Land use scenarios for assessing sustainable ecosystem services — a study for an energy-self-sufficient ecovillage in Japan

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The town of Yoichi is located approximately 20km west of Otaru city, the main port on the island of Hokkaido, in the lower reaches of the Yoichi River basin. Yoichi and the neighbouring town of Niki have similar climatic and topographical conditions and are well known for their orchards including apples, pears, peaches and cherries. The area is also home to several wineries that use locally produced grapes and there are also whisky distilleries.

The two towns have a combined population of around 23,000. The area is mountainous, and primary industries, such as agriculture and fishing, are the main economic activities. The area is relatively accessible from Hokkaido's capital city, Sapporo, and many farmers open their orchards to tourists from the city during harvesting times. The wineries also conduct tastings, attracting customers from as far away as Tokyo.

Hokkaido Ecovillage Promotion Project
The Hokkaido Ecovillage Promotion Project (HEPP) was created as a site for learning and practical engagement in the creation of a sustainable region. It is also a not-for-profit organization that offers hands-on experience of self sufficiency to members, students and the general public. Activities at the Yoichi Ecovillage are aimed at exploring environmentally-friendly lifestyles and forms of farming, while simultaneously developing a transitional movement that seeks to gradually transform the entire region via beneficial relationships between various local actors.

Within the Yoichi Ecovillage, facilities have been created to promote learning about and experiencing an environmentally harmonious lifestyle. With the help of participating engineers and builders, locally produced and recycled timber has been used alongside passive design principles to make the most of natural light and air flows, ensuring high levels of thermal insulation and air tightness during the coldest times of the year, when temperatures can fall to -10°C. The village also uses stoves that burn locally-sourced wood, and composting toilets that process human waste onsite. Both construction and installation of these facilities have been made possible by the participation of local residents and visitors to the Ecovillage, including cooperating farmers and, as such, has been a successful exercise in community-driven building, as construction staff and visitors now live together in a communal shared house.

Survey of the potential for self-supplied energy in the area
A study is now underway on the potential for renewable energy use within the region, based on the Ecovillage model. The study focuses on:
- Quantities of exploitable energy resources
- Energy demand
- Renewable energy scenarios

The ultimate aim of these efforts is the demonstration of sustainable energy, using scenarios involving the participation of both the Ecovillage and the local community.

Available energy resources
The most available renewable energy resources in the area include pruned branches from local orchards, and wood produced through forest management activities. The quantities of branches and the seasons in which they are pruned differ according to the type of tree and pruning methods used. Empirical studies have been carried out to ascertain the potential quantities, the amount of labour required for branch collection and the possibility of utilizing this resource as a source of energy.

These studies have shown that cherry trees will produce approximately 2.0–2.3t/ha of pruned branches from living trees. While the branches are pruned each spring, the grape vines are pruned in autumn. Also, new trees are planted over a 10–20-year cycle, at the end of which large amounts of waste wood are produced. Pruned branches are rarely utilized by local farmers, with most of these materials often burned in the fields as waste. Some of them are turned into mulch and returned to the orchards and some are treated as industrial waste.

The area also contains many mountain forests. These include forests planted for timber that are no longer properly managed, as well as secondary forests created by naturally occurring hardwoods growing in areas after timber has been removed. The Ecovillage also encompasses around 1.14 ha of forest which, although currently not adequately managed, may provide a viable energy source with the implementation of appropriate management.

A survey of local forest resources has identified around 250m^3 of above-ground biomass, the equivalent of some 140t of wood fuel. If this wood were collected in a sustainable manner over a 30-year cycle, 4.7t of wood fuel would become available for use each year.

Image: GER

Yoichi Ecovillage built as part of the Hokkaido Ecovillage Promotion Project

Energy demand
A study of current energy demands was conducted. The shared house is usually occupied by two or three people, but as much as ten during busy periods. Heat is produced by burning kerosene which is used to heat water for bathing, cooking and cleaning, and for heating the house. Electricity is used to power a kitchen oven, refrigerator, office appliances, boiler and lighting.

Meeting these energy demands with local sources requires a detailed demand analysis and the drafting of an energy plan based on the findings. In the winter of 2017, devices were installed to monitor the consumption of electricity and heat, and the size of the necessary renewable energy equipment has been analyzed. The largest consumption of electricity in a single day was found to be 12kWh, while the largest consumption of heat energy was 102kWh. During winter, over 90 per cent of heat energy was used for heating the rooms.

Scenario analysis
Considering available energy resources and energy demand, in what ways should these energy resources be used? Is it possible to balance supply and demand, supplying only the amount of energy required? Would such a scenario be sustainable?

