Interaction of Land Use Change and Water Pond Irrigation Management System on Rice Terraced Landscape in Hokudan-cho, Hyogo Prefecture, Central Japan

I G. A. A. ライ アスミウィヤティ*・一ノ瀬 友博**・片岡 美和***・ヌルハヤティ H. S. アリフィン****

兵庫県津名郡北淡町における土地利用変化と水資源管理方法の関係について

1. Introduction

The terraced paddy landscape as a cultural landscape reflects the long term interactions between socially organized human beings and physical forms. The disturbance by human beings has occurred for a thousand of years or more, creating a unique assemblage of patterns, species and processes. Changes in landscape patterns are determined by a combination of nature and human beings derived disturbance. Social, cultural and economic conditions are potentially the most influential factors in its change.

In Japan, terraced paddy fields were constructed in mountainous slopes with clearing forests and leveled by dry stone walling. They seem to be nature destruction, actually these created multiple functions as wildlife habitat, water storage, flood control and visual amenity. However, nowadays its management is difficult due to labor shortage, rice surplus, fuel revolution and government regulations in rural areas.

Focusing on this study area, due to shortage of rainfall, short river and steep slope condition, many rain water storage ponds have been built and complicated irrigation ponds management systems can be observed.

The objectives of this study were to identify terraced paddy field landscape change and to reveal their relationships to irrigation pond management systems.

2. Study site and methods

2.1. Study Site

A study site was located in Hokudan-cho, Awaji Island, Hyogo Prefecture, Central Japan (Figure 1) and covered 83 hectares. It is located in a mountainous topography with elevation ranging from 93 to 283 meters, where terraced paddy field and water ponds predominate the landscape. Yearly average precipitation is about 1300 mm. Mean maximum temperature in August is about 27 degree and mean minimum temperature in February is about 5 degree.

This area was selected because it represents the general terraced paddy features of Awaji Island and contains two types of paddy field irrigation systems. One of the two systems is called...
Tazu (43 hectares); it is the communal group that jointly owns the right for water source (water ponds), follows customary rules, and governs the allocation of water and maintenance of the facility [5]. The other is private management system which covers 40 hectares. In this system, personal ponds located near a farmer’s house or paddy fields are used for irrigation. The boundary of Tazu area and private management area was considered to determine study site boundaries.

2.2. Materials and Method

Change in pattern of land use was identified and analyzed from topographical maps produced in 1963 and 2000 with scale 1:2500. These were digitized using Geographical Information Systems. Land use types were classified into woodland, bamboo forest, paddy field, dry field, orchard, grassland, pond, stream, residential area, road, cemetery and bare land.

The height distinction in bamboo forest had associated the lack of bamboo forest classification on the topographical map. A field survey and aerial photographs were conducted to confirm bamboo forest condition in each period. Many bamboo forest patches were added based on aerial photographs and the field survey.

Clarification of the change in paddy fields during those periods with its social driving factors was made possible information provided in map analyses and interview. Social causes of landscape change, land use and irrigation management, government regulations were investigated through interviews with prefecture officials and available inhabitants in the study site. Interview with inhabitants were conducted using group and individual methods. The respondents were the farmers who using Tazu and private management system to irrigate their paddy fields.

3. Results

3.1. Terraced Paddy Landscape Pattern

A land use map in 2000 was showed in fig. 2. Paddy fields had been given priority over all land use. Using ponds to collect water precipitation, water was being available to irrigate all the paddy field. Two big water ponds in the highest place were built to irrigate all Tazu area. Meanwhile, many small ponds were built in private management area as a personal irrigation system. These types of irrigation systems are clearly separated as two areas.

Houses in private management area were far from each other. Every farmer’s residence was enclosed by their own cultivated areas such as paddy field, plantation, and dry field. Each residence including cultivated land was connected by narrow permanent road.

In Tazu area, members’ residences were located and concentrated in several separated residential areas. Their paddy fields connected in a large area and took the water from the same sources. Coppice woodlands were seen intersperse of fringe over them in the distance.

3.2. Land use change

A land use map in 1963 was showed in fig. 3. In 1963 the landscape was dominated by paddy field (57.3 % of total area) followed by woodland (21.4 %), grassland (6.3 %) and residential area (5.7 %).

Table 1. Transformation of land use from 1963 to 2000

<table>
<thead>
<tr>
<th>land use</th>
<th>1963</th>
<th>%</th>
<th>2000</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>woodland</td>
<td>17.7</td>
<td>21.4</td>
<td>13.5</td>
<td>16.3</td>
</tr>
<tr>
<td>bamboo forest</td>
<td>0.7</td>
<td>0.8</td>
<td>3.9</td>
<td>4.7</td>
</tr>
<tr>
<td>paddy field</td>
<td>47.6</td>
<td>57.3</td>
<td>36.8</td>
<td>44.3</td>
</tr>
<tr>
<td>dry field</td>
<td>0.0</td>
<td>0.0</td>
<td>3.6</td>
<td>4.4</td>
</tr>
<tr>
<td>orchard</td>
<td>1.0</td>
<td>1.2</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>grassland</td>
<td>5.2</td>
<td>6.3</td>
<td>9.7</td>
<td>11.6</td>
</tr>
<tr>
<td>pond</td>
<td>4.4</td>
<td>5.3</td>
<td>3.9</td>
<td>4.7</td>
</tr>
<tr>
<td>stream</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>residential area</td>
<td>4.7</td>
<td>5.7</td>
<td>5.9</td>
<td>7.2</td>
</tr>
<tr>
<td>road</td>
<td>1.1</td>
<td>1.4</td>
<td>4.4</td>
<td>5.3</td>
</tr>
<tr>
<td>cemetery</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>bare land</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>sum</td>
<td>83.0</td>
<td>100.0</td>
<td>83.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 2. Land use in 2000.
The result of land use change for the period 1963 and 2000 was described in Table 1.

