Research article

Factors affecting paddy landscape from the perspective of landscape structure

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Abstract The current landscape was constructed by the first settlement in approximately 120 years at the Shinotsu region located in the Ishikari River Basin, Hokkaido. The objective of this study was to investigate landscape elements and factors found during landscape changes as well as the problems associated with future developments. Data regarding landscape changes during each period were collected using topographic maps, and changes because of human actions and related projects in this region were recorded from town history and other related documents. Landscape changes occurred through the following steps: (a) primal natural landscape (peatland, primarily occupying the landscape); (b) natural and partial agricultural landscapes occurred during only good settlement conditions (alluvial plain); (c) decrease in natural landscape and gradual development of a dry field landscape with drainage of peatland (farmland expanded in hockmoor from niedermoor); and (d) paddy field landscape established using an advanced agricultural water-use system. From these landscape changes, it was clear that the changes in elements and factors were primarily human plans (motive), peatland characteristics (depending of Fudo, which is a holistic phenomenon based on the complex of interactions between factors such as climate, geography, and soil) and agricultural water-use system (tools and facilities). In addition, these elements and factors interactively affected landscape changes; thus, evaluation using each element or factor alone is difficult.

Keywords drainage, peatland, colonization lot-plan, irrigation, landscape change

INTRODUCTION

A landscape is not simple scenery. An agricultural landscape is formed by interactions between the ecosystem, climate, geomorphology, and human actions (Forman & Godorn, 1986). Any particular rural area (farming village) is composed of various combinations of farmlands and land improvement facilities, including production facilities, homes for living space, rivers, ponds, forests, and other natural environmental elements. Most studies have evaluated rural areas primarily on the basis of their production function or structure and function as individual elements because production was considered the first priority in rural areas. However, sustainable development is expected because of recent changes in circumstances surrounding life in rural areas as well as agriculture. Thus, natural environments can provide a fulfilling environment based on agricultural production, which generally indicates ecosystem stability. So, the holistic evaluation considering the relationship between each element is necessary for sustainable development. There are few evaluations like this in actually. Therefore, we suggest the landscape evaluation is effective.

A landscape is formed in a rural area by various elements. Landscape evaluation is an effective method to understand the relationships among the natural environment, life, production, and other elements. We can regard the landscape as an interaction between the visible phenomena on the land surface and the land-use pattern, which exhibits a material circulation and human interaction between natures in this region. Furthermore, evaluation of these phenomena is an

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effective method to understand the regional environment.

The objective of this study was to investigate landscape elements and factors observed during landscape changes as well as the problems associated with future developments.

METHODOLOGY

The target area of the study was the Shinotsu region located downstream of the Ishikari River Basin. In this area, the landscape represents the overview of pattern of land use.

We considered that investigation of land use and its patterns is an effective way to analyze the landscape. The distinguishing landscape forms and elements during each period were identified using Hokkaido soil maps (1985) and topographic maps issued by the Geographical Survey Institute as well as human actions and related projects for this area that were collected from town history and other related documents, including the history of irrigation, drainage and reclamation engineering in Hokkaido (1984), Shinshinotsu town history (1975), Tobetsu town history (1972), and others. Subsequently, a conceptual diagram was prepared from the collected data.

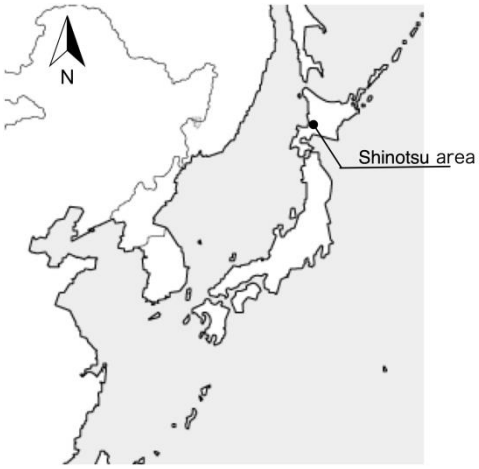

Fig. 1 Location of Shinotsu region

RESULTS

At present, an approximately homogeneous landscape, i.e., paddy fields, with a few land-use changes can be observed in the Shinotsu area. During each period, the natural landscape condition gradually changed because of policies, social and economic conditions, and progressive agricultural technology. Based on this developmental process, we considered that gradual development, factors restricting development, and human activities in the landscape differed during each period.

