

LANDSCAPE CHANGES IN THE SETO INLAND SEA, JAPAN

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Abstract

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The Seto Inland Sea is the largest sea in western Japan. Around the Seto Inland Sea the climate is mild and sunny. There are more than 1000 islands, ranging in size from 0.001 to 595 km², of which 160 are inhabited. Because of both the climate and the geography, the Seto Inland Sea is often called the Mediterranean Sea of Japan. The characteristics of industry on the islands are all different from each other, but classification using agricultural and industrial indicators identified 6 principal groups among the 97 municipalities that included inhabited islands (island-municipalities). Factors most affecting the classification into these groups were the differences in agricultural products, the decrease in area of farmlands, and the incomes of farmers. Production of oranges is a very important industry in 26 island-municipalities and fishery is an important industry in 9 island-municipalities. Subsidiary income was greater than agricultural income in 33 island-municipalities where the area of farmlands has recently decreased. This classification of the municipalities will be useful for predicting landscape dynamics. In the region surrounding and including the Seto Inland Sea, especially on the islands, there is only a limited area of land suitable for agriculture and settlement; because there was little flat area on the islands, people made terraced farmlands on the slopes. These farmlands were once used for upland crops, but were converted to orchards in 1960s along the rapid economic growth in Japan. However, the economics of orange production have now slumped and many orchards have been abandoned. Thus, large changes have occurred in the landscapes of this region. Conserving the agricultural landscape is very important from the viewpoint of reevaluating and conserving of Japanese cultural landscape.

Key words: cultural landscape, economics, landscape conservation

Introduction

The islands around the main islands of Japan are isolated from economic centers, and, as a consequence, emigration has been a serious problem since World War II. Some islands have become uninhabited and some have not been able to maintain their former rural ac-

tivities; other islands have successful industries, such as tourism, agriculture, and fishery (Editorial Board of Shimadas, 1998).

There are various types of islands in Japan, and several geographical studies have examined the islands' industries (Hiraoka, 1977), depopulation trends (Okuno, 1998), and social systems (Imazato, 1999). Earlier studies classified the islands in terms of natural indicators, such as location, size, and arrangement of islands (Tsumimura, Yamaguchi, 1935a,b), but recent studies have introduced new indicators such as industry (Tanaka et al., 1996; Suyama, 2003) and other qualitative data (Yumoto et al., 2002).

The conservation of regional characteristics and diversity is very important for regional planning. Because the uniformity of a particular region is disrupted when considered from the social and cultural points of view, especially in urban regions, the properties that create this diversity must be conserved. For a region to advance, individual regional plans must be established for each island; landscape ecology can contribute greatly to such planning (Ahern, 1999). The landscape is a holistic ecosystem that is complicated with by human–nature factors (Naveh, Lieberman, 1994). In areas where humans have had a great influence on the landscape, socio-economic information on changes in land use and human life is an indispensable resource for understanding the changes in the landscape (Nakagoshi, Hong, 2001). Human impacts are important factors in landscape heterogeneity. Therefore, classification of islands by social and economic indicators may give useful information for understanding their landscapes, predicting changes, and making regional plans.

In this study, we try to classify the islands in the Seto Inland Sea from the viewpoint of economics. The islands located nearest big cities have the biggest problems: economic and social changes on the mainland directly influence industry and life on these islands, and they experience rapid changes in the landscape. Our accumulated knowledge of the landscapes in the Seto Inland Sea has been applied and extended over its entire region (Nakagoshi, Ohta, 1992; Ikegami, Nakagoshi, 1995; Kamada, Nakagoshi, 1996; Nakagoshi, Ohta, 2000; Nakagoshi, Ohta, 2001; Kamei, Nakagoshi, 2002). To get the big picture of the landscape in this region, it is first necessary to classify the islands and generalize their landscapes.

