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IMPACT EVALUATION OF HAIZUKA DAM ON ITS UP STREAM: A CASE STUDY IN HIROSHIMA PREFECTURE, JAPAN

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ABSTRACT: Japan ranks fifth in the world for the number of large dams. Environmental impacts of large dams are known, such as enormous losses of water or disruption of fish spawning, however, impacts of the dams on their up streams are functions of topography of the up stream. Haizuka Dam is located in Hiroshima Prefecture, Japan and its implementation will start in 2006. This large dam influences its up stream through dam making activities, which occurs in order and with different spatial presences that were categorized into chronological and spatial impacts. In this case study, spatial impacts were further divided into horizontal and vertical ones. The horizontal impacts were identified as new roads, diversion tunnel, dam lake, and submerged cultivated land, while vertical impacts were recognized as submerged historical monuments, slope protections, dam body, and deforested area in the reservoir. There were convergences of spatial and temporal impacts, however, the extent of the impacts was limited to the lake boundary.

KEY WORDS: dam impact; up stream; Haizuka Dam; Japan

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1 INTRODUCTION

There are more than 45 000 large dams, with a relative height of above 15m, in the world. As for large dam number, China ranks first with approximately 19 000 dams, and the next four positions are filled by USA, former USSR, India, and Japan (World Commission on Dams, 2000). According to MILLER (1995), some of common impacts of large dams on environment were expressed as enormous losses of water through evaporation, earthquakes caused by mass of water, destruction of forestlands and croplands caused by flood and collapse, displacement of people, loss of nutrient-rich silts in downstream croplands and estuaries, and disrupted migrating and spawning of some fish. Also, dams and their reservoirs have some advantages, such as recreation, fishing, hydropower, and water for irrigation or residents. However, influences of dams on their up streams are related to dam′s geography due to strong relationship between human-origin impacts and socio-economic environment (NAKAGOSHI and OHTA, 2000). For example, impacts of a dam with small reservoir surface may generally be limited by and dependent on the desired developmental programs in a specific area, but on a larger scale such as Aswan Dam in Egypt, the dam highly affects its up stream (World Commission on Dams, 2000). Therefore, case studies of each dam are significant for understanding the visual impacts of dams on their up streams. A visual impact contributes to a reduction in scenic values (natural or traditional landscape) and the degree of change in resources and viewer response to those sources (CANTER, 1996). When the standard visual quality of an area is degraded, quantification and classification of the impacts are vital to reduce or manage the impacts.

In Haizuka Dam Watershed in Japan, dam making activities have degraded traditional landscape. Some of these impacts would remain for a longer time (e.g. dam body) after implementation and some would be terminated when the dam is completed (like dam constructing activities). Nevertheless, the presentations of impacts are functions of time and space. Hence, we categorized them into time- and space-related visual impacts. In REINERS and DRIESE (2004) ontological perspectives on time and space in the environmental sciences have been well explained. However, the mentioned authors emphasize on the materialistic approach of the Cartesian System as the common and dominant point of view in all environmental sciences. Thus, based on the Cartesian System, the space-related visual impacts were

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divided into horizontal and vertical impacts.

Several checklists were introduced to estimate the visual impacts (BEER, 1990; SMARDON *et al*., 1986), which have been used in different countries. In addition, the checklists imply theoretical dialect for justification of impact magnitudes, while spatial and temporal categorization can classify and quantify the impacts for further decisions. Therefore, we selected a calibrated checklist as the framework for our estimation of the study area, which was quantified according to the available maps such as projected-landslide, topography, historical monument, or new road.

2 STUDY AREA

Haizuka Dam Watershed is located in 34°38′ 52"–34° 51′11" N, 132° 58′41"–133° 10′ 37" E. This watershed, with an area of approximately 21 110ha, is located in the eastern part of Hiroshima Prefecture, Japan (Fig. 1). Haizuka Dam bed and top elevations are 201m and 251m a. s. l., respectively. The dam is scheduled to be completed in 2005 and its implementation will start in 2006. Dam lake area would be 3.52km^2 with a storage capacity of 52.0×10^{6}m^3. Haizuka Dam is being constructed to end the shortage of water in Miyoshi and Shobara cities, provide flood control and irrigation to agricultural lands in down stream (Haizuka Dam Constructing Committee, 1998). The lake and its surrounding area, which is the key area influenced by the dam on the up stream, was selected as the study area.

3 METHODS

3.1 Six Steps in Visual Impact Assessment

The assessment procedure introduced by CANTER (1996) was considered to evaluate the Haizuka Dam impacts on the up stream. The conceptual approach comprises the following six steps: 1) identification of types of visual impacts from proposed project/activity; 2) description of existing visual resources for the study area; 3) procurement of relevant laws, regulations, or criteria related to the impacts/conditions ("Conditions" are those frameworks that are mentioned in the Guide lines of the EIA); 4) prediction of the proposed project/activity impact on existing visual resources; 5) assessment of the predicted impacts; 6) identification and incorporation of mitigation measures. For the step 1, a checklist was created in several fieldworks to estimate the potential visual impacts of the Haizuka Dam Project on its vicinity.

