Community Environmental Mapping Using User-Friendly GIS:
A Case Study in Muko Neighborhood, Amagasaki

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Abstract
This study examines a method for producing a "Community Environmental Map" through public participation by using a Community Environmental Mapping Support System (CEMSS; user-friendly GIS). The authors developed a CEMSS and, as a case study, hosted a Community Environmental Mapping (CEM) Project employing the CEMSS. They describe the CEMSS and CEM project within the context of the following points: (1) Effectiveness of the CEM. (2) Effectiveness of the CEMSS in CEM. (3) Future challenges for improving the CEMSS. The findings revealed that participants were able to produce accurate maps using the CEMSS and that they were able to increase their knowledge of environmental design through CEM. For these reasons, the CEM Project was considered effective for community-scale spatial planning. Results from a questionnaire survey showed that CEMSS appears to be relatively easy for non-expert users of GIS to adopt, but that sufficient scope exists for improving the CEMSS. The potential for using CEMSS on a PDA with GPS in the field was considered particularly important as several participants found that they were unable to find their location on paper maps in areas with no obvious landmarks.

Keywords: environmental mapping; community involvement; landscape planning; GIS

1. Introduction
Public participation is becoming increasingly important in the field of urban planning, particularly in Japan where it is possible to observe community-scale, public participation at the level of district planning. In addition, environmental considerations in planning are also becoming more important. For these reasons, it is important to consider the local environment during community-scale spatial planning initiatives through public participation. In order to increase the effectiveness of community-scale spatial planning initiatives that consider the environment, it is useful for stakeholders to conceptualize, based on personal experience, a birds-eye view of the local environment. The production of environmental maps through public participation is particularly effective in allowing participants to gain a clearer understanding of their local environment through the physical experience of the mapping process.

Given these benefits, development of a method for producing "Community Environmental Maps" through public participation and the Community Environmental Mapping Support System (CEMSS; user-friendly GIS) may therefore be beneficial. As a first step, the authors developed a CEMSS and organized a Community Environmental Mapping (CEM) Project with public participation using the CEMSS. Here the authors present the findings of the CEMSS and the CEM project, and also discuss the following:

(1) Effectiveness of the CEM
(2) Effectiveness of the CEMSS in CEM
(3) Future challenges for improving CEMSS

In this study, a "Community Environmental Map" is defined as "a map that represents environmental elements, such as vegetation, fauna, water, air, and similar environmental attributes in the community", while "CEM" is defined as "The production of a Community Environmental Map through public participation".

2. Previous Studies and This Study
Conventionally, this kind of mapping has been conducted within the context of environmental education using paper maps (Hamaguchi, 1998). However, recent advances in GIS technology have meant that it is currently easier to use than before. Furthermore, GIS is well suited to CEM, because GIS can be used to produce and store numerous map layers (survey results) that can then be used for future planning. In addition, stakeholders can superimpose
these layers in order to understand the relationships among a myriad of environmental elements. In the U.S. and Japan, several environmental mapping projects using GIS have been undertaken to date (Ludwig and Audet, 2000; Itoh and Ugawa, 2001). However, these studies were not undertaken within the context of urban planning or environmental design, but rather for education.

GIS has been widely applied in the field of urban planning, particularly in western countries (Greene, 2000; Craig et al., 2002; Geertman and Stillwell, 2002), where "Participatory GIS" exercises have been used to collect and collate available local knowledge for planning purposes. On the other hand, CEM is used to facilitate a participant's understanding of the local environment for urban planning and environmental design.

Interestingly, there are few actual examples of "Participatory GIS" in Asian countries. This may be due to differences in the planning cultures of western and Asian countries, and even within Asian countries, planning cultures differ from one another (Sanyal, 2005). Therefore, it is necessary to examine "Participatory GIS" within a Japanese context. In Japan, web-based mapping systems have been developed to map the locations of sites of interest in towns by citizens (Manabe, 2003). Generally, however, web-based GIS systems are difficult for average Japanese citizens and local communities to develop. Consequently, a CEMSS was developed as a standalone software program for use on a personal computer. Given that most of the stakeholders involved in community-scale planning initiatives in Japan are relatively old and not familiar with operating complicated software, the design of the CEMSS was kept simple and functionality was limited.