Study area

The Seto Inland Sea lies in the western part of Japan, surrounded by the main islands: Honshu, Shikoku, and Kyushu (lat 33°20'–34°50'N, long 131°59'–134°29'E, Fig. 1). It is surrounded by the 9 prefectures of Osaka, Hyogo, Okayama, Hiroshima, Yamaguchi, Kagawa, Ehime, Fukuoka, and Oita. It is about 21 800 km², and the deepest point is 105 m below sea level. The area around the Seto Inland Sea (the Setouchi Region) has a mild and sunny climate; the annual average temperature is 15.9°C and the annual precipitation is 778–1699 mm (average 1223 mm). There are 1050 islands, and people inhabit 160 of them (Sugata, 1995). While these islands are of various sizes – the smallest island is less than 0.001 km² and the biggest one, Awajishima, is 595 km² – are most of them comparatively small islands, with falling into the 0.6 to 1 ha size class (Fig. 2). Because of both its

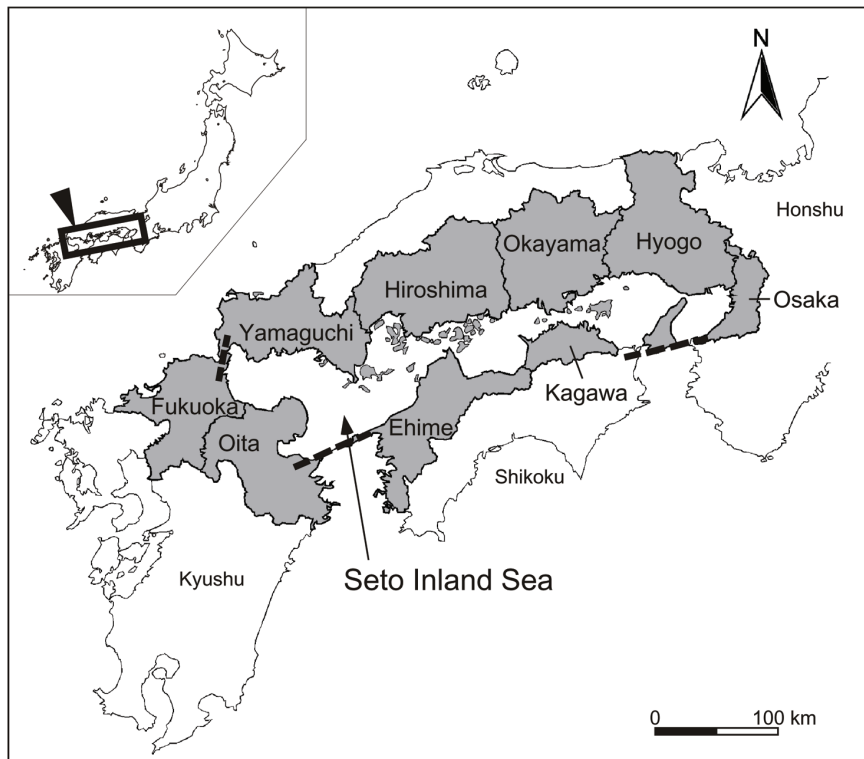


Fig. 1. Map of the Seto Inland Sea, Japan.

