Designing eco-villages for revitalizing Japanese rural areas

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Abstract

Reestablishing a sound environment in rural areas has become one of the most important environmental issues in Japan, not only in rural policy but also in national land policy. Physically speaking, regeneration of natural ecosystems, reestablishment of sound material flows, and the design of rural landscapes are important areas of research and practice. Another important issue in the management of rural areas, particularly in the mountainous areas that cover ~ 61% of the country, is the preparation of the landscape for urban dwellers. This paper considers methods for improving rural environments. The modeling of ideal eco-villages with sound natural environment, low input and sustainable material flow, and maintenance of villages through urban and rural interaction is considered. Three different types of typical eco-village models are designed in urban fringe areas, in typical rural areas and in remote mountainous areas. Further, a case-study for the search of reality in adopting such models is surveyed in Chosei-gun, Chiba prefecture as a case of an eco-village in a typical rural areas. © 1998 Elsevier Science B.V. All rights reserved.

Keywords: Eco-village; Semi-natural ecosystem; Material flow; Rural landscape; Urban and rural interaction; Eco-engineering; Japanese rural areas

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1. Introduction

In Japanese rural areas, in addition to delays in the development of infrastructure such as sewage, roads, medical services, and cultural facilities, shortage of people capable of supporting primary industries (or successors to them) due to the aging workforce and a decrease in the number of their successors are becoming very serious. All these problems are an indication that standards in the management of Japan’s natural environmental resources have fallen, and there are great concerns that this may lead to a diminution in the public benefit that agricultural land and forests provide, such as conservation of the national lands and environments (Yokohari et al., 1994).

However, with the changes in values and the pursuit of affluent living, more meaningful lives have greatly increased awareness of environmental conservation, and ways of living in harmony with natural environments are now widely discussed. In Japanese rural areas, it is necessary to establish new revitalization measures by effectively managing and using natural environments and resources.

The word ‘eco-village’ is a key word for establishment of sustainable human settlements internationally (Atkisson et al., 1991; Ansted and Franta, 1994; Dichtriant, 1996). Our group has studied the eco-village concept to achieve the goal of revitalizing rural areas through case studies of Japanese villages for some 5 years (Takeuchi, 1996). The main purpose of this paper is to study the possibility of establishment and development of pilot communities of eco-villages.

As there are severe constraints on the establishment of independent measures for the redevelopment of rural areas, the redevelopment of these areas must be based on their relationships with regional core cities, which are essential to the viability of rural areas such as urban front areas, typical rural areas and remote mountainous areas (Table 1). To overcome the serious problems of the overconcentration of population in large cities and to soundly utilize the rural lands, it is important to rebuild the multi-centered regional structure and to encourage people to settle in agricultural and mountainous areas.

2. General principles of the eco-village design

An eco-village is defined as a self-supporting area in which, with the support of environmental conservation technologies, both a productive economy and the maintenance of semi-natural environmental systems can be realized. This is based on the view that ecologically sound agricultural and forestry practices can be economically viable if the external economy is incorporated (Kada, 1990).

In the eco-village concept, ecosystem refers to a system created by the interactions (sharing co-existing or circulation) among elements within a village or between elements within a village and surrounding environments. The significance of eco-village design is the synergistic effects generated by combining the two positive elements or the positive effects generated by combining the two negative elements. Eco-villages are envisaged to attain the following two principles.
<table>
<thead>
<tr>
<th>Classification of rural areas</th>
<th>Urban front areas</th>
<th>Typical rural areas</th>
<th>Remote mountainous areas</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance (in time)</strong> from a city with a population of at least 100 000 people</td>
<td>Within or adjacent to an urban area</td>
<td>&lt;1 h by car</td>
<td>&gt;1 h by car</td>
</tr>
<tr>
<td><strong>Ecological environments</strong></td>
<td>&lt;Landform features&gt; flat</td>
<td>Flat-terraces/hills</td>
<td>Mountainous areas; upstream areas</td>
</tr>
<tr>
<td><strong>Geophysical environments</strong></td>
<td>&lt;Water systems&gt; natural: downstream, wetlands and silt covered land; artificial: irrigation systems and reservoirs</td>
<td>Mid-stream areas, river benches; irrigation systems, reservoirs</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1**