The elements and changing factors during each period are described as follows.

Landscape Changes, Elements, and Factors before the 1870s

Before reclamation and settlement, the region comprised a wilderness landscape with alluvial plains, hockmoor and niedermoor, forest, and river landscapes. The forest landscape was located on a neighboring hill and was characterized as a mixed forest with needleleaf and broadleaf trees. The wilderness landscape, located in the lower area, was characterized as the hinterland of the natural river basin. The wilderness landscape was formed by meandering rivers, floods, and sedimentation; thus, was considered an extension of the river landscape. This regional landscape was divided into hockmoor, niedermoor, and an alluvial plain based on its vegetation and pedogenesis.

The niedermoor formed the hinterland because of the effects of the Ishikari River. The hockmoor was formed and recharged by rain. The landscape change depends on the altitude of

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hockmoor, which was relatively higher than that of the other wilderness landscapes. The alluvial plain expanded along the Ishikari River and primarily comprised fluvial deposits; the primary vegetation was broadleaf forest. The alluvial plain landscape was characterized by the positional relationships among the river, soil, and vegetation.

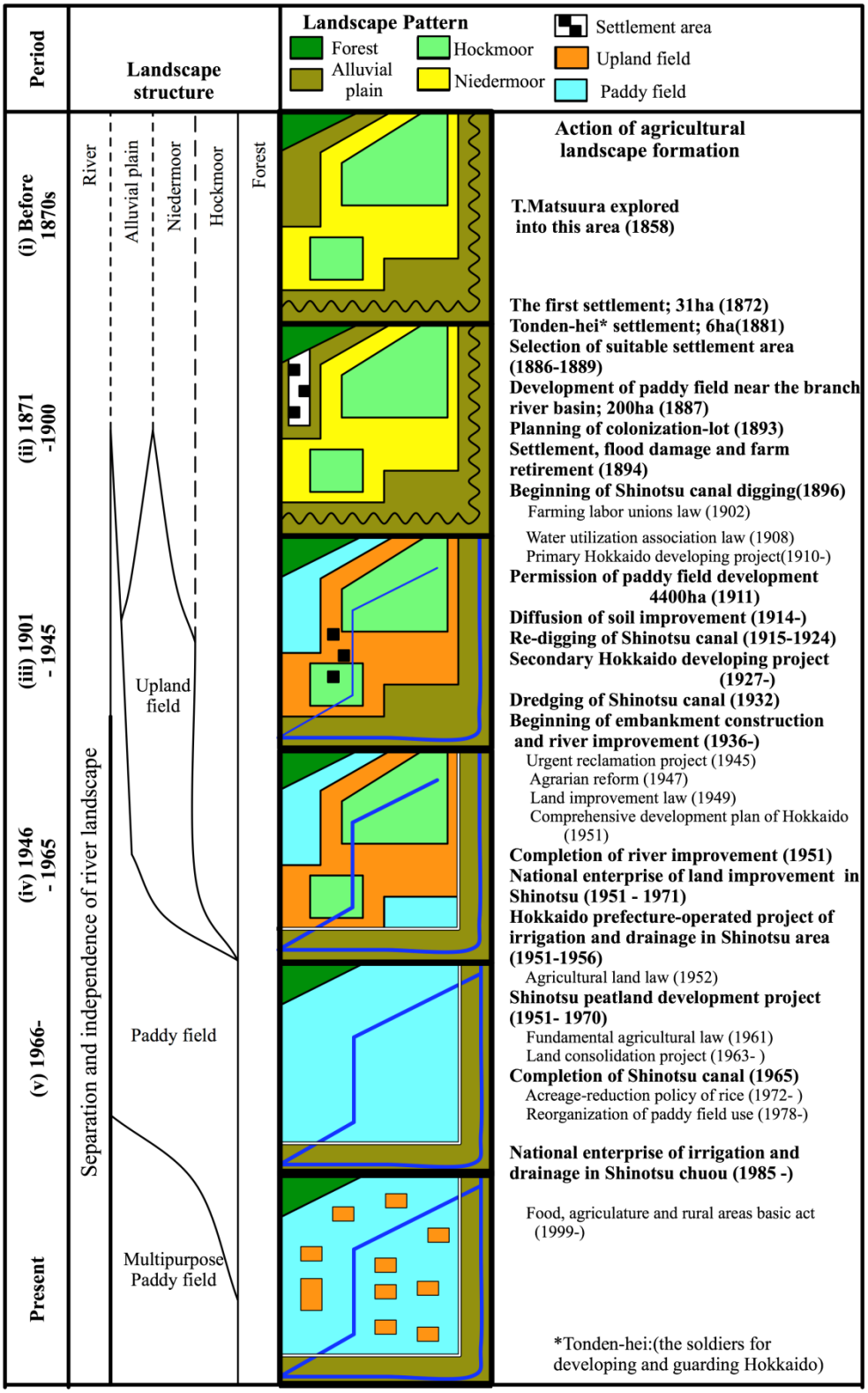

Fig. 2 Overview of landscape pattern changes

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The river landscape was characterized as a primeval river with spatiotemporal changes including natural levees and former river channels.

This landscape was stable as a natural ecosystem because of an absence of human activities.

Landscape Changes, its Elements, and Factors from the 1870s to 1900

During this period, the landscape largely comprised forest, wilderness, and river landscapes. An agricultural landscape formed by settlement was observed in a part of the landscape. With the exception of the agricultural landscape, each landscape element and the interrelationships are essentially similar to those of the former period.During this period, the agricultural landscape appeared in a part of the alluvial plain forming the wilderness landscape. However, it had not widely expanded yet. Moreover, it had a small impact on the natural landscape because the settlement comprised reclaimed land and houses. Although the colonization-lot plan had been planned by the government, it is yet to be regulated.