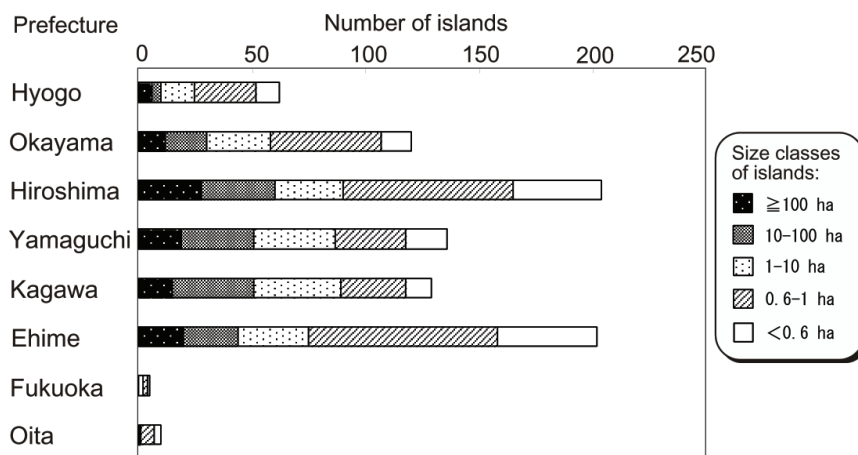


Fig. 2. Sizes and distribution of the islands in the Seto Inland Sea.

comparatively dry climate and the many islands, the Seto Inland Sea is often called the Mediterranean Sea of Japan. However, the density of marine resources in the Seto Inland Sea is far greater than that in the Mediterranean Sea. Although the Seto Inland Sea has an area less than 0.3% of the Mediterranean Sea, the population and the level of industrial production are similar to those at the Mediterranean islands.

Methods

Among the 9 prefectures surrounding the Seto Inland Sea, Osaka Prefecture has no islands and is therefore excluded from our analysis. In this study, we analyze the 146 municipalities in the remaining 8 prefectures that are on the Seto Inland Sea. There are 729 islands with an area greater than 1 ha included in 110 of the municipalities, but inhabited islands are in only 97 municipalities (referred to in this study as “island-municipalities”); the other 49 municipalities do not have inhabited islands (“non-island-municipalities”).

We extracted statistical data for 1970 and 2000 from the population censuses and the world agricultural-and-forestry-industries censuses. Recently, many municipalities have been merged; therefore, the names of some municipalities appear differently in the 2000 data and the 1970 data. Nevertheless, we have tried to compare the data for the present municipalities with those of the past by collecting statistical data for districts within the municipalities.

To clarify the characteristics of the 97 island-municipalities, we analyzed the population and industrial structures. Eleven items of data are used as variables in the factor and cluster analyses:

- Ratio of elderly people to the entire population (2000)
- Ratio of farmers to all workers (2000)
- Ratio of fishers to all workers (2000)
- Ratio of people who work in secondary industry to all workers (2000)
- Ratio of people who work in tertiary industry to all workers (2000)
- Changing rate of number of farmers (2000/1970)
- Ratio of farmers with sideline businesses to all farmers (2000)
- Changing rate of area of farmlands (2000/1970)
- Ratio of orchards to farmlands (2000)
- Changing rate of area of orchards (2000/1970)
- Ratio of farmers with above-average income in agriculture to all farmers (2000).

The year of 1970 is when agricultural conditions, especially the economics of orange production, were better than in 2000. Each variable is converted into a percentage to remove the disparity due to different population sizes. In factor analysis, we can derive the factors most affecting the division of island-municipalities. Then, in cluster analysis, the island-municipalities can be classified into a number of groups according to their own characteristics.

Changes in area of farmlands directly influences changes in the landscape. To find the factors affecting the changes, we performed multiple regression analysis with the same variables as for the factor analysis. The changing rate of area of farmland from 1970 to 2000 was set as the criterion variable. Eight variables were selected for the explanatory variables:

- Ratio of elderly people to all people (2000)
- Ratio of farmers to all workers (2000)
- Ratio of fishers to all workers (2000)
- Ratio of people who work in secondary industry to all workers (2000)
- Ratio of people who work in tertiary industry to all workers (2000)
- Ratio of farmers with sideline business to all farmers (2000)
- Ratio of orchards to farmlands (2000)
- Ratio of farmers with large income from agriculture to all farmers (2000).

