Keynote speech

What we have studied and what should be studied in the future on tropical rain forests in Sarawak

Tohru Nakashizuka [1,2,3]

[1] Research Coordinator, Japan Research Consortium for Tropical Forests in Sarawak
[2] Tohoku University, 6-3 Aoba, Aramaki, Aoba-ku, Sendai, Japan
[3] Author for correspondence (e-mail: toron@m.tohoku.ac.jp)

Abstract The collaboration between the scientists of Sarawak and Japan started officially in 1992, and has been continued for more than 20 years until now. At the beginning phase, rather basic subjects were our target to be studied. The description and inventory of organisms of tropical rainforests, which are essential information for both biological or ecological and more applied sciences, were the first interests of our study. Next, global issues, such as decreases of tropical forests, and their regeneration or restoration, came after that. The ecology of general flowering, and our large permanent plot study followed this context. Then, sustainable forest management, including biodiversity issues, came to be the major issue in our study after the 2000s.

Many facilities have been installed in Lambir hills National Park to enhance research capacity there. A laboratory, permanent plots, and a canopy walkway were installed in the initial phase, and a canopy crane, a hostel and instruments for assessing forest carbon budget were added in the beginning of the 2000s. These facilities accelerated research activities, leading to the publication of more than 250 scientific papers. And now, Lambir Hills National Park is one of the representative research centers of tropical forests of the world. The activities have been expanded beyond Lambir National Park to compare the results with those from other forests or forest types to gain more general perspectives, and to detect findings on interactions between forests and human beings in regional or global contexts. These new aspects of our collaboration are meant to meet needs of research on sustainable use of tropical forest ecosystems in general.

Recently, large efforts of ecosystem studies are being dedicated to sustainable use of biodiversity and ecosystem services. IPBES (Intergovernmental Platform for Biodiversity and Ecosystem Services), which was established in 2012 and aims to give relevant scientific information and advice for CBD (Convention of Biological Diversity), started its global assessment. Also, a new ‘trans-disciplinary’ research framework named “Future Earth” was launched to give scientific answers mainly for SDGs (Sustainable Development Goals). Future Earth includes not only inter-disciplinary studies, but also involvement of stakeholders in the planning

stage of research. While we celebrate our collaboration success in past years, it may also now be the time to discuss our new framework for future studies, considering these new scientific trends.

Keywords Biodiversity, Future Earth, Lambir Hills National Park, Sarawak, Sustainable forest management, Tropical rain forests

Introduction

Tropical rain forests are said to have the largest primary productivity with the highest biological diversity among the terrestrial ecosystems in the world, and they provide tremendous goods and services for human beings. In spite of such importance, biological and ecological information about tropical rain forests was limited until the 1980s, while tropical rain forests had been rapidly decreasing and/or utilized in rather un-sustainable ways at that time. Thus, sustainable management and conservation were critical issues for the study of tropical rain forests. In the 1990s, two international conventions on climate change and biodiversity came to consider central issues, and they have been integrated into the further issue of sustainable development in the 2010s. The collaborations among the scientists of Sarawak and Japan, which started in the late 1980s, developed with the changing research needs and interests up to the present.