Classification of rural areas

- **Remote mountainous areas**
  - Within or adjacent to an urban area
  - Distance (in time) from a city with a population of at least 100 000 people
  - Flat-terraces/hills
  - Mountainous areas; upstream areas

- **Typical rural areas**
  - Within or adjacent to an urban area
  - Distance (in time) from a city with a population of at least 100 000 people
  - Flat-terraces/hills

- **Urban front areas**
  - Within or adjacent to an urban area
  - Distance (in time) from a city with a population of at least 100 000 people
  - Flat-terraces/hills

**Diagram:**

- Rural areas
- Urban areas
- Areas within one hour
- Mountainous area
- Areas within one hour

Table 1 (continued)

<table>
<thead>
<tr>
<th>Biological environments</th>
<th>Urban front areas</th>
<th>Typical rural areas</th>
<th>Remote mountainous areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;Vegetation&gt; colonial sub-system: groves of trees planted around houses and shrines/temples; forest sub-system: groves of trees on flat land; farmland sub-system: rice paddies and other crops.</td>
<td>Groves of trees planted around houses and shrines/temples; groves of trees on flat land, copses on hills, natural forests, forests on hills; rice paddies, other cropland and yatsuda.</td>
<td>Groves of trees planted around houses; plantation and natural forest; terraced rice fields, terraced cropland, cropland on hills and pasture.</td>
</tr>
<tr>
<td></td>
<td>&lt;Animals&gt; crucian carp and carp, shellfish: corbicula and fresh water mussels; insects: large silver dragonfly and cabbage butterfly; amphibian: leopard frog; birds: great reed warbler, Indian water hen and kochidori.</td>
<td>Ayu and dace; stone shellfish; large dragonfly and black-striped butterfly; spring cicada and giant purple butterfly; ranid; kingfisher, sashiba and Japanese grossbeak.</td>
<td>Char and yamame (type of trout); large snail; river dragonfly and white butterfly; ezo spring cicada; singing frog; pied kingfisher, hodgson's hawk eagle and water ouzel.</td>
</tr>
<tr>
<td>Forms of agricultural production</td>
<td>&lt;Producer&gt; urban-style agriculture (greenhouses, gardening and rice paddies)</td>
<td>Intensive agriculture on flat land (rice paddies and other cropland).</td>
<td>Composite/resource utilization-type agriculture.</td>
</tr>
<tr>
<td></td>
<td>&lt;Urban dwellers&gt; citizens' farms</td>
<td>Self-sustaining agriculture</td>
<td>Green tourism experience-type agriculture.</td>
</tr>
</tbody>
</table>

Shellfish are at the lower level of the food chain and are vital as they consume organic material as nutrients. Birds are near the top of the food chain and indexes of health of an eco-system.
2.1. Restoration and maintenance of rural ecosystems

In our present rural society, the reestablishment of circulation systems derived from agriculture based on traditional agricultural methods utilizing coppices is no longer realistic. It is thus vital to reestablish circulation systems that metaphysically represent coppices, by using modern engineering technologies, as well as to make peoples lives more convenient and comfortable. In other words, we must preserve the natural circulation systems which remain in agricultural areas and develop sustainable communities by establishing new circulation systems.

Rural areas in Japan have a variety of ecological elements such as rice paddies, non-rice cropland, pastures, trees planted around houses, the footpaths between rice fields and reservoir and water conduits. However, due to changes in land use as a result of the decrease in agricultural population, the diffusion of industrialized agricultural technology and infra-structure, the expansion of urban areas and environmental loads have increased and species diversity has rapidly decreased.

To restore and maintain semi-natural ecosystems, we should not establish agricultural land policies based only on concerns for productivity and the aesthetic qualities of rural landscapes, but policies based on ecological perspectives for the designation of the environment and the creation of facilities.