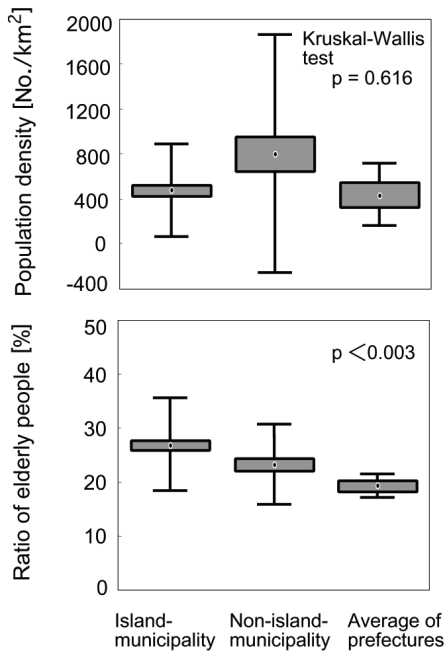


Fig. 3. Population structure of islands in the Seto Inland Sea.

Results

Characteristics of islands in the Seto Inland Sea

The average population density in the island-municipalities is 482 people per km², and that of non-island-municipalities is 807 people per km². The average over the 8 prefectures is 442 people per km². On the other hand, the average ratio of elderly people (older than 65) in the island-municipalities is 26.9%, and that in the non-island-municipalities is 23.3%. The average over the 8 prefectures is 19.4%. We used the Kruskal–Wallis test to examine the differences in distributions of values among these 3 groups (Fig. 3). Although no difference was found among the distributions of values for the population density, the values for the ratio of elderly people have different distributions among the 3 groups. The populations of the island-municipalities are aging.

Figure 4 shows the industrial structure. In island-municipalities, many people work in primary industries, such as agriculture, fishery, and forestry. In non-island-municipalities, the ratio

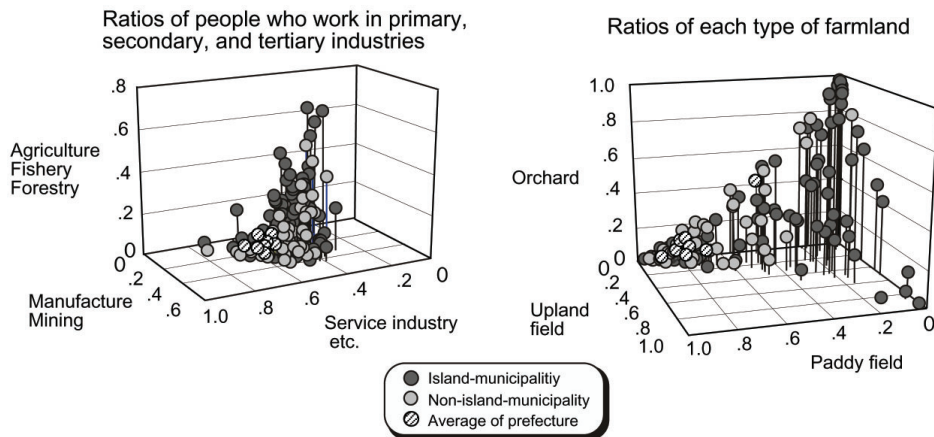


Fig. 4. Industrial structure of islands in the Seto Inland Sea.

of people working in primary industry is less than that of island-municipalities, but there is little difference: primary industry is a very important industry throughout the Setouchi Region.

In many island-municipalities, upland fields and orchards comprise the largest portion of the total area of farmland. On the other hand, in most non-island-municipalities, paddy fields comprise the largest portion.

Factors characterizing the island-municipalities

In the factor analysis, we chose the variables according to the principal characteristics of island-municipalities: aging and the importance of agriculture, especially fruit production. From the result of analysis, we extracted 5 factors with eigenvalues greater than 1.0. The cumulative contribution of these 5 factors is 81.82%. The main loadings of factors greater than 0.58 in absolute value are shown in Table 1.

The first factor has the largest contribution, 32.41%. The ratio of farmers and the ratio of farmers with above-average income in agriculture are disposed in the positive direction.