While several environmental maps have been produced for urban planning (Kubota et al., 2005; Miura et al., 2005), the separate map layers were not stored as GIS data. However, if such layers were stored in a GIS, they would be more useful and effective for planning. In the U.S., CEM-like projects have employed normal GIS applications which are expensive and complicated to use (Knapp et al., 2003). However, in Japan, citizens do not have access to normal GIS, which is why a CEMSS (user-friendly GIS) was developed for this study.

3. Outline of CEM
3.1 Study Area

Fig.1. shows the study area, which consists of a part of the Muko neighborhood in Amagasaki City. The area is mainly residential, but also contains some agricultural land. The irrigation channels used for agriculture in this area also serve as habitats for numerous species of flora and fauna.

3.2 Method for CEM

The authors organized this CEM Project with public participation as a case study on Saturday, September 30, 2006. At the event, the participants focused on recording the occurrence and distribution of flora and fauna in the channels because channels are important environments for biota in this area. The project outline is as follows:

(1) Schedule
-10:00–10:10 Introduction
-10:10–12:10 Field Survey
-12:10–13:30 (Lunch)
-13:30–14:10 Input Field Survey Results to CEMSS
-14:10–14:30 (Short Break)
-14:30–15:15 Open Discussion
-15:15–15:30 Questionnaires

(2) Participants
-Morning: 13
  (Citizens, 9; Students, 3; University Faculty, 1)
-Afternoon: 9
  (Citizens, 5; Students, 3; University Faculty, 1)
Four citizens returned home at noon due to previous commitments. Authors appealed to the public to participate in the study beforehand.

(3) Field Survey Methods
The authors divided participants into three groups, each containing citizens. Similarly, the channels in the neighborhood were divided into three areas, each of which was assigned to a group. Since the focus of the CEM on this day was on the natural environment of the study area, groups carefully examined the biotic components of the channels to which they were assigned. During two hours, each group walked along the channels and documented the occurrence of target species (Fig.2.). Target species (flora and fauna) consisted of the following:

Fig.1. Study Area
1) *Egeria densa* (plant)  
2) *Potamogeton crispus* (plant)  
3) *Potamogeton oxyphyllus* (plant)  
4) *Calopteryx atrata* (insect)  
5) Other Damselflies (insect)  
6) *Zacco platypus* (fish)  

The authors selected these target species from an ecological perspective (ecological health, biodiversity, and so on). Before the survey, they distributed photographs of target species (Fig.3.) and paper maps (scale: 1/1000) of the area among the groups. Upon sighting any of the target species, participants marked the corresponding point on a map.

(4) Method for Inputting Field Survey Results into CEMSS  
Each group then input their field survey results into the CEMSS by themselves (Section (3.3); Fig.4.). Participants then took a short break, during which time the authors integrated the data gathered by the three groups. These integrated maps were then presented to participants and discussed during an open discussion session.

(5) Open Discussion Method  
During the open discussion, each group viewed the integrated map on their CEMSS, using some of the mapping functions and reported on their findings. The integrated map was also projected on screen, which enabled all of the participants to examine and discuss their findings and aspects related to future environmental designs for the area.

3.3 CEMSS  
The CEMSS software developed by the authors and used in this study was based on a GIS that was developed using MapObjects Ver. 2.2 (ESRI Inc., Redlands), which is a set of GIS components, and Visual Basic.NET (Microsoft Corp., Redmond) a development language (Ralston, 2001). In addition, the GIS data created for the CEMSS can be used on the ArcGIS (ESRI Inc.) platform, which is popular among GIS specialists.

Fig.5. shows the user interface of the system, which was designed to be as user-friendly as possible to facilitate operation by the average citizen. The functions of this system therefore consisted of the following:

1) Map manipulation (Zoom In, Zoom Out, Zoom to Full Extent, and Pan)  
2) Visible/invisible control for the map layer showing target species distribution  
3) Visible/invisible control for the map layer showing the channel  
4) Visible/invisible control for the map layer showing the base map (When the base map is invisible, an aerial photograph will appear.) (Fig.6.)  
5) Zoom to entire study area  
6) Input field survey results (Add Point, Undo, Save to Layer) for each species on a separate layer  

For this system, the authors used scanned and geo-referenced cadastral maps produced by local governments as base maps. Since all local governments are obliged to produce maps such as these and make them available to the public, maps can be obtained anywhere in Japan. This also means that this system can be used in other Japanese cities.

