in Japan from different language

8 Derived from Machida City Homepage, last accessed on March 6, 2020, https://www.city.machida.tokyo.jp/kurashi/bouhan/bousai/bousaitaisaku/suisaitaisaku/kousui.html.
backgrounds and cultures further creates traits where personal connection contributes to information accessibility choices. It is also true that social media-based communication raises situation awareness [72] by receiving warning alerts as well as emotionally-oriented messages such as from friends and relatives [62]. Language barrier is likely to have been an obstacle that actually helped to shape the ecosystem identified in this study. During Typhoon Hagibis, responsible agents sent warning messages only in Japanese language as shown in Fig. 4, so this could have been a major factor in harnessing the full potential of social media for disaster communication.

Results from this study reveal a lack of local knowledge or reference points across Twitter communication, which shapes discussion within the ecosystem. For instance, in the case of the 2015 Chennai flooding in India, tweets covered subjects such as road updates, shelters, family searches and emergency contact information [73], none of which were much referred to in our sampled tweets. While in the 2012 and 2013 Philippine flooding, the most tweeted topic was prayer and rescue, followed by traffic updates and weather reports with more than half the tweets written in English [74]. Moreover, around 40% of those tweets were secondary information, i.e., retweets and information from other sources [75]. Our study recognizes the importance of secondary information. Information exchange between agencies and affected residents and tourists assists in reducing risks such as, for example, during Hurricane Sandy in 2012, where the top five Twitter accounts with a high number of followers were storm related organizations posting relevant news and the status of the hurricane [72]. As a remote actor becomes a source of secondary information, however, such information should guide people in what they should do next, rather than just point to the disaster situation.

In this context, we note the importance of instructional messages whose content guides risk reduction behaviors [76]. An example of such a message is “do not drive a car” which was tweeted by police during a snowstorm in Lexington [65]. It tells what specific life-saving action should be taken [77]. Generally, however, there appears to be little investigation of instructional information in crisis communication [65]. The findings of this study imply that there could be two types of disaster information: a) risk information that refers to the potential effect of the disaster, i.e., emergency alert or warning, and b) action-oriented information that carries instructions for reducing the risk, i.e., an evacuation order and itinerary to be followed. Risk information is published by remote actors while action-oriented information is provided by responsible agents. Both types of information must contain local knowledge and allow easy access when people search for that information [78]. In order to make sure people can reach instructional messages, it is not enough to just point to the information on organizational websites [65], as JMA did during Typhoon Hagibis. Instead, “localized hashtags” [64,65,79] can support people to find life-saving information as quickly as possible. A previously cited study argues that social media can be useful when sending a request for help [67]. “Typhoon 19 damage of Nagano” is an example of a localized hashtag, assisting a fire brigade in Nagano prefecture utilizing Twitter to respond to calls for help from residents during Typhoon Hagibis. A localized

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9 Last accessed on July 20, 2020, http://www.nhk.or.jp/politics/articles/las
tweeek/25652.html.
hashtag can also be used as a point of reference where people can find relevant information [65]. In future disaster communication, local information should be distributed using geographical information with instructions as to what to do next [62]. Responsible agencies should take this into account, while also analyzing which information was shared across social media in previous disaster cases [64]. Furthermore, cultural differences can also be considered, as Western culture emphasizes individual action [68] while Asian cultures prioritize collective actions or community commitment. As this may generate behavioral differences among Japanese and foreign residents or tourists, further investigation will be beneficial.

7. Conclusion

Based on information ecology framework and literature review, the structure of resilient communication ecosystem is proposed and verified through empirical data analysis. The resilient communication ecosystem is structured with heterogeneous actors who could be a driving force for collaboration or coevolution. The empirical case revealed that a media source might transmit warnings and evacuation orders through social media but that such information does not contain points of reference. Limited delivery of such information particularly in the English language results in confusion to non-Japanese communities who need it most. Based on study results and discussions, we suggest that in any disaster a form of ecosystem is spontaneously generated. Municipalities, which are often responsible agents should (1) produce instructional information in foreign languages on social media, (2) transfer such information through collaboration with transmitters who may have a strong base on social media to assist translating it to reach the wider audience, and (3) examine, in association with the mass media and weather forecast agencies, the use of local hashtags in social media communication for future disaster preparation. It brings various actors together, creates a sense of locality, and supplements individual efforts in risk reduction.

Our empirical data is limited to some extent as we only observed Twitter for one day, October 12, 2019. Again, we intended to extract tweets in English language just before and after the Typhoon Hagibis hit Japan. Hence, we chose hashtag #Hagibis and “#Typhoon_19” when we were crawling Tweets. We are also aware that our data is based on only a single disaster case and requires further data sets from other disaster events for corroboration. We may consider different characteristics of information and actors in the resilient communication ecosystem in future research. Nevertheless, our findings provide interesting insights into disaster communication which may guide the direction of future research. As instructional information sometimes contains ethics and privacy issues [62], rules for dealing with specific local or personal information should be taken into account. Behavioral differences are also worth investigating because of increasing human diversity in Japanese society.

The case of Japan reveals the importance and potential of communication as a main mechanism for offering information and response activities to promote resilience and reduce the risk of disasters. Social media space serves as a major platform that brings numerous stakeholders together. This platform creates the main avenue for information sharing on events and offers feedback mechanisms for assessment and improvement. For future disaster preparedness, then, we may benefit from a closer understanding of the nature of a resilient communication ecosystem, its structure and the knowledge that it allows us to share.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2020.101804.

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