T a b l e 1. Factor loadings and explanation of main factors

	Variables	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1	Ratio of elderly people to the entire population				-0.658	
2	Ratio of farmers to all workers	0.857				
3	Ratio of fishers to all workers			-0.707		
4	Ratio of people who work in secondary industry to all workers	-0.616				
5	Ratio of people who work in tertiary industry to all workers	-0.696				
6	Changing rate of number of farmers		-0.587			
7	Ratio of farmers with sideline businesses to all workers		-0.712			
8	Changing rate of area of farmlands		-0.584			
9	Ratio of orchards to farmlands					0.575
10	Changing rate of area of orchards			-0.609		
11	Ratio of farmers with above-average income in agriculture to all farmers	0.768				
	Contribution [%]	32.410	20.383	12.224	9.158	7.644
	Cumulative contribution [%]	32.410	52.793	65.018	74.175	81.820

And the ratios of people who work in the secondary and tertiary industries are disposed in the negative direction. This factor indicates the key industry. The second factor contributes 20.38%. For this factor, 3 variables have large factor loadings in the negative direction: the changing rate of number of farmers, the ratio of farmers with sideline businesses, and the changing rate of area of farmland. This factor indicates the changes in agricultural conditions. The third factor contributes 12.22%. Two variables, the ratio of fishers and the changing rate of area of orchards, have large factor loadings in the negative direction. This factor indicates the depression of agriculture and importance of fishery. The fourth and fifth factors contribute 9.16% and 7.64%, respectively. The fourth factor is biased in the negative direction, and is connected with the ratio of elderly people. The fifth is biased in the positive direction, and the ratio of orchards has a large value. Therefore, the fourth and fifth factors indicate population structure and agriculture, respectively.

Classification of island-municipalities

To classify the island-municipalities, we applied Ward's cluster analysis method to the factor scores. The dendrogram was cut at a distance of 6.0, and 6 groups appeared. The average score of the island-municipalities in each group is shown in Table 2.

Table 2. Average score of each group classified by cluster analysis

Group	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Number of island-municipalities
A	-0.853			-0.815		21
B	1.569	1.191				12
C		-1.117			-1.192	15
D					0.915	26
E		-0.750				18
F		1.111	-2.305	1.855		5

There are 21 island-municipalities in Group A, and the average scores are considerable for factors 1 and 4. The large negative values for these factors indicate key industry and population structures, respectively. This result shows that the main industries in these island-municipalities are secondary or tertiary industries and that the population is seriously aging. There are 12 island-municipalities in Group B, and the average scores are large for factors 1 and 2. Both factors have large positive values. Factor 2 indicates changes in the agricultural conditions. The main industry in these island-municipalities is agriculture. In addition, many farmers and farmlands remain, and the ratio of farmers with sideline businesses is not large.

In Group C, the average scores are large for factors 2 and 5. Factor 5 indicates agriculture, especially fruit production. There are 15 island-municipalities in this group, and both factors have negative values. This shows that changes in the ratios of farmers and the areas of farmland are considerable and that fruit production is not prosperous. Groups D and E have large

average scores for factors 5 and 2, respectively. Group D has positive values for factor 5, and fruit production is prosperous in these 26 island-municipalities. Group E has a negative value for factor 2; in these 18 island-municipalities, agriculture is no longer an important industry. Group F has large average scores for factors 2, 3, and 4. Factor 3 indicates depression of agriculture and the importance of fishery. There are 5 island-municipalities in this group. Both agriculture and fishery are significant industries, and elderly people are relatively few.

Groups B and D are distributed only on islands – they are summarized as island-municipalities where agriculture is important (Fig. 5, upper map). Island-municipalities in Group B are located in the western parts of the Seto Inland Sea and have especially good agricultural conditions. Island-municipalities in Group D are located in the intermediate parts. Groups C and E are summarized as island-municipalities where agricultural conditions have changed (Fig. 5, middle map). Island-municipalities in Group C are mainly located on Awajishima, and those in Group E are spread widely along the coastal zones of the main islands of Honshu and Shikoku. The island-municipalities of both groups are large and have the convenience of road and rail transport; therefore, secondary and tertiary industries have developed. Groups A and F are identified as island-municipalities where agriculture is not an important industry (Fig. 5, lower map). People in these island-municipalities work in manufacture, mining, and fishery. They have the advantages of industrial and marine resources.

