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Study on an Information Systems for Visualizing the Effectiveness of Local Cleaning Activities: Case Study of Iwate Prefecture in Japan

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ABSTRACT

The microplastics problem requires consideration according to local characteristics. This study is a case study of Iwate Prefecture in Japan. In order to understand the current conditions of collection and cleaning activities for coastal and river debris, Iwate prefectural residents need to be able to visualize the activities they perform in their daily lives, and the system for this is yet undeveloped. The research team designed the system with reference to the stages in SSM. And based on the systems design, we prototyped two systems that focus on data posting for users. After evaluating two prototype applications, we defined the data sets that users would contribute during and after the activities. This paper is useful for areas with similar characteristics.

Introduction

There is worldwide concern about the negative impact on ecosystems, living environments, fisheries, tourism, and so on, due to global environmental pollution caused by marine and river debris. Because marine debris flows into the sea from inland areas through rivers, in Japan, it is considered important not only to collect marine debris, but also to control the marine debris through a united effort of stakeholders in the basin areas from mountains to rivers and oceans, and local governments are urged to take actions ("Basic Policy to Take Measures against Marine Debris Comprehensively and Effectively" Ministry of the Environment, May 2019). This is now considered as an initiative related to SDG 12 "Ensure sustainable consumption and production patterns" and SDG 14 "Conserve and sustainably use the oceans, seas and marine resources" [1]. Specifically, the elimination of littering and illegal dumping, which are criminal acts, should be thoroughly enforced, and cleanup activities should be promoted to prevent plastic from flowing into the ocean [2].

The Environmental Office of Iwate Prefecture is also conducting research on this issue. Iwate's natural environment is said to be relatively well-preserved. In our surveys 202, field surveys of coastal debris were conducted at 40 model locations along the coasts and riversides of Iwate Prefecture, finding that the coasts in Iwate Prefecture were generally clean, with much of the coastal debris comprised of natural materials such as seaweed, as well as many pieces of driftwood and fishing gear that were likely caused by typhoons [3].

However, some microplastics have been found to be difficult to collect in Iwate. Garbage needs to be properly handled before it becomes microplastics. For this reason, Iwate Prefecture established a portal site in 2022 [4] with the goal of stimulating local cleaning activities by citizens. And Iwate Prefecture formulated the "Second Phase Iwate Prefecture Regional Plan for Promoting Measures against Marine Debris" (March 2023). In the plan, it is stated that the prefecture aims to build a system to visualize natural environmental conservation activities with the full participation of all citizens of the prefecture, because, in order to control waste plastics emissions to oceans, promotion of environmental cleanup campaigns not only in coastal areas but also throughout the entire prefecture is necessary, and also to secure diverse

players.

Nevertheless, Iwate Prefecture is aware of several problems. One is that the actual status of activities other than those funded by Iwate Prefecture is unknown. Second, there is no established methodology for making this an activity for all prefectural residents. Furthermore, in order to understand the current conditions of collection and cleaning activities for coastal and river debris, prefectural residents need to be able to visualize the activities they perform in their daily lives, and the system for this is yet undeveloped.

Aiming to solve the above problems, we discuss support methods using information systems. The main objective of this paper is to clarify the system design process for visualizing the effectiveness of citizens' cleaning activities. The first section provides an overview of the characteristics of the target region. The next section discusses the research methodology and existing related works. Subsequent chapters would reveal the system design that was done with reference to the SSM process. Then, prototype mobile applications based on the system design are discussed. Finally, conclusions and issues are discussed.

About the Target Region

Iwate Prefecture is located in the northern region of Honshu, the largest island of Japan. It is the largest prefecture in Japan following Hokkaido, and makes up 4% of Japan's total land area. Iwate has a land area of 15,275.01 km2, making it larger than all of Tokyo and its surrounding suburbs [5]. Forests cover 77% of Iwate Prefecture's total land area, making it the second largest forested area in Japan after Hokkaido. It accounts for about 4.7% of Japan's forested area. The population remained at the 1.4 million mark from 1978 until 2004, when it started to decline. In 2023, Iwate's population numbered around 1.2 million people [6].

