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Integrated Regional Resource Management in the Kesen Cycle-Type River Basin Economic Zone — Restoration of the natural ecosystem and the business of charcoal electric power —

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Summary

Through our research, we have been proposing a new concept—a cycle-type river basin economic zone—to restore the natural ecosystem with business (local environmental business).

We have been making plans to establish a cycle-type river basin economic zone in the Kesen area in Iwate Prefecture, in collaboration with local residents, entities, etc. This paper is an interim summary of the research for the development of technologies and the establishment of a social system needed to set up the zone.

The Kesen area is faced with natural environmental problems such as deterioration of the forestry ecosystem, the marine ecosystem and the discharge of huge quantities of manure of breeding animals in a river, and an economic problem: decline of the primary sector of the economy. Plans for a cycle-type river basin economic zone in the Kesen area are being made to use local resources that are either not used or that are disposed of (such as thinned wood in the mountains, manure of breeding animals in the Sato section, and eel grass and oyster shells in the sea) using new technologies (such as charcoal power generation, algal reefs, sea cleaning and composting) in order to restore the deteriorated natural ecosystem, while simultaneously activating the local economy.

This paper presents the state of execution of the plans for the mountain section (in an area called Oide) to restore the forestry ecosystem and to materialize a charcoal power generation business, and analyses future problems. As a result, it has become apparent that charcoal power generation will definitely promote thinning, will significantly contribute to restoring the forestry ecosystem, and will generate diverse social and economic effects; however, it will require some social support for the charcoal power generation to run as a profitable business.

1. Introduction: current problems

(1) Problems related to the environment and the economy

Today, agricultural regions in Japan are confronted with serious problems, described below, concerning the environment and the economy from the aspect of the sustainable development of society in the regions.

One problem concerns the natural environment. Firm examples are the advancing deterioration of the forestry ecosystem, collapse of the forest and river water cycle, frequent occurrence of floods and, increasingly, barren seas, etc. These are having a serious impact not only on production in the agricultural, forestry and fishery industries, but also on the lives of people in rural communities who are engaged in these industries.

Deterioration of the natural environment is expected to cause more serious problems in the future, considering that global warming is worsening. Already, the impact of global warming has been pointed out in the barren sea phenomenon. (Taniguchi, 2006) Also, there are concerns that the drastic climate change, which is forecast for the near future, will cause frequent natural disasters. The deteriorated natural environment and ecosystem must be restored as soon as possible to protect production and the life of agricultural communities.

The other problem concerns the local economy. It is widely known that the economic difference between the capital region and rural areas has been increasing in recent years. The economy is rapidly failing in rural areas that lack level agricultural land and where natural and economic conditions are particularly disadvantageous because of the slump of the primary sector of the economy, reduction in population and the increasing proportion of aged people, so problems in these areas are acute.

The extent of the involvement of the state in the nation's economy is rapidly diminishing because of the swift spread of the global economy in recent years. Therefore, an independent economic infrastructure must be established in rural areas for local communities to secure their livelihoods and welfare. (Jinno, 2002) The utilization of the resources available in the area is the basic requirement for an independent local economy.

(2) Thoughts about cycle-type river basin economic zones and requirements for their establishments

Environmental and economic problems must be solved simultaneously as a single unit to materialize the sustainable development of local communities, which means that restoration of the natural environment or ecosystem must lead to the development of the local economy. It is desirable that restoration of the natural environment be established as a business (called "local environmental business" below) and taken up by the local community, considering that today's

economic system is a market economy.

Local environmental business has not been established because the cost of restoring the natural environment is so high with the current level of science and technology. The cost should be borne or supported by society. In other words local environmental businesses should be supported by a new social system where the cost is borne by society.

Based on the ideas presented above, through our research, we have been proposing a new concept of a cycle-type river basin economic zone, where a local environmental business can be established with a new social system. (Morozumi, 2006) We are applying the concept in an agricultural area, and analyzing and studying its effectiveness. (Note 1)

The cycle-type river basin economic zone covers the whole river basin from the watershed to the coast, which is under the authority of one or more municipal governments. One reason why the cycle-type river basin economic zone is based on a river basin is because of the relatively strong economic and social ties that exist in the area ; but there is another reason.

The resources in an area are exclusively and separately used by industries such as agriculture, forestry, fishery and manufacturing industry. For instance, forest resources have been exclusively used by the forestry industry, and marine resources by the fishing industry. To restore the natural environment and eco-system, cross-industrial use of local resources will maximize the materialization of the potential of the resources. In fact, it is possible that a local resource no longer used by the forestry industry may be effectively used to restore the marine environment, as described later. In other words it is possible that local resources with negative value can be changed into resources with positive value by good use. (Note 2)

There are three major requirements for the establishment of a cycle-type river basin economic zone, which we have realized through the application of the concept in an agricultural area.

One is research and development of new technologies that can maximize the materialization of the potential of local resources, responding to the actual state and requirements of the local area. These technologies do not have to be highly advanced technologies, as will be explained later. Technologies already developed and in use will be sufficient in many cases.