Changes in farmlands

Farmland is an important element of the landscape. Abandonment of farmlands is currently a serious problem. From our multiple regression analysis, we found 2 factors affecting changes in farmlands: the ratio of farmers with above-average income in agriculture and the ratio of farmers with sideline businesses (Table 3). These factors have positive coefficients of regression. Therefore, the larger the values of these factors become, the more farmlands can be maintained.

Table 3. Factors affecting the changes in farmlands

Variables	Regression coefficient	Standard Regression coefficient	Level (p)
Ratio of farmers with above-average income in agriculture to all farmers	0.577	0.517	< 0.001
Ratio of farmers with sideline businesses to all farmers	0.806	0.572	< 0.001

$R^2 = 0.400$ $p < 0.001$

The values of the standard regression coefficients show the contribution of factors. These 2 factors have almost the same values, but the ratio of farmers with sideline businesses is slightly larger. However, the value of R^2 is very small; for greater precision, other variables must be examined, such as whether farmers have successors.

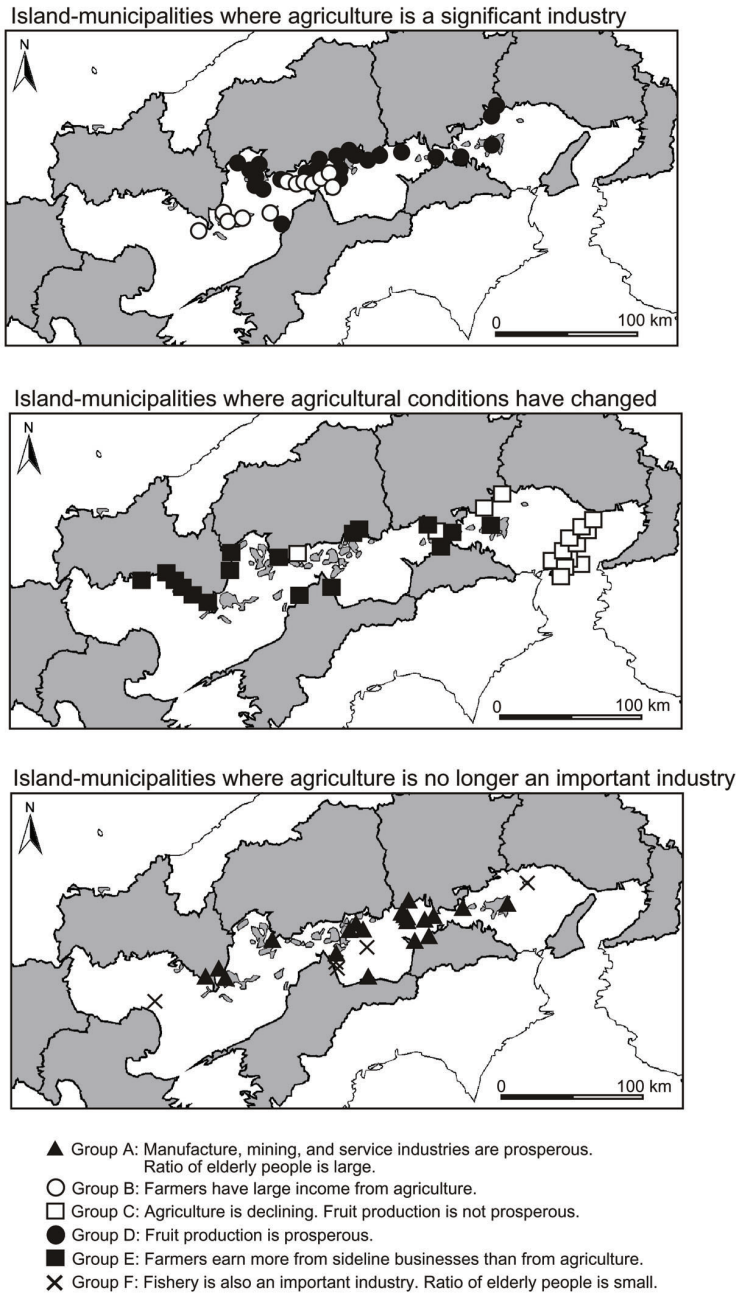


Fig. 5. Classification of island-municipalities in the Seto Inland Sea.

Discussion

The islands in the Seto Inland Sea have particular natural and industrial characteristics. The natural characteristics include the many small islands and dry climate. Many people live in the island-municipalities, especially elderly people. Industrial characteristics include the fact that agriculture is the main industry and there are many upland fields and orchards.

These natural and industrial characteristics were important factors for classifying the island-municipalities. They were classified by their main industries, then, by the agricultural conditions. Population structure also contributed a little to the classification. Suyama (2003) divided all of the islands of Japan into several groups by social and industrial characteristics. The islands in the Seto Inland Sea were classified into 5 groups: subsistence fishery, commercial fishery, agriculture, mining, and manufacturing. The results of our classification in this study follow Suyama's division: the 6 groups classified in our study can be sorted into 3 larger groups from an