2.2. Encouragement of interaction between rural and urban areas

Rural villages and urban centers have endured the inconveniences that occur each time they interact in order to maintain their complementary relationships. However, it is necessary to shift from these passive complementary relationships to positive ones that can provide solutions to environmental problems in both rural and urban areas and lead to the creation of attractive and comfortable environments.

Up to now, the population flow has largely been a uni-directional flow from rural to urban areas. The rapid development of transport and communication networks and sophisticated information, however, are going to generate a bi-directional flow between rural and urban communities. Further, the great changes in society, economics, politics and science and technology, which have emerged in the twilight of the 20th Century have had a tremendous impact on values and lifestyles. Such new values and lifestyles are likely to become increasingly powerful forces in the interactions between rural and urban areas.

3. Establishment of eco-village models

3.1. General characteristics of the eco-village model

In an eco-village, full advantage will be taken of the characteristics of rural areas and living infrastructures with advanced amenities that cannot be created in urban areas will be planned. However, a distinctive feature of the eco-village concept is
the positioning of the spatial resources (rice paddies, non-rice cropland, and hills and mountains) of rural areas as vital components of infrastructure networks.

It will be vital to create bi-directional interaction of people, information and goods. It is thus necessary to find ways of encouraging urbanites to stay in rural areas for medium and long periods of time, and even to settle there. By doing this, regional systems consisting of villagers who appreciate urban values and urbanites who appreciate rural values can be formed.

Concerning the infrastructure, eco-villages will adopt cooling and heating systems that effectively utilize regional resources. These systems should be as passive as possible, such as using greenery to block sunlight and to induce natural breezes for ventilation. When such passive systems cannot be used effectively, cooling and heating systems that harmonize with rural and urban areas, such as systems that use the specific heat of water in irrigation systems, should be adopted.

The use of disposers (devices for crushing organic garbage before releasing it into the sewage system) is not generally permitted in urban areas because of the increase in water pollution. However, in rural areas there will be little concern for pollution if the disposers are incorporated into a small-scale inter-village water system. Also, disposers can be used to circulate nitrogen by recycling compost onto local farmland.

The arrangement and allocation of the areas of traditional landscape elements are based on natural systems, production structures and the lifestyles of people living in rural areas. In traditional rural areas, windbreaks planted around houses, hedges, non-rice cropland, rice paddies and irrigation systems all have their own distinctive groups of plants and animals.

The ecotopes of rural areas can be classified into dot-type line-type and area-type ecotopes. When the circulation of materials and the supplying of species are done in organic continuations of each ecotope, rich ecological quality can be maintained. To preserve such ecotopes, ecological systems will be examined and important ecotopes will be selected. Then plans for improving the biological quality of land uses will be established in order to develop ecological networks.

3.1.1. Differences of three eco-village models

We have established three models based on the fundamental differences of the characteristics of rural ecosystems. The characteristics of three rural areas for model-making are presented in Table 1. The most important index to classify the models is population density. Expected population density in an eco-village in an urban front area, in a typical agricultural area and in remote mountainous area are 100 people/ha, 10 people/ha and 1 person/ha, respectively. Eco-villages with the area of 100 ha are considered commonly in the three models.

The second important index is the distance from a large city with a population of $\geq 100000$, which will satisfy the most fundamental urban infrastructures as working opportunity, information supply, cultural facilities, educational institutions and medical care. Villagers living adjacent to the large city can accept the advantages of it very easily. Villagers living within 1 h by car will rather easily
accept the benefits of the large city but those living > 1 h by car cannot easily gain access to the urban infrastructures.

3.2. Characteristics of the eco-village model in urban front area

The eco-village model in urban front area with 10000 urbanites and 60 villagers is the first model. In this 100 ha area model, 30 ha is used for residential development (new town), while 70 ha is for rural land uses in which a 20 ha allotment garden and non-rice cropland, and 40 ha of rice paddies are included. The system of this model, including data on important material flow, is shown in Fig. 1. Image perspective of designed eco-village is shown in Fig. 2.