3.2 Zone of Visual Impact (ZVI)

To assign a methodology to step 2, the arranged checklist in the step 1 was used to present the visual resources. MARTIN (1984), who explained several visual impact assessment techniques for appraising proposed development sites, presented the technique of "zone of visual impact" (ZVI) that works directly from topographic maps. The ZVI, then was used to plot the area where which a man-made structure can be seen (CANTER, 1996). For further assessments, ZVI technique

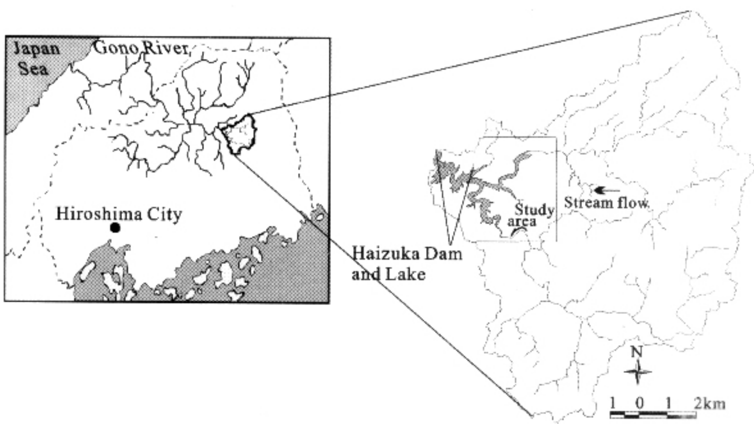

Fig. 1 Study area (Haizuka Dam Lake and its vicinity)

was concentrated on topographic, road, land sliding-risk, historical monument, and land use maps of the study area. In the steps 2 and 4 data were extracted from and transferred to topographic maps (scale: 1:25 000) and the magnitudes of the impacts were estimated according to the occupied area. These two steps were combined together since some of the predictions had already been conducted in the area. The other visual impacts such as diversion tunnel, historical monuments, and dam body were described (Haizuka Dam Constructing Committee, 1998).

The step 3 focuses on the "procurement of relevant laws, regulations, or criteria related to impacts/ conditions". Since Haizuka Dam is currently under construction, the project must have met the standards and regulations (Ministry of Environment, 1999). Therefore, this step was not considered in our study.

In step 5, significance of the predicted or estimated visual impacts has been clarified according to the relative magnitude of visual surfaces. For step 6, roads (FORMAN and SPERLIONG, 2003), and slope protections were identified and incorporated as mitigation measures. The two steps were explained in the discussion part of this paper.

3.3 Software and Data Sources

The maps used in the paper were digitized by using ArcView® 3.2a program and all of the calculations were performed in the same environment using X-tool extension. The lengths of the roads were extracted directly from the topographic maps. The width of each class of the roads was decided according to the Japanese standard of the roads (Ministry of Land Infrastructure and Transport of Japan, 2000). The widths of the roads, from type 1 to type 5, which were in the order of 9.3, 9.3, 4.3, 2.3, and 1.5m, were multiplied by the lengths of the roads, and subsequently, the areas of the roads were estimated. Types 1 and 2 roads are the same in widths, however, according to the legend; the "type 2 road" refers to those that do not have "national route number".

The extension of 3D Analyst ArcView ® 3.2a was used to estimate the visibility of Haizuka Dam Lake. The presumption was that the observer looks to the opposite side of the lake. As there were several possibilities to view the lake, we considered only the deepest valleys to check the lake visibility from the summits. The summits were decided as the registered points around the lake and the "line of eye" application of the program was calibrated as 1.7m for eye level.

4 RESULTS

4.1 Checklist Assigned to Impact

Erection of Haizuka Dam involved several activities and landscape conversions. The prepared checklist in the step 1 qualitatively identified the impacts of the Haizuka Dam Project on the up stream. The checklist of dam-making activities and their visual impact in the area were shown in Table 1.

4.2 Presence of Impact

The visual appearances of new roads and islands, slope protections and historical monuments, dam lake visibility, and roads and land uses submerged in the lake were depicted into Figs. 2, 3, 4, and 5 respectively. The quantification of their appearances in the Haizuka Dam vicinity, which is the steps 2 and 4 of the procedure, were depicted into Table 2.