agricultural point of view. Agriculture is prosperous only in really insular municipalities. In the island-municipalities along the coastal zone of the main islands of Honshu and Shikoku and on big islands, agriculture is declining. Thus, although agricultural landscapes remain intact in very insular municipalities, agricultural landscapes in the coastal zones of the main islands of Honshu and Shikoku and on big islands may have already changed in the early stage of declining process. Furthermore, the remaining intact agricultural landscapes are on the edge of large-scale change because of the current economic downturn. The factor analysis shows that island-municipalities where fruit production is prosperous (Group D) are in a precarious position with regard to maintaining their landscapes, because the economics of fruit production is very uncertain in this region. In addition, it will become increasingly difficult for elderly farmers to maintain their farmlands (Nakagoshi, Ohta, 2001). Therefore, although the landscapes are inevitably changing, we are worried that they may change very dramatically in the near future (Nakagoshi, Ohta, 2000).

Conclusions

Islands are isolated and people act mainly within the territory. They have their own industries and landscapes and have formed unique regional characteristics. These natural, industrial and social diversities are very important for the cultural landscape. Island-municipalities have social problems, such as depopulation and aging. In addition, agriculture is facing the severe economic conditions in Japan. Recently, large-scale abandonment of farmlands has been occurring in island-municipalities. Because most island-municipalities have lost their economic foundations, it is necessary for farmers to either have a large income from agriculture or sideline businesses for the purpose of maintaining the farmlands. In Japan, traditional rural landscapes, including agricultural lands, open forestlands and forests, have greatly changed because of societal, economic, and technological developments since 1970 (Fukamachi, 2002). Land-use change has a great impact on landscape integrity (Jongman, 2002). To conserve the cultural landscapes and characteristics, it is indispensable for agricultural systems to be re-construct from the ecological, social, and political aspects.