The characteristic of this model is taking full advantage of direct interactions between urban and rural components. For example, organic garbage and sludge from the new town, collected through disposers, are changed into organic fertilizers. The total amount of fertilizer produced is 115 t/year which is used on the 10 ha allotment gardens and the 20 ha non-rice farmlands. Application of such recycling systems will reduce the amount of garbage collected by the local government.

The 40 ha rice paddy is effectively used for the cultivation of groundwater (10 mm/day) as a mitigation treatment for taking well water used for cooling and heating systems. This treatment will avoid the over-loading of the sewage system and the lowering of the groundwater level. Of course, water from the heating pond is used for cultivating rice in the growing period.

In this model, the allotment garden is playing an important role in the exchange of new town residents and farmers. Farmlands are revitalized by the participation of urban residents and the farmers can earn extra income by renting their farmlands. Communication between both people can be activated through information exchange for cultivating vegetables and flowers.

3.3. Characteristics of the eco-village model in a typical agricultural area

The eco-village model in a typical agricultural area with 1000 people is the second model. In this model, with an area of 100 ha, 10 ha is used as a settled area, while 90 ha is used for farmlands in which there are 14 ha of non-rice cropland and 76 ha of rice paddies. The system and image of this model are shown in Figs. 3 and 4, respectively. In this eco-village model, the cooling and heating system use well/spring water and rice paddies for cultivation of groundwater and also, disposers with small-scale village sewage systems are combined with the conservation of productive farmlands and the utilization of recycling resources. For aerating the soil, use of rice paddies as a solar pond is limited to 7 ha, while the rest is kept dry during the winter period by the conversion to a non-rice cropland.

Another characteristic of this model is the creation of an ecological network by connecting rural landscape resources. The most significant components in the ecological network are the grove, that functions as a windbreak for farmland, and the trees planted along the road. This grove and roadside trees are also important as ecological corridors where animals can move. Wetland and riparian forests along riverside are also important wildlife habitats.
Fig. 1. Eco-village model in urban area (100 ha).
Fig. 2 Image perspective of an eco-village in urban front area.
Fig. 3. Eco-village model in a typical agricultural area (100 ha).
Fig. 4. Image perspective of an eco-village in typical agricultural area.
3.4. Characteristics of the eco-village model in a remote mountainous area

This eco-village model in a remote mountainous area with 60 villagers and 40 visitors is the third model. In this 100 ha model, 1 ha is used as a settled area, while 99 ha is for rural land uses—19 ha non-rice cropland, 40 ha rice paddies and 40 ha coppice woodlands. System and image perspectives of this model are shown in Fig. 5 and Fig. 6, respectively.

In the image perspective of the designed eco-village, pastures are shown in the lower part of the figure, which suggests another possibility for land use in the remote mountainous area. In the case of pasture, not only agricultural and human waste but also animal dropping are effectively used for producing methane gas, which is converted into energy through a power generation plant.

The cooling and heating system uses well and spring water. The disposer is used for recycling resources and for improving living standards, which is another feature of this model. However, the most significant characteristic of this model is to use coppice trees as a heating system, composed of charcoal plants and thermal water plants. Plant growing in a nursery can exhaust heat directly from charcoal plant. In this eco-village, housing for long-term residents is built, and the heating system is also used for residents who stay, even in the winter time. Radiant heating of floors with hot water will provide comfortable living conditions. Because woodlots for firewood and charcoal is 1 ha in area, coppice woodland with an area of 40 ha can be sustainably maintained.

Historical landscape elements such as terraced rice paddies and non-rice cropland on the mountainous slopes are conserved as typical rural heritage in mountainous Japanese rural areas. This landscape is attractive to the visitors from the urban areas. Since extensive plantation of needle trees are decreasing the value of mountainous rural landscapes, conversion of needle trees to more attractive broad-leaved deciduous trees is necessary for improving the landscape potential. This conversion is also effective for the conservation of wildlife habitats.