Landscape Changes, its Elements, and Factors from the 1900s to 1945

The regional landscape included forest, wilderness, agricultural, and river landscapes. It was characterized by paddy and upland spreads. The partial paddy landscape occurred under only good settlement conditions on the wilderness landscape, and sustainable upland field landscapes were present. The paddy landscape, with intake from natural rivers, was at the border of the wilderness landscape at the foot of a hill or an alluvial plain near river branches. The paddy landscape had not expanded at this time. However, the upland field landscape had increased gradually from an alluvial plain to the boundary between niedermoor and hockmoor. A large part of hockmoor remained devoid of human intervention.

The upland field landscape expanded in the wilderness by channeling the Shinotsu Canal for drainage to dry the peatland, and constructing a grid-like road, drainage ditch, and houses designed on the basis of the colonization-lot plan. Although these fields were upland fields, the current basic constitution, such as grid-like lots and scattered houses, appeared at this stage. This upland field landscape was influenced by floods and snowmelt run off from the river and wilderness landscapes.

Landscape Changes, its Elements, and Factors from 1946 to 1965

During this period, the regional landscape was characterized by forest, wilderness, extended agriculture, and disconnected river landscapes. The river landscape was separated from the alluvial plain and the agricultural landscape was improved with embankments. The agricultural and alluvial plain landscapes were affected by hydrological influence due to advancing river water drainage caused by construction. Moreover, preventing the damage from floods by improving river embankments has enabled sustainable agricultural production; however, it requires further upgrading.