Figure 1 shows the rivers in Iwate prefecture. Iwate has rivers of various sizes in parts of the area. This indicates that all residents must be aware of this issue. The Ministry of Land Infrastructure Transport and Tourism of Japan manages three major rivers, including the Kitakami River, which flows inland in Iwate Prefecture. There are 102 rivers managed by Iwate Prefecture.

In addition, the coastal areas are considered cleaner than before due to the recovery from the Great East Japan Earthquake and Tsunami of March 11, 2011. Iwate Prefecture has many scenic spots, so we are considering the possibility of collecting not only photographs of garbage, but also photographs of beautiful landscapes. They also plan to use the same system in the future for bear sightings and detection of specific invasive alien species.

Figure 1. Locate and Rivers in Iwate Prefecture [6].

Research Methods

To address the aforementioned issues, we aim to establish a system and which utilizes the cooperation of the general public to try to develop an understanding of effectiveness local cleaning activities. Specifically, we use information systems development methodologies and prototyping. The research team

consisted of environmental experts, local IT companies, prefectural government officials, and students. The system is designed with reference to the stages in Soft Systems Methodology (SSM). The internal and external environment analysis and goal-setting methods such as SWOT, PESTLE, and MOST, are well-known. The research team chose SSM because it contains elements of these well-known methodologies in a coherent methodology, and the objectives of our system are determined in Stage 3 of SSM.

The goals of this study are twofold. The first is to clarify the design process of the information system that contributes to this issue. We consider it a useful reference for communities with similar conditions and efforts to visualize their activities. The second is to experiment with data posting applications used by citizens. In order to visualize the cleaning activities of citizens, an application that can be used by citizens on a daily basis is essential. In this study, we discuss how such an application should be.

Related Works and Trends

Marine Debris Tracker (MDT) was developed by the National Oceanic and Atmospheric Administration and the University of Georgia [7]. It is developed from the same perspective as our task in terms of the visualization of cleaning activities. Posting data from a mobile application visualizes statistics on a map on the data platform. The mobile application allows data posting separately for organizational and personal activities. In fact, the system is available worldwide. The main users are in the United States, but the system is also used in Europe and India. However, it is rarely used in Japan. The reason is simple. The system is not multilingual.

On the other hand, Pirika [8] is a system adopted by local governments in Japan for similar purposes. Pirika is available in English and Japanese, so it is used in North America and Europe. Whereas MDT tallies the number of pieces of garbage, Pirika registers the size and number of garbage bags. Many Japanese municipalities have adopted Pirika because they are interested in bringing attention to this issue. Pirika is focused on the communication function. For this reason, it focuses on peer evaluation, communication, rankings, badges, and event awareness. However, it is not possible to select a visualization method for the data. It is also not possible to use the data for multiple purposes.

In recent years, cleaning activities have also become a hot topic on social media. Trashtag is based on hashtag and widely appears in hashtag form as #trashtag on social media. People clean up a heavily littered area, posting before and after photos with the hashtag #trashtag [9]. In Iwate Prefecture, however, before-and-after photo situations are few and far between, with the exception of major disasters such as earthquakes and typhoons.

Starting in 2019, the Nippon Foundation and the Ministry of the Environment are offering trash bags for activities involving 30 or more people under the title of " Zero Marine Litter Week". And individuals can participate by tweeting with the hashtag #umigomi [10]. The implementing organization reports photos and the amount of trash (number of 30-liter trash bags). And the government encourages the PR of information to raise the awareness. However, the reported data are not statistically aggregated.

Systems Design

We conducted the conceptual design of the system with reference to the SSM up to Stage 3 [11]. SSM is superior in structuring the problem and proposing the best solution. This is a summary of what the research team has been discussing in face-to-face and online meetings and via email since 2021.