In addition, the authors provided a brief introduction (approximately 5 mins.) of the system to the participants before inputting field survey results. During the open discussion, participants projected this system on the screen.

3.4 Results  
Fig.7. shows two of the resultant maps produced by participants. Each species was observed to have a unique distribution pattern.

4. Discussions  
4.1 Effectiveness of the CEM  
After the open discussion, questionnaires were administered to participants in the afternoon. The
number of effective answers was 8 (Citizens, 5; Students, 3). Questions related to the effectiveness of the CEM project were as follows:

**Question 1**
Was this project enjoyable for you?

**Question 2**
Did you acquire any new knowledge by participating in this Project?

**Question 3**
Is this kind of project useful for future community planning initiatives?

**Question 4**
What is a useful (or interesting) target for the next CEM project in this area?

Fig. 8. depicts responses to Question 1. All participants reported the exercise as being enjoyable with several participants expressing interest in being involved in subsequent CEM projects; this is important for ensuring the sustainability of this project.

Fig. 9. shows the responses to Question 2. We can see that all participants acquired new knowledge as a consequence of taking part in the project. For example,
when viewing the overlaid maps that were produced using CEMSS during the open discussion, participants became aware of the fact that each species had a unique distribution pattern. The maps also revealed that *C. atrata* lives on *E. densa* or *P. oxyphyllus* and that they also require a large forest nearby. It became clear that if we want to live with *C. atrata*, we must ensure the survival of *E. densa* or *P. oxyphyllus* in the channels and maintain a large forest nearby. This is one example of how knowledge can be acquired by participants in a CEM project and illustrates its potential application to environmental design (Fig.10.). In addition, the open discussion was important for CEM, because participants were able to share knowledge through the discussion.

Fig.11. shows the responses to Question 3. All participants felt that this kind of project is useful for future community planning initiatives. However, some participants identified the need for continuous surveys in order to collect sufficient data for planning. For example, some participants mentioned that the flow and velocity of runoff in the channel will also affect *C. atrata* habitat and that this should be measured in subsequent projects; continuous CEM projects therefore seem to be necessary.

Table 1. shows the responses to Question 4 that were organized into four categories (Ecosystem, Channel, Culture, and Artificial Environment). The results show
that the potential application of this CEM is broad. There may therefore be a need for local communities to prioritize a set of targets for the CEM, based on the characteristics of the local environment.

4.2 Effectiveness of the CEMSS in CEM

Every group was able to input all of their field survey results into the CEMSS accurately and correctly. During the open discussion, by overlaying some of the layers in the CEMSS, participants were able to find that *C. atrata* require *E. densa* or *P. oxyphyllus* to live on, and need to have a large forest nearby. Participants were able to locate forested areas by viewing aerial photos on the CEMSS. Given this example, the CEMSS seems to be useful for CEM. In addition, "Visible/invisible control for the map layer" is important in CEMSS and aerial photos appeared to be an essential component of the CEMSS because they contain valuable qualitative information.

After the open discussion, questionnaires, related to the CEMSS were also distributed among participants. As before, eight valid responses were obtained (Citizens, 5; Students, 3). The questions were as follows:

**Question 5**

Did you operate the CEMSS?

**Question 6**

Was the operation of the CEMSS easy? (This question is intended only for participants who answered "Yes" to Question 5.)

Fig. 12 shows the responses to Question 5. We can see that, of the participants that operated the CEMSS, two were citizens. All CEMSS operators use personal computers in their daily lives, and from a practical viewpoint, for future CEM projects, every group should have one person that uses a personal computer daily. This should not be difficult because personal computers are very popular in Japan.

Fig. 13 shows responses to Question 6. All CEMSS operators, even those who were not experienced GIS users, felt that the CEMSS was very easy to use. Therefore, it appears that participants are able to use CEMSS easily if they can use a personal computer.

4.3 Future challenges for improving CEMSS

After the open discussion, questionnaires related to subsequent challenges and necessary improvements to the CEMSS were also administered to participants. A total of 8 effective responses were obtained (Citizens, 5; Students, 3). The questions were as follows:

**Question 7**

What function would you like to see added to the CEMSS?