Another requirement is the development of a new social system that is needed in order to perform the business using developed technology. The social system will be devised for society to bear the cost of restoring the environment and for local governments and residents to provide support, for which local currency, etc., may be effective.

The final requirement is the formation of the entities that will establish and run the new social system. It is desirable that such entities be NPOs or voluntary

organizations of local residents, companies, etc., who are new local innovators, because the functioning of current bodies such as municipal governments and agricultural cooperatives is declining.

(3) Issues with this paper

We started setting up a cycle-type river basin economic zone in the Kesen area in Iwate Prefecture in 2003, in collaboration with local innovators, etc. More concretely, we began to develop the necessary technology, an integrated management to utilize local resources to restore the environment, and a new social system for the environmental restoration to be a business, and to form an entity to establish and run the new social system.

We are at the point where the research and development of the required technology has made some progress, an entity to establish and run the new social system has been formed, and preparations for the integrated management of local resources are underway. We are planning to intensively develop the new social system from now on.

This paper has two major aims. One is to study the meaning of the cycle-type river basin economic zone by reviewing and examining the ideas and actions for the cycle-type river basin economic zone in the Kesen area (Section 2). The other aim is to formulate a view for the ideal new social system by examining the conditions necessary for environmental restoration as a business using the restoration of the forest ecosystem as an example (Section 3).

2. Plans and actions for a cycle-type river basin economic zone in the Kesen area

(1) Environmental and economic problems in the Kesen area

1) Environmental problems

The cycle-type river basin economic zone in the Kesen area includes Sumita-cho, which has Mt. Takashimizu as the watershed, and the basin of the Kesen river that flows into Hirota Bay at Rikuzentakata city. The zone covers Rikuzentakata city and Sumita-cho. Rikuzentakata city has a population of about 25,000 and an area of 232 km^2 ; Sumita-cho, about 6,400, and an area of 335 km^2. More than 70% of the land in Rikuzentakata city and Sumita-cho is forested mountains; less than 10% is cultivated. Sumita-cho does not have a coast; Rikuzentakata city has Hirota Bay, on the Sanriku Coast. (Fig. 1)

The natural environment and ecosystem of the Kesen area are deteriorating, similarly to many rural areas elsewhere in Japan. The following describes situation. (Rikuzentakata city History Committee, 1994, 1996, 1997, 2005)

First of all, the forestry ecosystem is deteriorating because of delayed thinning in artificial forests (Araki *et al.*, 2005) Between the end of World War II and

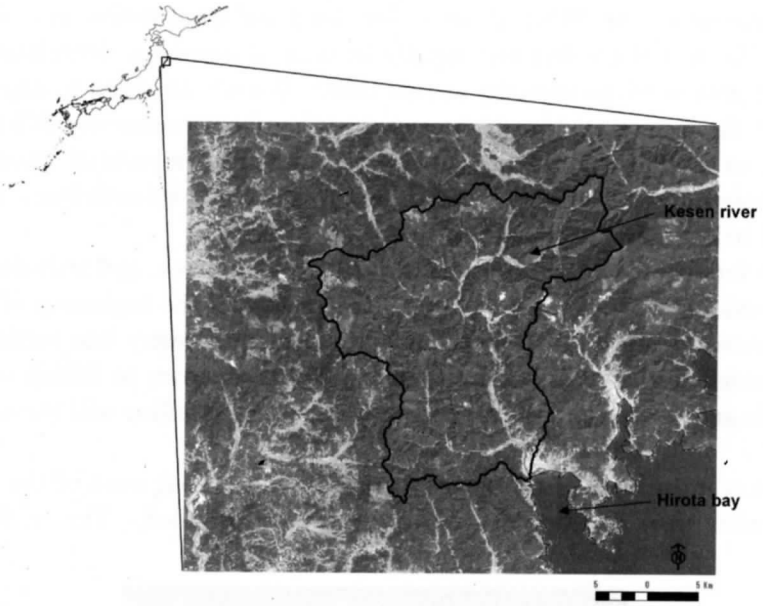

FIG. 1. Kesen river basin
▭ = Kesen river basin ⬚ = Oide river basin
The picture was observed by the artificial satellite Landsat 7 (ETM+) at 2001.9.24