In the beginning of this period, a large part of hockmoor comprised the wilderness landscape. After drainage, land reclamation and paddy construction were enhanced. Then, the alluvial plain area decreased and changed to a paddy landscape. In addition, the upland field landscape was present with large qualitative changes. The paddy landscape appeared close to the Ishikari River and the upland field landscape decreased in size because of paddy construction on the alluvial plain. Niedermoor was used as an upland field.

Landscape Changes, its Elements, and Factors after 1965: Quantitative Changes in the Paddy Landscape

During this period, the regional landscape comprised forest, paddy, and river landscapes. The paddy landscape was homogeneous and the low-lying area was developed. Thus, most of the upland field and hockmoor landscapes changed to paddy landscape. Moreover, the wilderness

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landscape disappeared during this period. The paddy landscape was formed by grid-like drainage as well as irrigation channels and roads regulated by colonization-lot planning; Houses and facilities filled these lots. The Shinotsu Canal, a dual-purpose canal, was located at the center of this area. The establishment of an irrigation system and reinforcement of the regional drainage system maintained the landscape.

This mixed area of paddy fields and upland fields changed by creating multipurpose paddy fields in the paddy landscape.

The paddy landscape has been primarily sustained by a drainage and irrigation system, which is centered on the Shinotsu Canal and takes water from the Ishikari River. Because such a system created a new watershed, a new independent landscape appeared in the low-middle part of the Ishikari River Basin.

DISCUSSION

Landscape Forming Elements and Factors

The pattern changes [from (i) to (ii)] in Fig. 2 characterize the appearance of an artificial landscape and disappearance of the natural wilderness landscape. The artificial landscape formed by reclaiming farmlands and houses appeared along the reclamation settlements. This landscape is limited to appear in a relatively convenient location that is easier and effective in the development of an alluvial plain. Moreover, it is less common in inferior drainage areas such as peatlands and lower alluvial plains. This land condition makes it easier to reclaim settlements as well as set-up water for agricultural use and houses as regulated factors of the landscape changes.

The changes from (iii) to (iv) in Fig. 2 were characterized as advanced systematic reclamation and the appearance and expansion of large-scale agricultural landscape in the niedermoor and alluvial plains. Social factors for landscape changes such as planning and implementation of colonization-lot plan form a base of agricultural development. This agricultural landscape expanded with the advancement in drainage for using the alluvial and niedermoor areas. Subsequently, the drainage specified the landscape changes during this period.

The changes from (iv) to (v) in Fig. 2 indicate a sustainable agricultural landscape which has been unaffected by floods due to river improvement, thereby upgrading the condition for agriculture with an advancement in river water drainage. Therefore, the factors specified for the maintenance of the Shinotsu Canal by the systematic improvement projects of agricultural production base are implementation or advancement of regional drainage, soil dressing in peatland, and improvement of agricultural water management systems.

CONCLUSION

We evaluated the changes in regional landscape structure from the perspective of social and natural factors. The current Shinotsu area landscape was built based on the regional natural, social, and technical conditions in a low-lying area on the Ishikari River Basin. The landscape developed because of the interaction between human actions and previous conditions. From the beginning of the settlement to the present, the regional landscape has changed gradually due to systematic and large-scale human actions. The changes in the natural and agricultural landscape structures influenced by human action were specified by the niedermoor characteristics. These changes depended on land drying by drainage. The changes to farmlands and more sophisticated farmlands occurred because of enhanced drainage. Moreover, the sustenance of drainage function can be further advanced to drain water from wilderness plain around the areas that have been drained before.

From these landscape changes, it is clear that the primarily changed elements and factors were the motivation (planning), the peatland characteristics (depending of Fudo, which is a holistic phenomenon based on the complex of interactions between factors such as climate, geography, and soil) and agricultural water-use system (tools and facilities). Furthermore, these influences are

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affected by a difference in perspective or the time of evaluation. In addition, these elements and factors have an interactive effect; thus, evaluation using each element or factor alone is difficult.

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