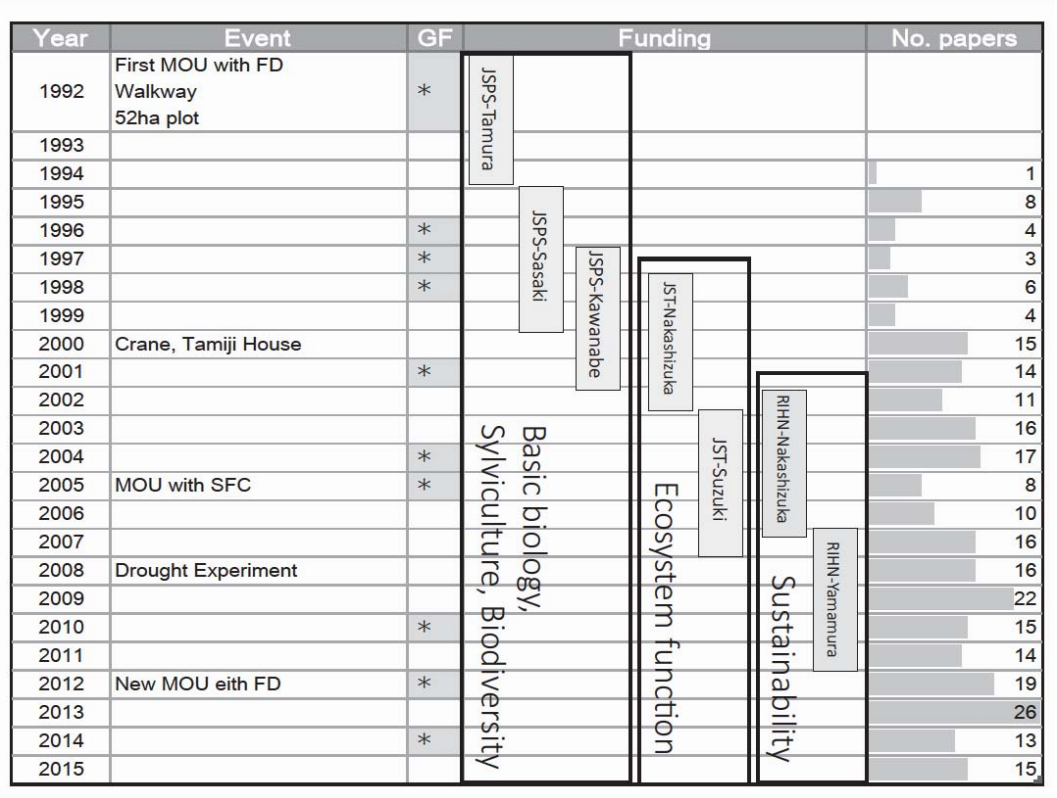

Fig. 1 Research history on tropical forests between Sarawak and Japan. GF means the general flowering events that occurred in the year with an asterisk. The column Funding shows the main funding projects of the Japanese side. No. Paper indicates the number of scientific papers related to tropical rainforests in Sarawak published by international journals.

In this paper, I would like to look back at the research history on tropical rainforests by Sarawak-Japan collaborations, and introduce some of the key activities. Then considering this history, new trends of research will also be reviewed.

History of the studies

The collaborations between Sarawak and Japan started to be discussed and prepared for in the 1980s, and this resulted in succeeding to have an official Memorandum of Understanding (MOU) on the Long Term Ecological Research Project between Forest Department Sarawak (FD) and Japanese Scientists in 1992 (Fig. 1). In 2005, in response to the establishment of Sarawak Forest Corporation (SFC), Japanese scientists organized the Japan Research Consortium for Tropical Forests in Sarawak (JRCTS) to make a new MOU with SFC. After that, another MOU between FD and JRCTS was established in 2012 to meet new administrative requirements for the research studies. At present, Japanese scientists from more than 10 universities and 3 institutes are members of the JRCTS.

Through these processes to formalize the research framework, we have succeeded in installing several research facilities in Lambir Hills National Park (LHNP), which have been the main research sites of the project. In 1992, a laboratory, a canopy walkway system and two tree towers were established in LHNP (Fig. 2). A 52 ha permanent plot was also established in collaboration with the Smithsonian Tropical Research Institute, USA. In 2000, a canopy crane (Fig. 3) and a hostel (named Tamiji House) were installed in LHNP, and facilitated the research activities there.

Those activities were supported by both the Sarawak Government and several Japanese governmental funding agencies. On the Japanese side in particular, the Japan Society for the Promotion of Science (JSPS) contributed largely at the initial stages, and has contributed continuously for personal research studies throughout the period. The Japan Science and Technology Agency (JST) funded two projects related to global environmental change during 1998–2007. The Research Institute for Humanity and Nature (RIHN) also funded two projects on sustainable management of tropical forests and ecosystems during 2002–2011.

Research topics

To determine research topics, it has been important to take into account the uniqueness of tropical forests in Sarawak. The climate in Sarawak is hot and humid throughout year, having no winter or clear dry season. Such climatic conditions are associated with high biological production and diversity. Actually, the tropical forests in Sarawak have some of the highest biological production and the highest biological diversity in the world, which is also related to the functional aspects of the ecosystems. The utilization of tropical forest ecosystems should also consider such conditions.