Discovery and Expression of the Problematic Situation (Stage 1,2)

The purpose of stage 1 and 2 is to grasp the overall image and issues of the system. The research team discussed their respective points of view and compiled them into a rich picture (Figure 2). Iwate Prefecture

wants to visualize citizens' cleanup activities. However, they are hesitant to implement an existing system. They have received reports from the organizations they fund and also want to spread their activities to individuals. Iwate Prefectural University, to which the author belongs, is participating in UN Academic Impact and wants to commit to sustainable environmental education activities. NPOs/NGOs regularly conduct cleaning activities in cooperation with the prefectural government. They want to increase the number of participants in their activities. The same is true for community associations. In addition, many people participate individual participation or are indifferent, and the government is unable to grasp the actual situation.

Stage 2 finds related systems from each position based on the rich picture. Iwate Prefecture is looking for a system that provides data from the citizens of the prefecture, a system that visualizes the data, and a system based on the characteristics of the locale. Citizens, on the other hand, are considered to need a system that can be used on a daily basis, and a system that leads to motivation. In particular, for those who are indifferent, it is necessary for the system to provide motivation. For NPO/NGO, which conducts cleaning activities, it is useful to have a system that can record activities and a system that contributes to the increasing the number of participants.

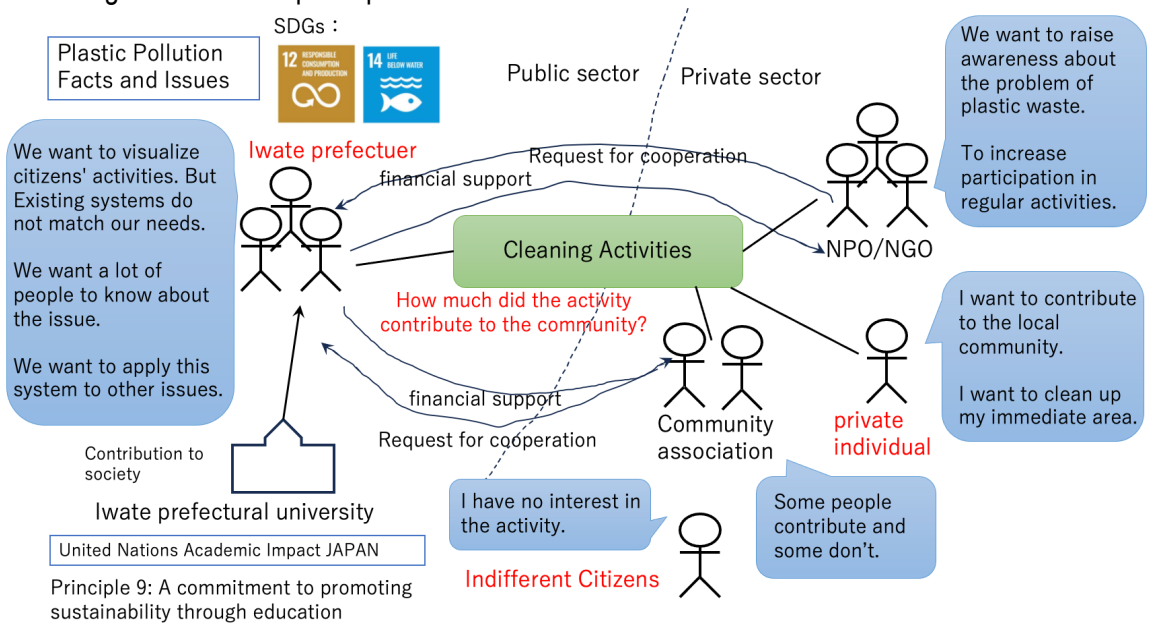

Figure 2: Rich Picture(ex.).

Deriving Root Definitions of Relevant Systems (Stage 3)

The next step is to perform a CATWOE analysis for root definition. CATWOE analysis shows that as long as a sufficient study is conducted, it is possible to create a model, which becomes a fundamental part of the new system (Figure 3). In light of this, as a result of the CATWOE framework as well as studies into root definitions. We defined the new system after the XYZ analysis. X is revealed by Iwate Prefecture. Y is related to CATWOE T. In addition, Z is related to the long -term goal of the Owner.

C(Customers)：Citizen, Government
A(Actors)：Citizen
T(Transformation Process)：Cleaning activities are carried out individually → The activity data will be posted and visualized.
W(World View)： Interested in environmental issues
O(Owner)： Citizen, Government
E(Environmental Constraints)：Tackling the plastic pollution issue

Figure 3: CATWOE.