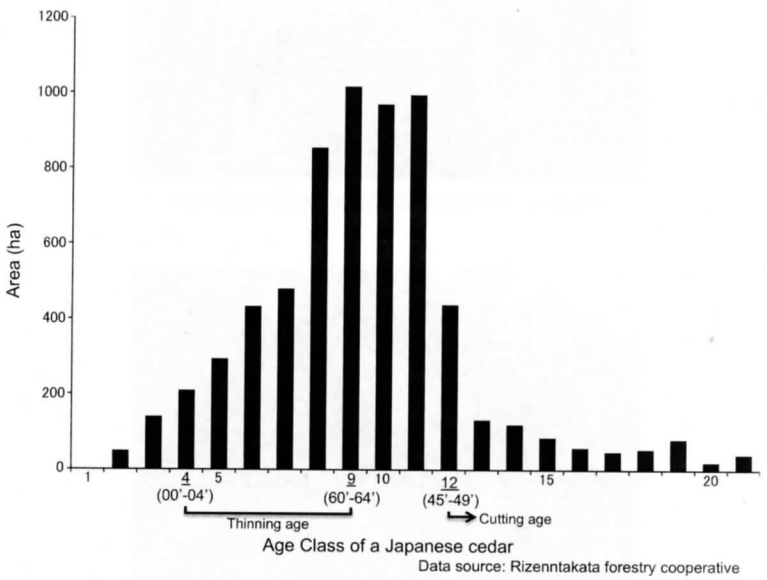

FIG. 2. Area of a Japanese cedar per each age class in the Rikuzentakata City
( ) = afforested period

the beginning of the 1970s, demand for wood for construction and as a raw material for manufacturing rose rapidly because of economic revitalization and the brisk growth of the economy at that time. Wood production in Japan could not meet the increasing demand because trees had been excessively felled during the war, so in 1961 the government started emergency imports of wood. After that, imports rose steadily so that in 1970, the wood self-sufficiency rate had dropped below 50%. The current rate is about 20%.

The forestry business was sound also in the Kesen area, and artificial forests, mainly cedar stands, expanded between the 1950s and the beginning of the 70s. Wood prices remained low from the mid-70s, pushing forestry into decline. The trees planted in the artificial forests in the 50s have grown to felling size (12th age-grade and above), and the number of trees ready for felling will increase. (Fig. 2)

However, collapse of the forestry business meant that most of the artificial forests with trees reaching felling size were not thinned. This is having a

Plate. 1 Delayed thinning artificial forest

Plate. 2 Artificial forest after thinning

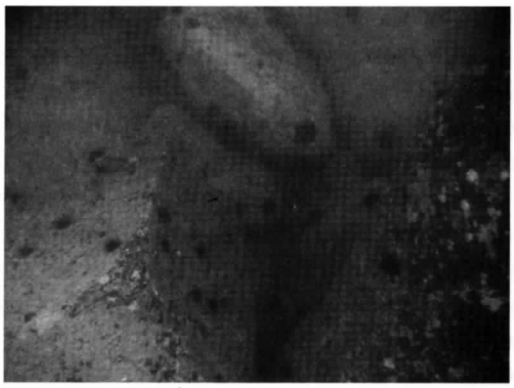

Plate. 3 Barren sea phenomenon
The white area shows the coralline algae and the black dot shows the sea urchins.

negative effect on the natural environment and the forestry ecosystem. (Maleque, 2007 ; Ishii, 2008 ; Ito, 2006)

For instance, humus has not accumulated in the top soil of forests not thinned, reducing the absorption capacity of rain water in the soil and becoming a factor to increase flooding of the river. Even in thinned forests, about half of the trees are not removed and are washed away with soil during floods, exacerbating flood damage.

Secondly, the marine ecosystem is deteriorating, including barren seas. Seaweed forests on the seabed along the coast have been disappearing all over Japan in recent years. As they disappear, so do most of the resident creatures, causing a significant impact on coastal fishery. According to Professor Kazuya Taniguchi (Taniguuchi *et al.*, 2008), disappearance of seaweed forests occurs under marine conditions of high water temperature and low nutrient level, and persists because of rising populations of herbivorous creatures, such as sea urchins. In recent years, the rise in sea water temperature caused by global warming has accelerated the growth of barren seas. (Seki *et al.*, 2008 ; Taniguchi *et al.*, 2008)

In Hirota Bay, too, disappearance of seaweed forests is spreading along the coast at depths of about 5–10 m (an area of 2 km^2-5 km^2). Consequently, hauls of sea urchins and abalone, which eat dead seaweed, have badly suffered. On the one hand, sea urchins increase in number in barren seas, but these sea urchins are unsuitable for eating.

Other reasons for the deterioration of the marine ecosystem include sludge generated by the aquaculture of oysters and scallops which piles up at the bottom of the sea (producing an anaerobic state in the sea) ; a change in the river flow into the bay caused by construction of an industrial estate at the mouth of the Kesen river (causing sea water stagnation in part of the bay) ; overabundant growth of

eel grass, and large quantities of disposed oyster shells. Finding solutions to these problems, in addition to measures to deal with barren seas, are major issues for the fishing industry.

Thirdly, the ecosystem in the area of human habitation is affected by large quantities of manure. Companies, etc., have large-scale pig farming and broiler breeding operations in Sumita-cho, upstream of the Kesen river and part of the Kesen area, generating huge quantities of manure. Some of this has entered the Kesen river and caused problems in the past. Measures are now in place whereby large-scale pig breeders use sewage treatment equipment and broiler breeders carbonize the poultry manure.

2) Economic problems

Formerly, primary sector industries, mainly forestry and the fishing, formed the core economy of the Kesen area. Both industries declined rapidly in the 1970s, which is the fundamental cause of today's economic slump.