The research activities in tropical forests include several aspects. They may be classified into mainly three categories: basic studies on biology and ecology, functional studies of tropical forest ecosystems and watersheds, and research on sustainability of the human-ecosystem interface. The relative importance given to consideration of these categories has been changing during 1992–2015, and this change was also affected by the funding situations (Fig. 1). At first we started by performing basic biological and ecological studies, with some studies with applications for sylviculture. Since the late 1990s, many of the studies examined functional aspects of tropical rainforests, such as the interaction between ecosystem and atmosphere through carbon

sequestration, evapo-transpiration, etc. After 2000, the sustainable use of tropical forest ecosystems became an important issue to be studied.

These activities were summarized in several reports of symposia and projects. Inoue and Hamid (1994) reported the early findings on plant reproduction systems, while Inoue and Hamid (1997) documented a general flowering event in 1996 in detail. Itioka et al. (2001) showed the progress of canopy ecology studies. Roubik et al. (2005) gave updated information on the progress of pollination ecology in LHNP. Sakai et al. (2014) showed socio-economic environmental

Fig. 2 Canopy access systems installed in RHNP in 1992.

Fig. 3 Canopy crane installed in RHNP in 2000. The lower-left photograph shows the gondola getting into a small canopy gap.

Fig. 4 Big umbrella set for the experiment to artificially cause drought for a target tree.

variations in Sarawak. More than 250 scientific publications have been published thanks to these research activities thus far.

Basic biological and ecological studies

Basic biological and ecological studies include biological inventories of various organisms, phenology, tree demography, forest dynamics, tree eco-physiology, interactions among plants, animals and fungi including pollination and herbivory, and soil ecology etc. Performing inventories along with collecting specimens of plants, insects and mushrooms are important in particular tropical forests, where taxonomic studies are still not yet completed because of the high biological diversity. Tree demography, tree eco-physiology and forest dynamics may give answers to the question of the reason for the high tree diversity in tropical forests. Also, determining the interactions among organisms is essential for examining the maintenance of the high biodiversity in tropical forests. Soil ecology will give useful information on functional aspects of tropical rain forests as well as forest dynamics and tree eco-physiology.

Among the basic biological and ecological studies were studies that revealed that one of the most unique phenomena in tropical rain forests in Sarawak is so-called ‘general flowering’. General flowering is known as a unique phenomenon that has been observed only in tropical rain forests in Southeast Asia, which lack a clear winter and dry season. We have continued monitoring of plant phenology in Sarawak for more than 300–500 plants every 2 weeks since 1992, and found that a short-term dry spell should be the cue to cause general flowering (Sakai et al. 2006). The studies on other organisms have revealed that they are also influenced by general flowering. Pollination, herbivory, and mammal population dynamics are also greatly affected by general flowering and the subsequent mass fruiting (Momose et al. 1998). These findings have sparked an

interest in making manipulations of droughts. Since 2008, we have tried to make artificial droughts for target trees by covering their root ranges by big umbrellas (Fig. 4). It is difficult to prepare for unpredictable droughts in natural conditions, and such manipulation could provide us the opportunity to obtain important suggestive findings.

Functional aspects of tropical rainforests

Knowledge about functional aspects are important for knowing the role of tropical rainforests in regulating the global environment and climate. Since establishment of the canopy access systems, carbon cycling, including carbon sequestration, and water cycling have been studied by flux measurements continued in LHNP. Data on carbon sequestration started to be collected in many ecosystems at almost the same time as LHNP, though there are no data from tropical rain forests as humid as LHNP. Also, data on water cycling give essential information for constructing climate models that include the interaction between atmosphere and terrestrial ecosystems.

As for carbon and water cycling studies, basic ecological studies and eco-physiological studies can collaborate very closely. Studies have been conducted on forest dynamics and tree eco-physiology, which can give verifying data about carbon and water cycling. We also include research groups on remote sensing. One powerful tool is to utilize satellite data for scaling-up the locally observed facts into larger spatial scales. Such interdisciplinary research integrations of various fields are truly necessary for global environmental studies.

Sustainable use of tropical forest ecosystems

Recently, addressing the human aspects has become increasingly important to solve global issues not only in terms of the environment but also other aspects of sustainability (Millennium Ecosystem Assessment 2005). In this context, firstly we started studies on forest management and biodiversity after 2000. These included studies on the land-use changes in recent decades in the areas around LHNP and their impacts on biodiversity and ecosystem services. We surveyed the relationships between flora, fauna and forest types there to detect the effect of forest utilization on biodiversity. Such studies rely heavily on the basic biological and ecological data obtained in LHNP. The findings also included changes in interactions among organisms, such as pollination and herbivory, which may cause unexpected changes depending on land-use patterns.