The area of paddy field registered 13 points declined across the 37 years. Woodland registered 5.1 points decreased in area. There was a substantial increase in the number of dry field, grassland and bamboo forest. The large increase of dry field was due to the appearance of new uses. In 1963, there were no dry fields in this site. Almost cultivated lands were occupied by paddy field and few orchards. In 2000, 4.4 % of all area in study site were cultivated as dry field. It changed the ponds of paddy field which small and located nearby the farmer’s residence. Grassland increased 5.3 points and bamboo forest registered a 3.9 points increased.

3.3. Paddy field change in Tazu and private management area

The highest of land use change both in Tazu and private management area occurred in paddy field. The difference of paddy field changing pattern on Tazu and private management area is described in Table 2. Typical of terraced paddy landscape change in spatial at 1963 and 2000 can be seen on Table 2.

The change of paddy field occurred more in private management area than in Tazu area. In Tazu area, the change of paddy field was dominated into grassland (37.7%), followed by residential area (21.7%), road (16.2%) and dry field (15.7%). Meanwhile in private management area, the change was dominated into dry field (28.6%) followed grassland (26.3%), road (14.0%), woodland (12.1%) and bamboo forest (6.5%).

Other changing patterns from paddy field into bamboo orchards, pond, stream and bare land also occurred but it did not give significant influence on the structure of rice terraced landscape in each irrigation management system area.

4. Discussion

Government regulations to reduce the acreage of paddy plantation and to give financial support for other cultivations were responsible for changes of paddy field. The other correlated social factors were labor shortage and rice surplus in each household. Thus, the efforts to keep paddy field caused great cost and energy. Based on these conditions, the farmer selected part of their paddy field to be changed into other utilization or abandoned them as uncultivated land. However, those regulations induced the different impact on the changing pattern of paddy field in Tazu and private management area.

The difference of changing patterns could chiefly be explained by differences time distance to and from residence and variations in the topographic features of the land units 6. Most of abandonment of paddy field was widely observed in the areas with...
difficult conditions for mechanized agriculture and far from farmer’s residence. All small paddy fields used by private management system which located in the mountain were abandoned without maintenance and have changed become woodland. Beside that, after earthquake in 1995 that destroyed the ponds, many farmers abandoned their paddy fields in the mountain. Meanwhile, the paddy fields at convenience location nearby residence were preferred to change into dry fields. It was because management and harvesting of dry fields are easier with low energy for their daily live.

The transformation of paddy field patterns depended on different recognitions by local inhabitants as to their importance of each land unit. The land use change of paddy field into dry field occurred more in private management area than in Tazu area. In Tazu area, the change was dominated into grassland. It was because of not all the farmers who used Tazu living on this Tazu area. Several of them live in private management area or outside of the study area. Considering the cost, energy and not necessary for their daily live, they preferred to abandon paddy field into grassland.

In the private management area, the land use change of paddy fields was more easily occurred due to no social rules. Physically, it was because of most paddy field in private management area were enclosed by road, elevation or natural physical elements. Thus socially, the land belonging to nearby farmers would not be impacted by the change of their paddy fields. In contrast on Tazu area, because of each unit of paddy field is adjacent to each other, forming terraced paddy field in a large area, Tazu members have responsibility to manage their paddy field well to avoid disturbance to other farmer’s land.

Regularly paddy field management in Tazu area would influence the increase of biodiversity. For example, continually grass and shrub cutting were effective in decreasing the amount of bamboo and other invasive species, thus increasing the diversity of vegetation. Beside that, the farmer efforts to maintain the network of irrigation system for keeping water right and harmonizing with the other fellows provided suitable habitats for aquatic plants and animal year around 6).

5. Conclusion
The land use change from 1963 to 2000 was dominated by the decrease of paddy field into other utilizations. It became clear that the social factors which cannot be seen directly in the field induced influences on the pattern of landscape change and the land management in the the two types of irrigation system. Customary social rules which contained in Tazu system were strongly contributed to the sustainability of the paddy fields.

It has been clearly understood that the conservation of terraced paddy landscape is one of the most essential objectives to maintain both biological and cultural significance in these regions. Therefore, further researches to find out an appropriate land and water management system in order to support the conservation of terraced paddy landscape is required. This effort should consider the traditional management systems, such as the Tazu system, and find out the way to solve the current social problems those happen in the system.

References
5) Cheng, S., Asada, M., and Ichinose, T. (2001), Topography and the Tazu system of Awaji’s rainwater storage pond (Tameike) - a comparison study of the farming social structure in Hokudan-cho and Mihara-cho, Hyogo Prefecture, Landscape Planning and Horticulture 2, pp.9-14