In Rikuzentakata city, in 1970, the primary sector comprised 42% of the city's net production, with nearly 30% generated by fishing. However, the 200 nautical mile regulations and the oil crisis in that decade wiped out round-haul

Table 1. The net production by industries in Rikuzentakata city

(unit: %, 1,000 yen)

	1970	1980	1990	2000	2005
Primary industries	42.2	28.2	14.6	6.1	5.7
Agriculture	8.7	3.6	4.2	1.6	1.4
Forestry, hunting	4.7	1.8	0.9	0.3	0.7
Fishery	28.8	21.9	9.5	4.2	3.6
Secondary industries	17.2	24.2	28.0	30.1	21.6
Mining	0.9	0.5	0.5	0.1	0.1
Construction industry	8.0	13.0	11.9	15.5	8.3
Manufacturing	8.4	10.7	15.6	14.5	13.2
Tertiary industries	40.5	52.7	61.3	67.4	60.3
Wholesale, retail	7.2	13.1	15.0	12.5	13.5
Finance, insurance, real estate	10.3	9.5	13.0	17.3	21.5
Transportation, communication	4.0	3.4	3.5	3.4	4.1
Electricity, gas, water, heat service	0.4	0.3	0.6	1.0	0.8
Service	14.1	22.0	23.9	26.6	20.4
Public business	4.5	4.3	5.3	6.7	17.1
Exclusion Imputation interest	0.0	−5.1	−3.9	−3.6	−4.8
Total	100	100	100	100	100

Data source: Statistics of Rikuzentakata city (2000, 2008)

netters, decimating net catches. The main business of the fishing industry is now aquaculture of oysters, etc., and it no longer has the vigor of earlier years. The city has been striving to attract factories and promote commerce, but its net production started declining from around 2000. (Table 1)

The city's working population peaked in the 70s, then steadily declined until the 90s, when it started declining more rapidly. The major cause of the decline in the working population that started in the 70s was a drop in the number of workers in the primary sector ; and the causes of the decline that started in the 80s were economic sluggishness and a reduction in the population engaged in the secondary sector. (Table 2)

It should be noted that in recent years in Rikuzentakata city, the fishing industry has supported the local economy, although the industry is not as powerful as previously. In the primary sector, the net production of and the working population engaged in fishing represent more than half. In the secondary sector, the foodstuff manufacturing industry represents more than half. Most of foodstuff manufacturing is closely associated with the fishing industry.

Table 2. The working population by industries in Rikuzentakata city (over 15 years old)

(unit : %, number)

	1970	1980	1990	1995	2000	2005
Primary industries	48.6	33.4	25.0	21.3	17.3	16.4
Agriculture	33.4	19.0	13.4	12.1	9.4	8.8
Forestry, hunting	0.8	1.0	0.8	0.6	0.5	0.5
Fishery	14.5	133.3	10.8	8.5	7.4	7.0
Secondary industries	21.3	30.7	35.0	35.1	36.0	31.7
Mining	0.5	0.4	0.3	0.2	0.2	0.2
Construction industry	9.7	15.0	12.0	13.1	14.3	12.5
Manufacturing	11.1	15.4	22.6	21.7	21.4	19.1
Tertiary industries	30.1	35.8	40.0	43.7	46.7	51.9
Wholesale, retail	11.3	14.0	15.0	16.1	16.6	15.2
Finance, insurance, real estate	0.7	1.1	1.4	1.5	1.3	1.3
Transportation, communication	3.8	3.9	3.8	4.5	4.5	0.2
Electricity, gas, water heat service	0.2	0.2	0.2	0.2	0.2	0.1
Service	11.9	14.2	17.0	18.7	21.4	28.6
Public business	2.1	2.5	2.6	2.7	2.7	2.7
Non classified	0.0	0.1	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Total number of working population	15,590	14,278	13,696	12,989	12,650	11,616

(2) Plans for the cycle-type river basin economic zone of the Kesen area

We have plans, as shown in Figure 3, to establish a cycle-type river basin economic zone to restore the natural environment in the Kesen area as a local environmental business, in collaboration with local residents and entities. Two types of resources that will be mainly used are thinned wood from mountains, and eel grass, oyster shells, etc., from the sea. Currently, these resources are not used ; they are disposed of. The technologies to be researched and developed are technologies for charcoal power generation, algal reefs, sea cleaning and composting. Integrated management for the utilization of local resources will be carried out by an organization called the Kesen Industrial Research Organization, which is a cross-industrial organization with participation by the local forestry cooperative, the fishery cooperative, the agricultural cooperative, businesses and residents. The research and development of social technologies will be carried out by the Kesen Industrial Research Organization and Tohoku University in collaboration. (Note 4)

We are planning to restore the natural environment roughly according to the following procedures using local resources and social technologies to be developed.