Table 1 Checklist of presentation and purposes of dam-making activities

Activity	Purpose
Dam constructing activities	Trucks for excavation, debris, and quarries to or from the dam site
Diversion tunnel	To keep the dam bed dry by temporarily changing the river stream
Reservoir deforestation	To facilitate other dam making activities
Slope protection	To protect the soil from land sliding risk
Replacing roads or bridges	To renew the previous passages and for further accesses
Migration of dwellers	To search new rice fields and residential areas

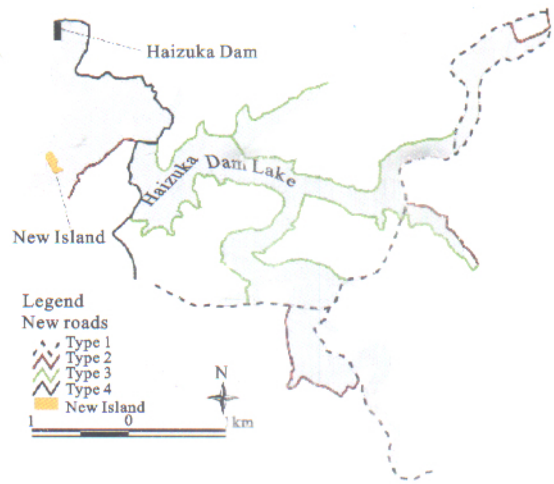

Fig. 2 New roads and islands

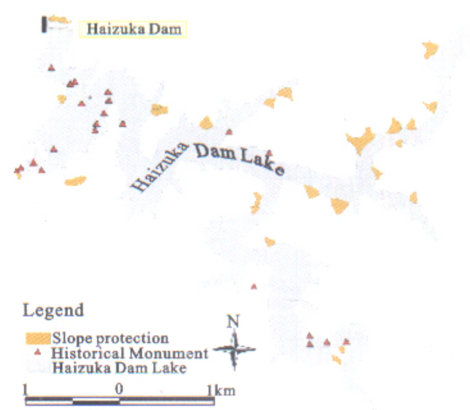

Fig. 3 Slope protection and historical monument

5 DISCUSSION

5.1 Chronological Impact

The six-step methodology deployed to delineate exist-

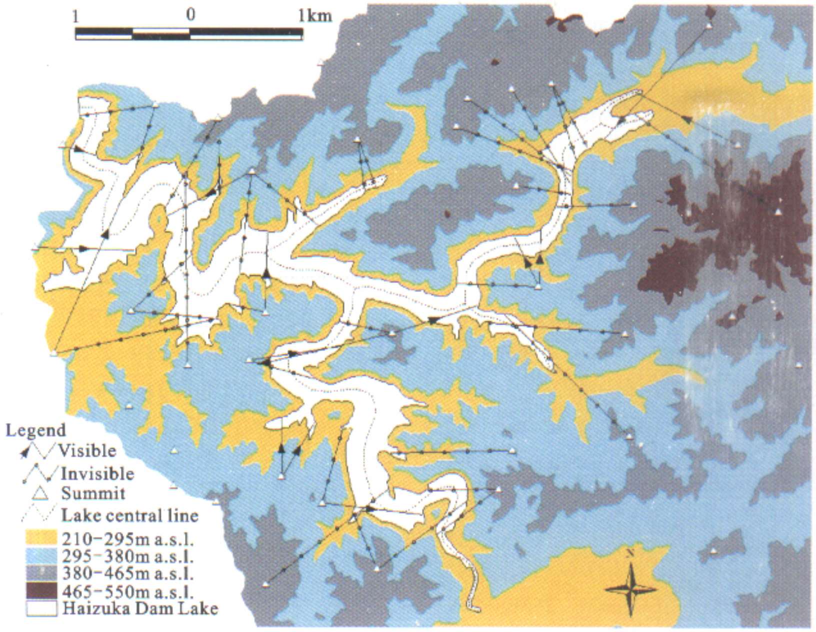

Fig. 4 Visibility and invisibility of Haizuka Dam Lake from summits

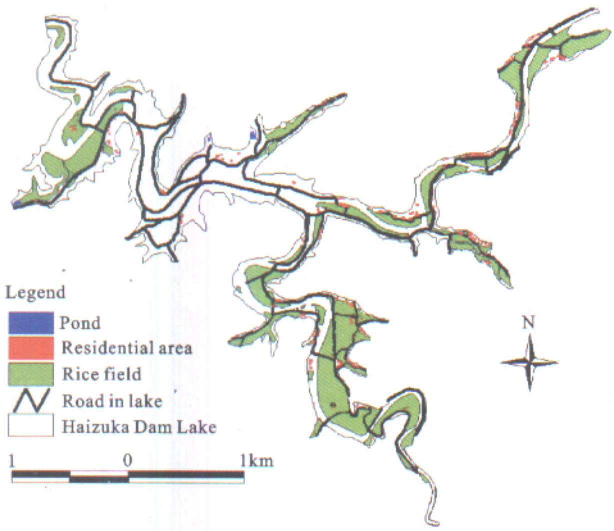

Fig. 5 Roads and land uses submerged in Haizuka Dam Lake

Table 2 Dam-making impact and their quantities

Dam impact (up stream)	Length, volume, area, or visibility
Diversion tunnel	300m length inside the southern side of the dam site
Land sliding risk areas	25 places, 26.2ha
Historical monuments	23 points
New roads	35.4km, 254031m^2
New bridges	1.2km with in 6 cases (only bridges cross the lake central line)
Deforestation	Reservoir surface plus slope protection surface
Land use sank in the lake	114.3ha of farmland, 211 cases of residential areas
Roads sank in the lake	31.8km, 123456.6m^2
New island	One case with 1.9ha
Dam body	180×10^{3}m^3 of concrete
Dam lake surface	3.52km^2 (including main body, northern and southern bays)
Dam reservoir	52×10^{6}m^3 of water (appearing after implementation)
Dam lake visibility	Lake was visible from 12 out of 30 summits
Dam body visibility	Visible only up to a distance of 260m toward up stream

ing visual resources and to predict the Haizuka Dam impact on its up stream. Construction activities have occurred in hierarchy, such as making roads and slope protections before completion of the dam body. These activities would be terminated after the year 2005, but the visual appearance will remain for a long time. Nevertheless, the lake and the small island emerge in the area after the dam implementation, which leads to recreational activities (e.g. sports, fishing, or boating). These visual impacts were categorized as chronological impact.

5.2 Spatial Impact

Detailed quantification of spatial impacts in Haizuka Dam was divided into horizontal and vertical impacts. These types of impacts of Haizuka Dam on the up stream were quantified based on the surface, volume, or dam lake and its body visibilities, which are the result of dam making. For example, after completion of the dam, the valley should carry 52.18×10^{6}m^3 mass of water and concrete (found by adding the volume of water in the reservoir and the concrete of dam body: 52.0×10^{6}m^3+0.18×10^{6}m^3. The lake we estimated was visible from 50% of summits around the lake (Table 2 and Fig. 4). However, the dam body was almost invisible over a distance of 260m (looking toward dam highest from the mountain top). We did not have access to the slope protection layout maps, therefore, maps of landslide risk were assigned to reflect the magnitude of the slope protecting areas. Moreover, no attempt was done to esti mate the slope protection structures in the lake that would be partially submerged after the dam implementation.