Here is what we notice. The rich picture and CATWOE could be divided into two main sectors: public and private. In other words, it can be understood that cooperation between the two sectors is a prerequisite for a sustainable system. However, many system designs in Japan have failed for this reason. For example, the " COVID-19 Contact-Confirming Application: cocoa" application, a government initiative developed during the COVID-19 pandemic, required public cooperation, which many ignored or did not trust the results. Although the cause of this situation has not been identified, we believe that a major factor was the failure to build trust. Takagi et al. [12] reported that trust in performance, perceived benefits, perceived risks, and negative affect were significant determinants for all technologies. Therefore, we analyzed the public sector and private sector separately. Figures 4 and 5 show the results.

X (What)	：visualizes the actual state of cleaning activities or local photo
Y (How)	：by citizens' data posting
Z (Aim)	：to solve plastic pollution issues

Figure 4: XYZ analysis for public sector.

X (What)	：the system for posting the results of the cleaning activities or local photo
Y (How)	：by smartphone application
Z (Aim)	：used on a daily basis to store data in the platform system

Figure 5: XYZ analysis for private sector.

Defining the Development Policy

We defined the policy for the system based on the XYZ analysis and research results. The resultant objectives of the system were organized as follows:

1)Visualization of the coastal environment being maintained by people engaged in cleaning activities (Edification);

2) Provision of opportunities for individuals to participate in environmental activities (Participation);

3) PR to publicize the local conditions in Iwate Prefecture (PR).

4) Separation of the concepts of the visualization system, which will serve as the platform, and the data posting application to be used by local residents (Sustainability).

The system overview and user activities have been organized based on the above. For 1, the results of organized cleaning activities are recorded. It is expected that photos of the cleaning process or photos shown will be recorded along with basic information such as the organization's name, date and time, and location. For 2, the focus is on sustainable activities by local residents. As a result of individual efforts, it is expected that the conditions of debris and the amount of litter picked up will be recorded along with the date, time and location. The gist of 3 is that, since the coasts and rivers of Iwate Prefecture are also full of scenic spots and as well as scattered geosites, we will collect not only photographs of coastal debris, but also beautiful photographs which we plan to make use of. Finally, for 4, it is necessary to ensure that a variety of services can be introduced, as the cooperation of prefectural residents is essential.

Determination of Posting Data

In 2020, field surveys of coastal debris were conducted at 40 model locations along the coasts and river-side of Iwate Prefecture [3]. The coasts in Iwate Prefecture were generally clean, with much of the coastal debris comprised of natural materials such as seaweed, as well as many pieces of driftwood and fishing

gear that were likely caused by typhoons. Much of the manmade debris was plastic, and debris from China and Korea was also seen. In coastal areas, conditions are likely to change after a typhoon, etc., so the users who would presumedly be posting data would likely be people involved in the fishing industry, organizers of events such as clean-up activities, and local residents who go to the coast or riverside on a regular basis. These can be considered as a target. Since some coastal debris includes hazardous materials and items that are difficult to remove, it is necessary to distinguish whether administrative action is required when inputting data into the monitoring system (Figure 5).

On September 25, 2022, an “Zero Marine Litter Week 2022 in Iwate" was held at Ainohama, Mizuumi, Ryoishi-cho in Kamaishi City (Figure 6). The research team members participated in the event in order to understand the actual situation of coast cleanup activities and collect image data intended to be registered in the system. The resulting findings include: there is debris that can be collected (beverage bottles and cans, pieces of wood, fishing nets, etc.) and debris that cannot be collected (debris in dangerous places, large debris, microplastics, etc.); there was more garbage at the water's edge; it was difficult to record during cleaning activities.

From the above, for organizational activities, the number of bags of trash collected, the number of participants, and photos are the contents of our system's contributions. One contribution by a representative should be sufficient. It is also necessary to be able to report to the government when it finds hazardous garbage or large amounts of garbage are discovered. On the other hand, the system referred to in the related work encourages the submission of photographs of the status and number of pieces of trash. In the case of individual activities, it is conceivable to include these in the submitted data.