The studies have been expanded into the aspect of resource uses by humans. They include studies on the relationships between forest types and ecosystem services, including the potential amounts of forest resources. They are also to be integrated into geographic information systems to contribute to the local decision makings and/or planning for sustainable use by the local society. In the past several years, such activities have been enlarged not only in local communities around LHNP, but also in those of various localities in almost all of Sarawak, and have included socio-economic studies in Sarawak (Sakai et al. 2014).

Recent research trends

Recently, new approaches to global issues are being emphasized, as represented by the Future Earth program. In this program, the research framework should be established with collaboration in a way that addresses 1) Fundamental interconnections between natural and human drivers of change, the resulting environmental changes and their implications for human well-being, 2) Studies across a range of time and spatial scales, and 3) Fundamental, holistic understanding for

developing transformative pathways and solutions for global sustainability (Future Earth Interim Secretariat 2013). This program also covers a wide range of sciences in terms of the environment, including forests and human communities in tropical areas. Research is required to be not only inter-disciplinary, but also trans-disciplinary, in which studies should be designed and produced in collaboration with various stakeholders. These studies are expected to meet Sustainable Development Goals (United Nations 2015).

Also for Asian regions, the Future Earth program has worked to build initial strategic research studies, and they include many aspects which may concern tropical rainforests (Manton et al. 2015). Thus, the research studies we are going to conduct in the future should also have the scope to meet these trends.

Conclusions

Since 1992, collaborative research studies between Sarawak and Japanese scientists have accumulated knowledge on tropical rainforests. This includes the natural history of organisms living in the forests, functions and services provided by tropical forests and some techniques towards sustainable use of the forests utilizing well-established research platforms and long-term monitoring. This collaboration has given some answers to global issues such as climatic change and the biodiversity crisis. All of the collaborative studies have been accomplished on the basis of reliable and skilled collaboration systems.

We should utilize these findings and research frameworks to further development. In particular, in addition to the continuation and expansion of collaboration and accumulation of scientific knowledge, we should enhance inter-disciplinary and/or trans-disciplinary studies to advance sustainability sciences.

References

Future Earth Interim Secretariat (2013) Future Earth Initial Design. Oktoberduck, Berlin

Inoue T, Hamid AA (eds) (1994) Plant Reproductive Systems and Animal Seasonal Dynamics. Long-term Study of Dipterocarp Forests in Sarawak. Center for Ecological Research, Kyoto University

Inoue T, Hamid AA (eds) (1997) General flowering of tropical rainforests in Sarawak. Center for Ecological Research, Kyoto University

Itioka T, Nakashizuka T, Chong L (eds) (2001) Proceedings of the International Symposium “Canopy Processes and Ecological Roles of Tropical Rain Forest.” Forest Department Sarawak and Japan Science and Technology Corporation

Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: Biodiversity synthesis. Island Press

Manton M, Yasunari T, Ailikun, Mallee H, Lasco R, Ramesh R (eds) (2015) Initial strategic research plan for Future Earth in Asia. China Meteorological Press

Momose K, Yumoto T, Nagamitsu T, Kato M, Hagamasu H, Sakai S, Harrison RD, Itioka T, Hamid AA, Inoue T (1998) Pollination biology in a lowland dipterocarp forest in Sarawak, Malaysia. I. Characteristics of the plant-pollinator community in a lowland dipterocarp forest. Am J Bot 85:1477–1501

Roubik, WD, Sakai S, Hamid AA (eds) (2005) Pollination ecology and the rain forest. Sarawak studies. Ecological Studies 174, Springer

Sakai S, Keong CY, Koizumi M, Kishimoto-Yamada K, Kato Y, Takano TK, Soda R, Samejima H, Nakashizuka T, Itioka T, Ichikawa M (2014) Geographical variation in the lives of local people and socio-economic environments in Sarawak. Center for Ecological Research, Kyoto University

Sakai S, Harrison RH, Momose K, Kuraji K, Nagamasu H, Yasunari T, Chong L, Nakashizuka T (2006) Irregular droughts trigger mass flowering in aseasonal tropical forests in Asia. Am J Bot 93:1134–1139

United Nations (2015) Open Working Group Proposal for Sustainable Development Goals