Translated by the authors

References

- Ahern, J., 1999: Spatial concepts, planning strategies, and future scenarios: A framework method for integrating landscape ecology and landscape planning. In Klopatek, J.M., Gardner, R.H. (eds): *Landscape Ecological Analysis, Issues and Applications*, Springer-Verlag, New York, p. 175–201.
- Editorial Board of Shimadas, 1998: *Shimadas—Guide of Japanese Islands* (in Japanese). National Institute for Japanese Islands, Tokyo, 1151 pp.
- Fukamachi, K., 2002: The change of a satoyama landscape and its causality in Kamiseya, Kyoto Prefecture, Japan between 1970 and 1995. *Landscape Ecology*, 16, 8, p. 703–717.
- Hiraoka, A., 1977: Colonization and plantation management of Daito Islands—Its historical development (in Japanese). *Human Geography*, 29, p. 227–252.
- Ikegami, Y., Nakagoshi, N., 1995: Landscape structure of the Setoda, Hiroshima Prefecture (in Japanese). *Memories of the Faculty of Integrated Arts and Sciences, Hiroshima University, Ser. IV*, 21, p. 131–144.
- Imazato, S., 1999: Sociosemiotic approach to an interpretation of rural space: A case study in Madara Island, Western Japan (in Japanese). *Geographical Review of Japan*, 72A, p. 310–334.
- Jongman, R.H.G., 2002: Homogenization and fragmentation of the European landscape: ecological consequences and solutions. *Landscape and Urban Planning*, 58, p. 211–221.
- Kamada, M., Nakagoshi, N., 1996: Landscape structure and disturbance regime at three rural regions in Hiroshima Prefecture, Japan. *Landscape Ecology*, 11, p. 15–25.
- Kamei, M., Nakagoshi, N., 2002: Assessing integrity in cultural landscape: a case study from Japan. In *Proceedings of the Conference on Space Application for Heritage Conservation*, P3, ESA Publications Div., Noordwijk.
- Nakagoshi, N., Hong, S.-K., 2001: Vegetation and landscape ecology of East Asian ‘Satoyama’. *Global Environment Research*, 5, 2, p. 171–181.
- Nakagoshi, N., Ohta, Y., 1992: Factors affecting the dynamics of vegetation in landscapes of Shimokamagari Island, southwestern Japan. *Landscape Ecology*, 7, p. 111–119.
- Nakagoshi, N., Ohta, Y., 2000: Predicting future landscapes of islands in the Seto Inland Sea, Japan. In Mander, Ü., Jongman, R.H.G. (eds): *Landscape Perspectives of Land Use Changes*, WIT Press, Southampton, p. 83–106.
- Nakagoshi, N., Ohta, Y., 2001: Landscape dynamics of the orange-producing islands in the Seto Inland Sea, Japan. In van der Zee, D., Zonneveld, I.S. (eds): *Landscape Ecology Applied in Land Evaluation, Development and Conservation*, ITC, Enschede, p. 95–113.
- Naveh, Z., Lieberman, A.S., 1994: *Landscape Ecology, Theory and Application*. Springer-Verlag, New York, 360 pp.
- Okuno, K., 1998: Development policy and realities in the remote islands (in Japanese). *Geographical Review of Japan*, 71A, p. 362–371.
- Sugata, M., 1995: *Dictionary of Islands in Japan* (in Japanese).* Sanko-sha, Tokyo, 495 pp.
- Suyama, S., 2003: Quantitative regional division of islands (in Japanese).* In Hiraoka, A. (ed.): *Research into People, Life and Industry of Japanese islands*, Kaiseisha Press, Ohtsu, 218 pp.
- Tanaka, N., Miyazaki, H., Kondo, T., 1996: Evaluation of regional structure on remoted island depending on location and social characteristics; a study on an environment evaluation in remoted island area (1) (in Japanese). *Transactions of AIJ. Journal of Architecture, Planning and Environmental Engineering*, 489, p. 249–254.
- Tsujimura, T., Yamaguchi, S., 1935a: Classification and distribution of islands in Japan (1) (in Japanese). *Geographical Review of Japan*, 11, p. 703–728.
- Tsujimura, T., Yamaguchi, S., 1935b: Classification and distribution of islands in Japan (2) (in Japanese). *Geographical Review of Japan*, 11, p. 794–808.
- Yumoto, Y., Soshirota A., Tsutsumi, T., 2002: A basic analysis of the types and the factor for increasing in population in the remote island (in Japanese). *Papers on City Planning – City Planning Review Special Issue*, 37, p. 793–798.

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