Left: Example of cleanable coastal debris (plastic bottles); Right: Example of coastal debris that may require government response (fishing gear).

Figure 5: Coastal debris conditions.

Figure 6: Collected litter and activity scene.

Systems Development

Based on the results of our analysis, we have developed a system. The role of the researcher in system development is project management. The local IT company developed the platform and the students developed the data posting applications.

Prototyping of Visualization System as a Platform

Based on related research and field studies, a prototype platform system is being developed [13]. Basic functions will be confirmed with this system. The system has the following three functions: a function for reporting cleanup activities by organizations or individuals, a function for reporting hazardous waste or illegal dumping to the government, and a function for submitting pictures of beautiful scenery. Data visualization functions are maps, statistics, and user rankings (Figure 7).

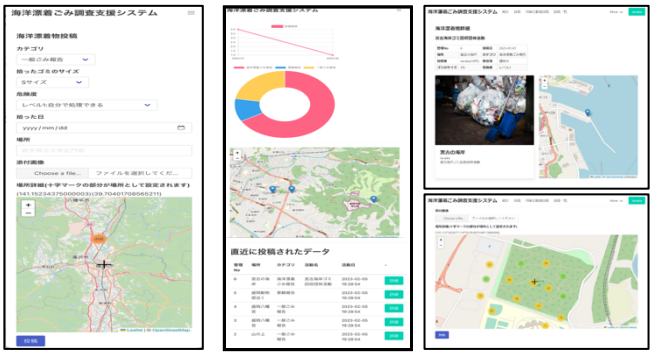

Figure 7: Screenshots of visualization platform.

Prototyping of Data Posting Application

For the visualization of cleaning activities, data must be routinely contributed by citizens. Therefore, this paper discusses the results of a prototype focusing on a data posting application. Based on the results of our fieldwork, we have developed two applications for the data to be submitted. These were developed as responsive web applications using PHP, JavaScript, HTML, and MySQL.

Integration with Health Promotion Activities

In order to reach not only users who are interested in this issue but also those who are indifferent to it, we focused on health promotion activities that are similar to cleaning activities. In recent years, more and more people are becoming physically active as people become more health-conscious. Walking and strolling are particularly popular because they do not require special equipment and can be started easily by individuals. Many people walk along rivers, beaches, and other promenades [14].

Based on walking and strolling, in this study, we prototyped two different applications that focuses on walking, which has attracted a lot of attention in recent years. One system focused on the walk rally (call prototype 1) and the other on the trash cans (call prototype 2). The walk rally was considered useful as a motivation for strolling because it connects destinations and aims at a goal (Figure 8).

Prototype 1 Prototype 2

Figure 8: Screenshots of two prototypes.

Evaluation

The two prototypes were evaluated by experts or citizens at a large-scale exhibition of SDG-related initiatives in Japan (Eco-Products 2021 and 2022). Figure 9 shows the scene. After the demonstration or hands-on experience, the participants were asked how good the concept was, whether they would use it on a daily basis, and whether they would recommend it to others.

Figure 9: Demonstration and Evaluation Scenes.

Prototype 1 was exhibited at Eco Products 2021 (12/8-10, Tokyo Big Sight), where the concepts of the system received high praise from experts and interested parties. We received comments from experts in Okinawa who are struggling to deal with coastal debris, saying that if the inter-user communication function is improved, it could be used for raising public awareness. However, users did not attempt to operate their phones during the walk rally. This fact differed from our prediction.

Prototype 2 was evaluated at the "Eco-Products 2022 (12/7-9, Tokyo Big Sight)". We received comments such as, "it would provide a good opportunity to think about litter collection, which you don't usually," and, "it seems useable for sightseeing, emergencies, and other settings," and, “the idea to map the garbage cans is interesting.” On the other hand, we encountered the opinion here as well that, “I would like game elements that parents and children could enjoy together.” In order to encourage users to contribute the amount of trash they pick up, it would be effective to have the system indicate nearby trash cans.

Discussions

In this paper, we have also defined the root of the system with SSM followed by the root definition of the application to reach the indifferent segment of the population. We then developed prototypes of two types of data submission applications for daily use. The following sections discuss the findings.