Charcoal will be produced by carbonizing thinned wood. The charcoal will be used for charcoal power generation in the mountains and Sato sections (Sato

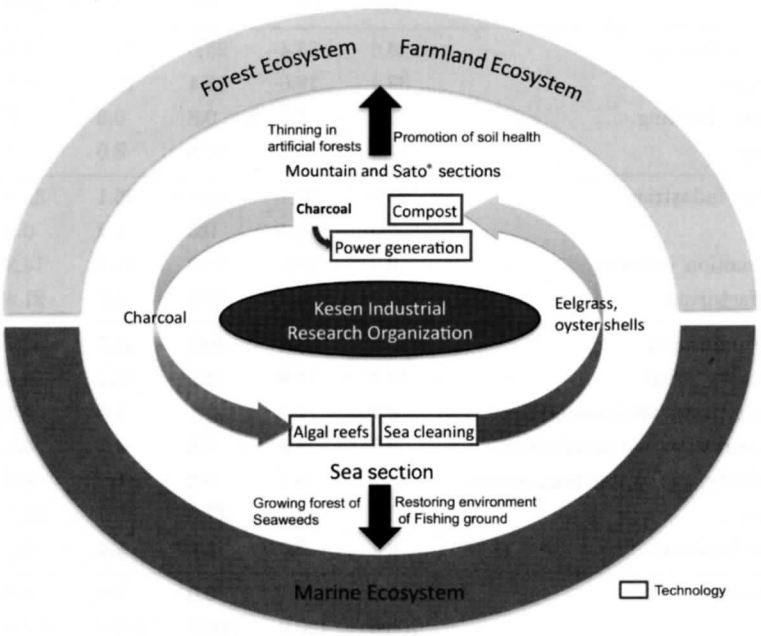

FIG. 3. Plan of the Kesen cycle-type river basin economic zone
Sato section is a section which is neither mountain nor sea section.

section is a section which is neither mountain nor sea section. and so forth) and supplied to the sea section. In the sea section, a mixture of charcoal and carbonized poultry manure will be used to make algal reefs that will form nurseries for the growth of seaweed. Algal reefs will be put at the bottom of barren seas along the coasts. The sea section will clean the sea (removing eel grass and Mediterranean mussels—which hinder aquaculture—and disposing of the shells of oysters, scallops, etc.) supported by the mountain and Sato sections. The removed eel grass, etc., will be supplied to the mountain and Sato sections and composted. The compost will be spread on agricultural land.

If local resources are used in a cross-industrial way, as stated above, in the mountain and Sato sections, thinning will restore the forest ecosystem, and use of the compost will restore the ecosystem of agricultural land. At the same time, in the sea section, seaweed forest will form, eliminating the barren sea phenomenon, and the fishing environment will be improved by the sea cleaning.

The flow of local resources to be used for environmental restoration between the sections will increase the use of thinned wood and raise employment in the mountain and Sato sections. This means that the economy in the mountain and Sato sections, which are stagnant because of the slump in forestry, will be supported by the economic power of the sea section, where there is scope for raised production by improving the marine environment. It is possible that the local environmental business to be set up to restore the environment will form a new local industrial cluster by establishing the required social system and collaboration between sections and industries.

(3) Actions taken to establish the cycle-type river basin economic zone

Among the plans stated above, the Kesen Industrial Research Organization, local residents and Tohoku University are collaborating in field testing of charcoal power generation and the algal reefs with the prospect of developing business from

Plate. 4 Equipment of charcoal power generation

Plate. 5 Algal reefs using charcoal with kelp that includes *Eisenia bicyclis*.

them. Concerning the charcoal power generation, the Oide community in the mountain section and Tohoku University have produced three units of charcoal power generation equipment since 2005, and have been performing tests including tests of charcoal generation efficiency. With regard to algal reefs, the Kesen Industrial Research Organization, fishermen and Fishery cooperative based at Hirota Bay, Tohoku University and other bodies started making trial algal reefs in collaboration in 2006, and are performing tests to grow forest of seaweeds using the algal reefs set under the sea.

These technologies have not reached the stage of practical application. The restoration of the forest ecosystem and the development of the charcoal power generation business, are at a stage of having some potential, based on the results of work so far. Following are an analysis of and a discussion about the work in Oide, a community in the mountain section in Rikuzentakata city.

3. Assessment and issues of integrated management of local resources —Feasibility of the restoration of the forest ecosystem and a charcoal power generation business—

(1) State of thinning

Oide has 3,280 ha of forest, including 2,021 ha of artificial forest (2,015 ha conifer, 6 ha deciduous). The national government currently subsidizes thinning of artificial forests with trees in the 4th or 5th age grade, which applies to 523 ha of the forest in Oide. The average price of wood has steeply dropped to 10,643

Table 3. Estimated forest owner's income of doing thinning work and payment to the forestry cooperative (yen/m³)

Owner's Income		Payment to the cooperative	
Sale of wood*	7,000	Thinning	3,500
Subsidies**	3,000	The cost to the thinned wood to the road	3,500
		The cost to the wood to the market place	2,000
		Commission of the cooperative	1,000
Total	10,000	Total	10,000

Data source : Rikuzentakata forestry cooperative
Note :
1) *Wood price is for logs 14 cm in diameter and 2 m in length.
2) **The Japanese government grants subsidies of about 150,000 yen/ha. Amount of cedar wood per ha is about 50 m³. 1 m³ is equivalent to 3,000 yen/m³.

yen per m³, which is 56% of the average price one decade ago of 18,949 yen per m³, because of sluggish demand for domestic wood in recent years. At this price, it is difficult for foresters to thin woods without aid.