In order to answer those questions, the Yoichi Ecovillage was used as a model to estimate the amounts of energy both required and available over a one-year period, based on the findings of resource and energy demand surveys. Two scenarios for the use of locally-sourced energy were considered:
- Scenario A: Energy supplied to the shared house only.
- Scenario B: Energy supplied to all Ecovillage facilities.

Scenario A is simple. The annual amount of energy required by the shared house is estimated at 3,200kWh of electricity and 16,000kWh of heat energy. In this scenario, electricity would be supplied by photovoltaic solar panels, while heat would be provided by woody biomass in firewood boilers, boiler stoves and rocket stoves. The wood would be supplied by the pruning of orchard trees. To generate the required amount of electricity would need 4kW solar panels, covering an area of 24m^2. The necessary heat energy could be supplied by 5.5t of fuel wood obtained from 1.4ha of forest, provided that the forest management practices were carried out, or 9.6t of pruned branches from 4.6ha of orchards.

This scenario envisions supplying energy to each residence separately and is the most individually distributed system.

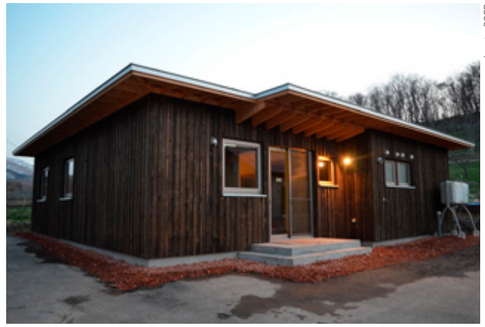
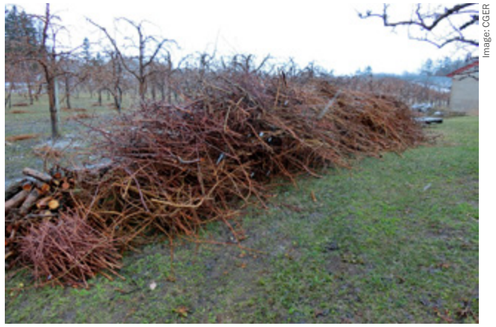


Image: CGER

The shared house used as the base for the assessments



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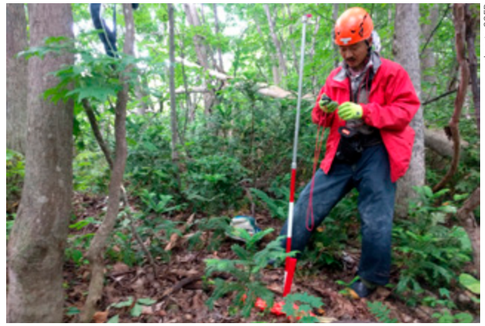
Pruned branches collected from the orchards for fuel



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Sample plot survey used in the sustainability analysis

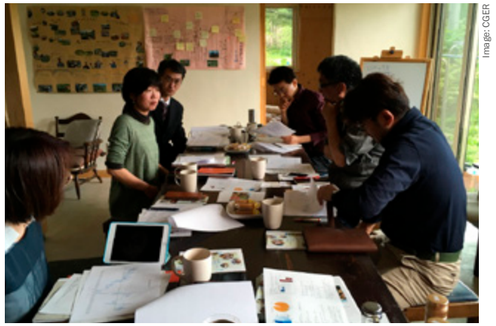

Image: CGER

Study meeting within the shared house

Scenario B widens the scope of energy supply to include surrounding facilities and residences such as a café and cottages, and envisions energy supplied according to a local heat delivery system. Unlike Scenario A, this would involve supplying energy to multiple buildings simultaneously, requiring larger equipment but also achieving higher energy efficiency and improving maintainability. While installing energy delivery equipment would require additional costs, it would be possible to limit costs per unit of energy from boilers owing to the benefits of scale. Chip boilers have the additional benefit of automatic operation.

Efforts are underway to consider these scenarios jointly with stakeholders and to identify potential methods of obtaining energy resources and introducing efficient system operations.

Training programme of sustainable regional development

Training programmes, conducted mainly for national and local governmental officers in charge of natural resource management from developing countries, were held at the HEPP from 2015 to 2017, organized by Rakuno Gakuen University, Japan, and the Japan International Corporation Agency (JICA).

The programmes focused on the methodology used to analyze ecosystem services using geographic information systems, remote sensing and the InVEST (integrated valuation of ecosystem services and tradeoffs) model, developed by Natural Capital Project. After that, the participants visited HEPP and its surroundings for a closer understanding of the area. With this first-hand experience, participants attended a workshop to discuss a future vision for the region's sustainability, with scenarios proposed throughout the workshop.

It was found that technical training was not always necessary. But, in order to focus on the future visions and scenarios, integration systems and datasets are being developed to evaluate and compare several ecosystem services.