Interaction between urban and rural dwellers is important for the maintenance of this area, because depopulation and increase in aging workforce are quite obvious. Therefore, this model is proposing the necessity of building house for long-term residents. They will be able to help in maintaining semi-natural ecosystems through their volunteer activities. Rapid progress of lighthouse information access will help the residents to have full-time contact with the world-wide information networks. Arrangement of information networks will accelerate the long-term stay of visitors in this area.

4. A case of eco-village model application

In implementing the eco-village project, based on the fundamental directions described above, detailed plans for redesigning agricultural villages based on the characteristics of each locality should be established. This paper discusses the project menu, costs and the effectiveness of the test case project to be conducted at Chosei-gun, Chiba prefecture, 80 km south-east of Tokyo (Table 2).
Fig. 5. Eco-village model in a remote mountainous area (100 ha).
Fig. 6. Image perspective of an eco-village in remote mountainous area.
<table>
<thead>
<tr>
<th>Technological element</th>
<th>Content</th>
<th>Costs</th>
<th>Results</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial costs (US$): A</td>
<td>Number of years to repay: B</td>
<td>Amortization costs: A/B</td>
<td>Materials circulation</td>
</tr>
<tr>
<td>Living infrastructure</td>
<td></td>
<td></td>
<td>Running costs (US$/year)</td>
<td>Biodiversity</td>
</tr>
<tr>
<td>Community plants</td>
<td>Wastewater processing plant/installation of a plant upstream of the village (1-km-long wastewater discharge pipe)</td>
<td>4181820</td>
<td>360</td>
<td>(104550)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Preservation of water quality</td>
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<tr>
<td>Compost plant</td>
<td>Plant for composting sewage sludge</td>
<td></td>
<td></td>
<td>Use of a Klein-garten</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil enrichment</td>
</tr>
<tr>
<td>Technological element</td>
<td>Content</td>
<td>Costs</td>
<td>Results</td>
<td>Evaluation</td>
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</tr>
<tr>
<td><strong>Restoration of natural environments</strong></td>
<td>Semi-natural Embankments (1850 m × 1818$)/Greenification along waterways (1850 × 20 m × 2 × 4S/m²)</td>
<td>672720</td>
<td>—</td>
<td>—</td>
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<tr>
<td></td>
<td>Restoration of natural environments along rivers</td>
<td></td>
<td>‘Adoption’ of green areas</td>
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<tr>
<td></td>
<td>Restoration of living organisms</td>
<td></td>
<td>Potential of living organisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Restoration of landscapes/creation of recreational areas</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Potential of living organisms</td>
<td></td>
<td></td>
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<td></td>
<td>Environmental studies</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Conservation of the potential of living organisms, which is being reduced as more rice is cultivated on dry land</td>
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<td></td>
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</tr>
</tbody>
</table>

Table 2 (continued)
Table 2 (continued)

<table>
<thead>
<tr>
<th>Technological element</th>
<th>Content</th>
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<th>Results</th>
<th>Evaluation</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Initial costs (US$): A</td>
<td>Number of years to repay: B</td>
</tr>
<tr>
<td>Greenification of the area</td>
<td>Biotype (ponds and groves of 3000 m$^2$ × four locations × 91$/m^2$)</td>
<td>8045450</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Interaction between agricultural and urban areas</td>
<td>Kleingarten</td>
<td>2363640</td>
<td>—</td>
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</table>
Table 2 (continued)

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<thead>
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<td></td>
<td>Initial costs (US$): A</td>
<td>Number of years to repay: B</td>
<td>Amortization costs: A/B</td>
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</tr>
<tr>
<td></td>
<td>Running costs (US$/year)</td>
<td>Materials circulation</td>
<td>Biodiversity</td>
<td>Better mutual understanding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cultural circulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers’ market</td>
<td>Direct sale of fresh vegetables <em>(30 m² × $ × 3640$/m²)</em></td>
<td>872730 550 (14550)</td>
<td>—</td>
<td>Nitrogen circulation (distribution of organic vegetables)</td>
</tr>
<tr>
<td></td>
<td>Nature observation center/educational center <em>(1000 m² × 3640$/m²) /recycling corner</em></td>
<td>3636360 550 (60910)</td>
<td>—</td>
<td>Bi-directional interaction between people and urban areas leading to better mutual understanding</td>
</tr>
</tbody>
</table>