Table 3 shows the estimated income (per m³) of foresters doing thinning work that has been assigned to the forestry cooperative. It is usual in Rikuzentakata city to assign thinning to the cooperative. Payment to the forestry cooperative of 10,000 yen per cm³ (for logs 14 cm in diameter and 2 m in length) consists of 3,500 yen for thinning, the cost to move the thinned wood to the road, the cost to transport the wood to the market place, and the commission for the cooperative. The charges for thinning, transportation and commission are more or less the same as the values shown in the table for any forest. On the other hand, the charge to move the thinned wood to the road in the table is an average figure and, in reality, varies widely depending on the distance moved. The total paid to foresters for thinning is 10,000 yen, comprising 7,000 yen from the sale of the wood and 3,000 yen in aid.

It should be noted that although the government promotes thinning with the subsidy, thinned wood is not often used. There are many cases where the charge to move the wood to a road exceeds 3,500 yen. In these cases, woods are thinned purely for the grant (3,000 yen), and the thinned wood is left. This is called thinning with thinned wood left. The proportion of thinned forest is low at about 30% (based on the size of thinned forests with trees requiring thinning), where more than half of the thinned wood is left in the forest (Note 5).

(2) Costs of producing charcoal from thinned wood and of generating electricity from charcoal

To restore the forest ecosystem by thinning, it is necessary to lift demand for thinned wood. One way to do this would be to produce charcoal from the thinned wood, and use it to generate electricity.

The electricity generated from charcoal could be used for the following. One possibility is to power electrical equipment for forestry work. The average age of people working in the forestry industry is increasing, so use of electric equipment should be expanded as soon as possible to reduce the physical burden. Another possibility is to secure a power source during emergencies such as natural calamities. In recent years, mountain villages have been hit frequently by natural calamities, so securing lifelines, particularly electricity, has become an important issue. Charcoal power generation is effective in solving the issue because charcoal can be stored for a long time. The electricity could be used for electric cars and vehicles for aged people. Also, power generated by charcoal could be used for greenhouses for agricultural use, and at public facilities.

We have produced estimates of the cost of charcoal power generation, below, to examine the conditions to use thinned wood for charcoal power generation. We have already made trial charcoal power generation equipment, so data obtained from separate tests is used as the value for the efficiency of generating electricity from charcoal (the quantity of power generated by charcoal per ton), etc. (Note 6)

Table 4 shows the producer price of charcoal in Iwate Prefecture in 2009. The average producer price of charcoal in the prefecture in 2009 is about 20% higher than the average in and before 2006 because the utility value of charcoal has been revised in recent years. The price differs by area and season. The difference in price by area is mainly due to the difference in productivity per person; the difference in price by season, to the balance of supply and demand.

Table 4. Producer price of charcoal in Iwate Prefecture in 2009 (yen/kg)

	Southern part of Iwate		Northern part of Iwate			
	Mizusawa	Tono/ Rikuzentakata	Miyako	Kuji	Ninohe	average
2009.3	153.3	153.3	103.3	100.0	93.3	120.7
2009.8	146.7	140.0	103.3	73.3	86.7	110.0

Data source: Iwate charcoal association

Note: Producer prices are shown by branches of the association. In every year, usually, producer price is highest in March, and lowest in August.

Table 5. Estimates of the cost of generate 1 kWh of electricity from charcoal

Range of cost of charcoal power generation	Producer price of charcoal (yen/kg)	Amount of electricity generated from charcoal* (kWh/t)	Cost of charcoal power generation (yen/kWh)
Maximum	153.3	2,300	66.7
Minimum	73.3	2,300	31.9

Note :
1) Depreciation cost and operation cost of the generation equipment are not included
2) *We have gotten this data from the experiment of charcoal power generation equipment by Mr. Wada *et al.* since 2005

Table 6. Comparison between the estimated highest and lowest cost of generation against the cost paid by residents in Oide

Range of cost charcoal power generation	Cost of charcoal power generation (yen/kWh)···(A)	Cost paid by residents* (paid to Tohoku Electric Power) (yen/kWh)···(B)	Difference between (A) and (B) (yen/kWh)
Maximum	66.7	28.0	38.7
Minimum	31.9	28.0	3.9

Note : *Data was surveyed by Mr. Wada *et al.* at 2008

In 2009, the highest producer price marked was 153.3 yen in March, and the lowest at 73.3 yen in August.

Table 5 shows estimates of the cost of to generate 1 kWh of electricity from charcoal, assuming that the producer price of charcoal continues to vary within the range. Only the cost to procure charcoal (the producer price) is included in the cost of charcoal power generation : depreciation cost and operation cost of the generation equipment are not included. This is because we cannot estimate the cost of depreciation (since we are currently using a trial charcoal power generation equipment for tests) or the cost of operation (since the cost of labor—the major part of the operation cost—differs according to the specifications of the equipment ; for instance, the possibility of automatic operation).