Aesthetics can be defined as what is concerned with characteristics of objects and of human being perception that makes the object pleasing or displeasing to the sense (US Army Construction Engineering Research Laboratory, 1989). But in this study aesthetics was not considered and the term visual impact was only referred to the significance or magnitude of visual-resource quality change as a result of anticipated activities in land uses that are to take place (or have taken place) on or adjacent to the landscape. For example, the small island or six bridges on the lake will add new site-seeing dikes to the areas′ perspectives that would be positive on the scenery, as reflections on the lake surface would add pleasant landscapes to the Haizuka Valley. However, no attempt was conducted to score or evaluate these new sceneries.

Measures of mitigation were modified and suggested based on the checklist and the types of activities (step 6), of which the magnitude has been assessed (step 5) through the horizontal and vertical surfaces. Subsequently, the significant visual impacts have been identified, such as the reservoir surface, dam body, roads, and slope protections, etc. The danger of dam-wall collapse makes slope protection inevitable, however, these structures in the other parts of the reservoir can be converted into natural substitutions. The length of new roads was 4km shorter than that of old one, but the area they would cover was almost two times expanded; therefore, narrow winding park-like roads, which have low traffic volume, vehicle speed, traffic noise, pollutant level, and road kill rate (FORMAN, 2003) have less degradation impact than wide roads. Then, we can recommend the roads in types 3 and 4 around the Haizuka Dam Lake to be more suitable to preserve the traditional landscape than the types 1 and 2. Displacing the historical monuments has been a solution to these structures though it deteriorates the traditional landscape, but will save the original mounds. Cultivated lands and forests would be vanished and traditional landscape would be degraded in the area, but the lake would provide a new source of food and recreation. In other words, agriculture would be converted to aquaculture.

6 CONCLUSIONS

This case study was defined to interpret the human visual impacts on the original landscape. Even if not all of the sceneries were visible, or occurred at the same time, vertical and horizontal concepts reflect the relative magnitude of the visual impacts of Haizuka Dam making activities (for example we can compare the area of the roads before and after implementation). This is where chronological classification of the impacts revealed the hierarchy of occurrences of the impacts. However, in both spatial and temporal categories of impacts, the intensity was swarmed to the Haizuka Dam Lake boundary.

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