Better mutual understanding between people in agricultural and urban areas through the selling of fresh vegetables leading to better mutual understanding.
### Table 2 (continued)

<table>
<thead>
<tr>
<th>Technological element</th>
<th>Content</th>
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<th>Results</th>
<th>Evaluation</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Initial costs (US$): A</td>
<td>Number of years to repay: B</td>
<td>Amortization costs: A/B</td>
</tr>
<tr>
<td>Total for development of an eco-village</td>
<td>25736360</td>
<td>—</td>
<td>—</td>
<td>—910</td>
</tr>
</tbody>
</table>

Assuming sites are leased and fees are paid to reduce the area of land for rice production. Target rate for the increase in biodiversity: of the 28 species selected, it is predicted that 10 will become extinct if the present situation continues and that none will become extinct if an eco-village is developed. \((28/28)/(19/28) - 1\) is set as the target rate for the increase in biodiversity.
Chosei-gun is classified as an eco-village within an urban front area. The key area for redesigning is a value added area for settlement where land is meant to be used as a traditional village. In this area, in response to the recent popularity in rural lifestyles, a cluster-type housing area featuring a communal vegetable garden will be developed.

The goals of the project are to maximize the advantages of the eco-village by using man-made wetlands as a place for wildlife habitats and also for the secondary processing of water discharged from the area. This process involves using wetland water to maintain a base-flow discharge by discharging water subjected to secondary processing into irrigation systems in order to prevent a decrease in water volume and using semi-natural river embankments.

Advancing farmers’ market projects will increase the number of people interacting between rural areas and surrounding cities. Further, by using the compost, generated from the organic waste of each household (processed by disposers) and the sludge generated by the processing of water discharged within the village, on the allotment gardens, and distributing the products of the gardens will increase the amount of nitrogen circulated within the area.

In terms of costs, revenues are very likely to cover expenditures. For example, the cost of secondary processing at a discharged water processing plant can be greatly reduced if the villages discharged water processing plant and its wetlands are integrated and the discharged water can be processed in the wetlands. In other words, if the site of a wetland to be redesigned can be leased at a cost equal to the fee paid to reduce the area of land for rice production, the only costs that would arise would be equivalent to the cost of performing high-tech processing to the amount of water that would be discharged by 1000 people.

This project will be very effective at preserving eco-systems and rice paddies, even in the face of the trend towards the cultivation of rice on dry land. Further, it will be very effective at removing nitrogen and phosphorus from discharged water. Along with the above mentioned technologies, each project will represent an economically effective eco-technology that can be implemented within a limited space based on the environmental features of Chosei-gun’s flat, rice paddy-studded landscape.

5. Conclusion

At present, there are various ongoing movements to establish eco-villages through projects such as the Natural Environment Redesigning Project in Agricultural Land of the Ministry of Agriculture, Forests, and Fisheries, Japanese Government and studies by NGOs. However, many of these projects and studies are just at the conceptual stage and there are still many issues that have to be resolved before the concepts being developed can be applied to actual villages. These issues pertain to the establishment of programs for converting existing villages into eco-villages, estimating costs, establishing systems to help villagers incorporate
urbanites into their communities, and establishing systems for the maintenance and management of semi-natural ecosystems.

We believe that the key factors in the popularization of the eco-village concept and the reestablishment and development of sustainable communities in Japanese rural areas are the early implementation of an actual project. As a result, a model eco-village can be established resulting in the accumulation of a body of knowledge on eco-villages, and publicizing the attractions and advantages of eco-villages.

The result of our study clearly shows the reality and advantage of eco-villages, which is applicable to various types of rural areas of Japan. Further, the three models proposed in this paper can be modified and applied in other countries, in particular in east and southeast Asia where urban sprawl into rural areas is very rapid and rice paddies are the most important component in the rural landscapes.

References