(3) Cost of charcoal power generation and effectiveness

The estimates of the charcoal power generation cost stated above are to show the connection between the producer price of charcoal and the cost of generation. The estimated cost of generating electricity must be lower than the cost of the electricity paid by the residents of the area in order for charcoal power generation to be a viable business. Table 6 shows a comparison between the estimated highest and lowest costs of generation against the cost paid by the residents, which is 28 yen/kWh (paid to Tohoku Electric Power). (Note 7)

The comparison shows that, in the case of Oide, for each kWh generated by

Table 7. Feasibility of thinning and generation in Oide

Items	Base of calculation	Figure
The area of forest requiring thinning	Forest between the 4th-9th age grade in 2009 : 523 ha/5*	105 ha
Weight of thinned woods	Amount of wood (3,268 m^3) * 0.9 (rate : weight to cubic content)	3,250 t
Amount of charcoal	Weight of thinned woods (3,265 t) * 0.2** (rate : wood to charcoal)**	689 t
Total Amount of generation	Amount of charcoal * 2.3 MWh/t***	1,585 MWh
Maximum Number of households which can use the generation	Total amount of generation/average electricity consumption per households in Oide (12.5 MWh)****	126 households
Coverage rate of households in Oide	Maximum number of households/total households in Oide (113 households)	112%

1) *1 age grade includes 5 years
2) **Data from the experiment used by the charcoal kiln in Oide. Dr. Kunii *et al.* have done at 2009.10.
3) ***Data from experiment used by the generation equipment done by Mr. Wada *et al.*
4) ****Data surveyed by Mr. Wada *et al.* (at 2008).

charcoal, support of between 3.9 yen at the minimum cost and 38.7 yen at the maximum cost is needed to be given by society, one way or another ; otherwise, charcoal power generation cannot be run as a business, and it will be difficult to restore the forest ecosystem using thinned wood for charcoal power generation.

The following two points were investigated to clarify the meaning of the establishment of charcoal power generation business in Oide. The first point was to estimate the area that will be thinned and the quantities of thinned wood that will be supplied, charcoal that will be produced and the electricity that will be generated in Oide. The second point was the amount of support that will be required, based on the maximum possible generation and the effectiveness of thinning.

First of all, the first point. Table 7 shows the feasibility of thinning and generation in Oide. The area of forest requiring thinning with trees between the 4th and 9th age grade, which the national government subsidizes, was 105 ha in 2009. Based on this area, if 10% of the wood volume is thinned over five years and charcoal is produced from the thinned wood, this will generate 1,585 MWh of electricity. The average electricity consumption per household is 12.5 MWh (surveyed in 2008). Total amount of generated electricity is sufficient for 126 households. This number is more than the actual number in the area.

Next, the second point. Table 8 shows the estimated amount of support needed to materialize a charcoal power generation business and the estimated

Table 8. Estimated amount of support needed to materialize a charcoal power generation business and environmental, socio-economical effects

	Cost of charcoal power generation In the case of minimum (31.9 yen/kWh)	Cost of charcoal power generation In the case of maximum (66.7 yen/kWh)
<Required support from society>		
Total amount of generation	1,585 MWh	1,585 MWh
Required social support to 1 kWh	3.9 yen/kWh	38.7 yen/kWh
Total required support	$6{,}182*10^3$ yen	$61{,}540*10^3$ yen
<Effects on restoration of eco-system>		
Thinning	105 ha	105 ha
Required social support/ha	$59*10^3$ yen/ha	$586*10^3$ yen/ha
<Effects on socio-economy>		
Required workers and days for thinning/ha	20 workers, days/ha	20 workers, days/ha
Total additional required workers for thinning in Oide	8 workers/year	8 workers/year
Number of days employed in thinning operation/worker	250 days/year	250 days/year
Wage rate	8,500 yen/day	8,500 yen/day
Total amount of wage	$17{,}779*10^3$ yen	$17{,}779*10^3$ yen

effectiveness of thinning.

According to the estimates, if charcoal power generation is performed to carry out the necessary thinning, support between the minimum of 6,182,000 yen (at the minimum generation cost of 31.9 yen/kWh) and the maximum of 61,540,000 yen (at the maximum generation cost of 66.7 yen/kWh) will be required from society, somehow. Currently, most of the privately owned forest in Oide is not thinned. However, if society gives support of between 59,000 yen and 586,000 yen per hectare (between the minimum and the maximum cost of charcoal power generation), thinning will be performed and the forest ecosystem will be restored. The government currently grants subsidies of about 150,000 yen per hectare. However, the subsidy has had such little effect on thinning. If an additional subsidy between 59,000 yen (at the minimum generation cost) to 586,000 (at the maximum generation cost) truly promote thinning, the extra subsidy is effective and worth thinking about.

This will be socio-economically effective because more people will be employed if the area of forest thinned increases. According to estimates, eight new foresters will be needed, at a total wage bill of ¥18 million. This is a great effect, considering that employment is in steep decline in mountain villages.