Responses to Question 7 are as follows (numbers in brackets reflect the number of respondents):

1) Inputting of text (comments) on the map. {4}
2) Attaching of photographs to certain areas on the map. {5}
3) Using CEMSS on a PDA with GPS in the field. {3}

These functions appear to be necessary for CEMSS. Especially, the potential for using CEMSS on a PDA with GPS in the field, as some participants stated that they were unable to ascertain their location on paper maps in areas where there were no landmarks. Such
GPS technology already exists for PDAs and tablet PCs and has already been used in the field (Clegg et al., 2006). The next step, therefore, is for the authors to incorporate this into the CEMSS.

In addition, to make the CEMSS available anywhere in Japan, the authors need to add functions that permit the addition of new layers to increase CEMSS flexibly.

5. Additional Case Study

As an additional case study, the authors convened another CEM project using the CEMSS in the relatively rural neighborhood of Sugo in Takizawa Village in Iwate prefecture. The outline of the CEM is shown in Table 2. In this CEM project, participants who were not GIS specialists were also able to produce maps by using a CEMSS accurately and correctly (Fig.14.).

As before, when viewing maps that had been overlaid and produced using the CEMSS during the open discussion, participants became aware of the fact that each species had unique distribution patterns. The maps also revealed that target species inhabited trees along the side of the road and a small stream. Participants therefore realized that coexisting with these species would require conservation of these roadside trees and the small stream environment.

This exercise also demonstrated how knowledge can be acquired by participation in a CEM project and illustrates the potential application of the method to environmental design. In addition this CEM project also revealed the following:

(1) Participants who are not expert GIS users were able to produce informative maps using CEMSS.
(2) Participants gained new insights about the local environment. Consequently, CEM appears to be an effective method for increasing knowledge about the local environment among participants.
(3) During the open discussion, the CEMSS was found to be useful for acquiring knowledge required for environmental design.

6. Conclusion

The most significant outcomes of this study were:

(1) The authors developed a CEMSS (user-friendly GIS) for study areas.
(2) The authors developed a method for "Community Environmental Mapping (CEM)" involving public participation. As a case study, the authors hosted a CEM Project using the CEMSS.
(3) Participants were able to accurately capture their field survey results using the CEMSS and produce informative maps (Figs.7. and 14.), indicating that participants appear to have used the CEMSS correctly.
(4) Participants gained new insights into their local environment. Consequently, CEM appears to be an effective method for increasing knowledge about the local environment among participants.
(5) During the open discussion, the CEMSS was useful for acquiring knowledge and transferring ideas required for environmental design.

The questionnaire responses also indicated the following minor outcomes:

(1) Participants found the project to be enjoyable; an important prerequisite for making this kind of project a sustainable activity.
(2) Participants felt that this project was useful for future community planning. However, continuous CEM activities appear to be necessary.
(3) The CEM covered a broad area. Local communities may need to assess the priority of targets for CEM, and that this depended on their local environment.
(4) The CEMSS appeared to be easy for non-expert GIS users to use.

Challenges for future work include the following:

(1) The authors should increase the number of case studies and questionnaires given the relatively small sample size in this study.

Table 2. Outline of CEM in the Sugo Neighborhood

| Schedule | Same as the case in Muko neighborhood. |
|----------|----------------------------------------|
| Participants | 11 persons (Authors appealed to the public to participate in the exercise beforehand. The participants in the Sugo CEM were not the same as those who took part in the Muko CEM.) |
| Target species | Eupatorium chinense (plant) Desmodium oxyphyllum (plant) Miscanthus sinensis (plant) Pueraria lobata (plant) Aster ageratoides (plant) Polygonum filiforme (plant) Ambrosia trifida Linn. (plant) |
| CEM method | The CEM was the same as that employed in the Muko neighborhood. However, in Sugo, participants focused on all accessible areas, not just on channels as in the case of the Muko neighborhood. |
| Functions of CEMSS | Same as that employed in the Muko neighborhood. |

Fig.14. Target Species Map (Sugo neighborhood) (Circles represent locations at which participants observed target species.)
(2) The authors should extend this project using public participation to collect environmental data that can be applied to ecosystems, local culture, river channels, and built environments in this study area. The effectiveness of CEM in the long-term planning process also needs to be assessed.

(3) Several new functions need to be incorporated into the CEMSS. Specifically, the potential to use the CEMSS on a PDA with GPS in the field is important because some participants were unable to determine their location on the paper maps in the absence of landmarks.

(4) To make the CEMSS available anywhere in Japan, the authors need to increase the capacity in order to flexibly add new layers to it.

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