Basic Functions of the Platform System

Regarding the platform system, in addition to designing the database, we developed a submission form and statistical data display section to check the overall flow, and verified the operation of these. There were three categories for submissions: general litter reports, coastal conditions reports, and scenic reports. The system accepts three categories of data: general litter reports, beach condition reports, and landscape reports. It also has a standard data posting interface; it is important that it be simple for users interested in this issue, as demonstrated by related systems such as MDT.

The subjects for visualization were a graph tracking the number of posts; a pie chart representing beautiful scenery and general litter; and a map of posting locations. When the research team tested the system's operation, they found issues such as “posted images not appearing on the details screen” and “difficulty in adjusting map points on a smartphone.” As a result of this review, we also recognized the following as issues for future implementation: providing a user-friendly UI, statistical user information and ranking functions for each municipality, and a sustainable system operating environment.

User Scenario for Data Posting Application

Based on the evaluation, we examined user scenarios for the data posting application. First, prototype 1 required the user to take pictures during the process to the goal. However, users concentrated on the rally and did not take pictures. On the other hand, with prototype 2, the timing for taking pictures was clear. Therefore, users did not hesitate to take pictures.

The first is when we find a beautiful view, and the second is when we finally throw away the trash. Although not present at this time, the timing for photographing hazardous trash and illegal dumping is likely to be the same as when one finds a beautiful view. Therefore, this study concludes that data posting applications should be developed with the assumption that cleanup activities are conducted during routine walks. In addition, the postings should include the size and number of trash bags and location information, indicating the location of the trash cans. Figure 10 illustrates the user scenario.

Figure 10: Illustrates the user scenario for data posting application.

Assumption of Concept Change for Data Posting Applications

In SSM, the componentization of the root definition of the system and the construction of the conceptual model are said to be repeated multiple times to increase feasibility. In our case, it is expected that the root definition of the platform system will remain the same after operation. However, given social changes in user preferences and trends, as well as mobile device updates, data posting applications should be reviewed every few years.

In recent years, many game companies offer many smartphone games that can be played while walking. There are also many applications that combine health care and point system. These applications compete with ours because they are designed to be used in the same situations, but they also have the potential for collaboration. Of course, there would be no problem if there were multiple applications capable of posting the same dataset. For example, a local government could develop a fixed-term application to be used for events. Flexible ideas and trends, such as gamification and AI, could be considered for incorporation into data posting applications.

Future Works

Once data collection has begun, it is important to consider what statistical methods will be used to visualize the data. Based on the previously mentioned policies of "Edification," "Participation," "PR," and "Sustainability," the team must consider how to develop the effects of visualization. For example, the research team is currently considering the inclusion of zip codes in user data in order to visualize contributions by region.

In addition, we must consider a management system for the collected data. Inappropriate postings should be reported to the system administrator by means of a reporting function. The platform system should also be able to compile the user's contributions on a yearly basis by administrative region, group, or individual, and allow for visual comparison. However, if the daily photo data is not properly managed, the data processing burden on the system will increase, making it difficult to use. Since the photo data will overwhelm the system storage, we plan to manage the data on an annual basis, and to archive the data from two or three years ago.

In Sweden, where a culture of prioritizing the environment has taken root in the national consciousness, the household recycling rate is said to be almost 99% [15]. And when it is time to dispose of garbage, recycling bins are installed in residential areas, and it is common practice to sort garbage into six categories, including paper, bottles, cans, plastics, and so on. We, who are in the process of doing so, should consider an information system to educate people about the classification of garbage. This could contribute to the promotion of carbon neutrality.

Although there is an aspect that the beautiful scenery and marine resources of some of the prefecture's rivers and coastlines are protected through organized volunteer cleaning activities, however, such contribution are not widely known by many citizens in the prefecture. Daily cleaning activities by individuals are also essential for natural environmental conservation.

We will continue to develop and evaluate the system. In particular, the data-posting application requires quantitative and qualitative evaluation of Iwate Prefecture residents. And we contribute to the promotion of nature conservation activities through our knowledge of systems design.

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