(4) Establishment of a social system

Supporting the materialization of a charcoal power generation business in Oide would help to restore the natural ecosystem, generate socioeconomic effectiveness by increasing employment, be effective in reducing the physical burden of foresters and be a measure to cope with natural calamities. However, the level of support required is so high as to exceed the means of the residents of Oide and of the Kesen Industrial Research Organization, which is coordinating the cycle-type river basin economic zone. Therefore, how to raise this support from society is a problem.

This problem should be solved by two means. The first is to lower the cost of generating electricity from charcoal by raising the efficiencies of charcoal production and of power generation. The Kesen Industrial Research Organization and Tohoku University are working on this. The other is to solicit the cooperation of as many people and organizations as possible, inside and outside of Oide, by giving explanations to solicit support from society. A forestry cooperative in Kuzumaki-cho in Iwate Prefecture, where natural and economic conditions are similar to those of Oide, is making efforts to promote thinning. The cooperative ships thinned wood in Kuzumaki-cho to a paper manufacturer, then sells the product to members of the Office Chonai-kai, an environmental NPO located in Tokyo, at a price 10% higher than usual paper. A 10% premium in the cost of paper is only a small part of the cost of printing for the members, which means they can contribute towards improving the environment relatively easily. For the cooperative, the 10% premium means more than twice as much for the thinned wood and promises sufficient profit by thinning, which consequently increases thinning. (Note 7)

Success in Kuzumaki-cho was achieved because the Kuzumaki-cho forestry cooperative mentioned the current state of thinning to companies who want to contribute to improving the environment one way or another. If the aims and the meaning of generating electricity from charcoal in Oide are sufficiently communicated, it will probably be possible to attract support for the generation from people and organizations inside and outside of Oide who are interested in the environment. There are various ways to obtain funds from society. A lesson learned from the success of Kuzumaki-cho is that the critical factor is the power of the self-governance of the Oide community and the Kesen Industrial Research Organization.

4. Conclusion

We are proposing a new concept—a cycle-type river basin economic zone—to restore the natural ecosystem with business (local environmental business), and

the setting up of such a zone in the Kesen area in Iwate Prefecture.

The first section of the paper introduces the concept of the cycle-type river basin economic zone. The second section presents ideas for the cycle-type river basin economic zone and plans for local resource integrated management, required to solve the environmental and economic problems confronting the Kesen area. The third section includes an analysis of the results of the feasibility and the meanings of the restoration of the forestry ecosystem and a charcoal power generation business in Oide. It is pointed out that charcoal power generation promotes thinning and greatly assists in restoring the natural ecosystem ; further, there are various social and economic effects. Running a charcoal power generation business needs support ; so the question is : how to obtain this support from society ? The answer to this question is to set up a new social system.

This paper examines the feasibility of generating electricity from charcoal, which is somewhat technically advanced, as a local environmental business. A considerable number of issues remain outstanding and include the fact that we do not yet know the cost of depreciation of charcoal power generation equipment, or the cost of operating it. Also, although we feel confident of lowering the cost of charcoal production, we do not have sufficient supporting data. More detailed analyses are required.

Establishing the cycle-type river basin economic zone requires supporting data about algal reefs, which this paper barely mentions, and about the sea cleaning and composting that we are planning to do in full scale. We are still in the middle of our research, so this paper is an interim summary of the results of our research.

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Notes

1) Morozumi *et al.* proposed the concept of the cycle-type river basin economic zone in "Research into the establishment of a cycle-type river basin economic zone in Iwate" (2003-2008), which was a research and development project of the Japan Science and Technology Agency.
2) Research concerning river basin economic zones was thoroughly reviewed by Nishizawa (2007). No research has been performed in Japan or overseas from the viewpoint of the compatibility of the environment and

the economy.

3) Reference was made to the history of Rikuzentakata city (1994–2000) concerning nature, economy and society in the city.
4) The Kesen Industrial Research Organization is a voluntary organization set up in July 2007. The organization consists of the Rikuzentakata city forestry cooperative, the Rikuzentakata city agricultural cooperative (the former Ofunato agricultural cooperative), the Hirota fishery cooperative, Yagisawa Shoten (a local firm), residents and others.
5) The thinning area in Oide district was about 35 ha from 2004 to 2006, and the area were 140 and 170 ha in 2007 and 2008, respectively. The thinning area was increased from 2007, but there were a lot of area not to be finished thinning yet until 2006. Therefore there is a lot of area which is need of thinning in Oide district.
6) The first trial charcoal power generation equipment was produced in 2006. Three units (with outputs of 3.5 kW, 10.0 kW and 1.5 kW, respectively) have been produced so far. Data relating to charcoal power generation was obtained through experiments performed by Wada of the Graduate School of Environment Studies, Tohoku University, and members of Oide community. The results of the experiments are planned to be announced in the future.
7) Data is from a survey of about eighty households in Oide performed by Wada and others in 2008.
8) Informed orally by the Kuzumaki-cho forestry cooperative.

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