Balancing Fishery Resource Utilization and Conservation for Environmental Sustainability and Socio-economic Stability

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The coastal areas of Southeast Asia contain great biodiversity, where livelihoods of people are directly and indirectly dependent on the natural resources. In order to pursue sustainable development of the natural resources for rural area advancement, attempts have been initiated to harmonize the utilization of the resources with conservation. However, such efforts have encountered certain difficulties that hinder further development as the linkage between natural resources and ecosystem services and utilization represents a complex web of processes. It has therefore become necessary to study the relationship between the ecosystem and human capability as means of improving the management of coastal resources for the benefit of people dependent on such resources for their livelihood and well-being. It is under such scenario that the Research Institute for Humanity and Nature (RIHN) and some renowned universities in Japan partnered with research institutions and the academe in Southeast Asia to launch a joint research project on Coastal Capability Enhancement in Southeast Asia. Thus, a collaboration was forged by RIHN with the Southeast Asian Fisheries Development Center (SEAFDEC), as well as with the Eastern Marine Fisheries Research and Development Center (EMDEC) of the Department of Fisheries of Thailand, Faculty of Fisheries of Kasetsart University in Thailand, University of the Philippines in the Visayas, Aklan State University in central-western Philippines, and other related institutions/organizations to carry out the said project. By adopting the "holistic approach" to obtain full understanding of how people utilize the coastal resources against the backdrop of the so-called conservation, the project aims to establish rational and practical measures for social and ecological sustainability. Based on the holistic data and information, a new rural development concept known as "Area-Capability" would be crafted which demonstrates how the ecosystem health could be harmonized with the welfare of the people. Inventories of ecosystem services and livelihoods of coastal areas would be compiled for the development of necessary guidelines for the implementation of this new research approach, which is based on the concept of "Area-Capability," in coastal rural communities of Southeast Asia.

Coastal area ecosystem services refer to the benefits that human society derives from coastal area ecosystems that include coastal seas, sea grass beds, coral reefs, estuaries, mangrove areas, and kelp, among others. UNEP (2006) and Duffy (2006) reported that in addition to the benefits that human society could gain from biodiversity, various services offered by the coastal area ecosystems could also be availed of by humans. Such services could be grouped into four categories, namely: provisioning, regulating, cultural, and supporting services (**Table 1**).

UNEP (2006) also indicated that a majority of the world's population lives in coastal areas and are dependent on coastal area ecosystems and the resources available within, for their livelihoods and existence (**Table 2**). The information in **Table 2** also suggests that majority of coastal people takes advantage of the services offered by coastal area ecosystems. However, the irony is, anthropogenic activities are threatening and risking the sustainability of coastal area ecosystems and their resources, more particularly through changes in land utilization, over-exploitation of the resources, illegal fishing activities, ineffective utilization of resources, and pollution and other impacts from a rapidly increasing population. The inadequate efforts by stakeholders to conserve the resources therefore needs immediate attention and should be considered an urgent issue to be addressed at the national and/or regional levels in order to sustain the services offered by coastal area ecosystems.

Furthermore, there is also a need to sustain the close relationship between resource utilization and conservation in order that the resources could continue to provide services necessary for people to survive, especially those in rural coastal areas (Ishikawa and Arimoto, 2008). Considering that no research studies had been carried out to evaluate the health of coastal area ecosystems corresponding to the services that the ecosystems offer for the benefit of humans, the collaborative project on "Coastal Capability Enhancement in Southeast Asia" therefore envisions to adapt the concept of "Area-Capability" to pave the way for the sustainability of the ecosystems and at the same time enhance the livelihoods of peoples in the coastal areas of Southeast Asia (Ishikawa, 2014). Yap *et al.* (2013) specifically outlined the approaches necessary for the development of Area-Capability Concept, *i.e.* natural

Table 1. Ecosystem services that could be provided by coastal area ecosystems

Major groupings	Estuaries and marshes	Mangrove forests	Lagoons and salt ponds	Inter-tidal zones	Kelp forests	Rocks and shell reefs	Sea grass beds	Coral reefs	Inner shelf
Biodiversity	X	X	X	X	X	X	X	X	X
Provisioning services									
food	X	X	X	X	X	X	X	X	
fiber, timber, fuel	X	X	X						X
medicine, others	X	X	X		X			X	X
Regulating services									
biological regulation	X	X	X	X		X		X	
freshwater storage and retention	X		X						
hydrological balance	X		X						
atmospheric/climatic regulation	X	X	X	X		X	X	X	X
human disease control	X	X	X	X		X	X	X	
waste processing	X	X	X				X	X	
flood/storm protection	X	X	X	X	X	X	X	X	
erosion control	X	X	X				X	X	
Cultural services									
cultural and amenity	X	X	X	X	X	X	X	X	X
recreational	X	X	X	X	X			X	
aesthetics	X		X	X				X	
Supporting services									
biochemical	X	X			X			X	
nutrient cycling and fertility	X	X	X	X	X	X		X	X

Sources: Adapted from Millennium Ecosystem Assessment as reported by UNEP (2006) and Duffy (2006)

science method to identify the key factors in maintaining ecosystem health and services; social and anthropological method to describe the patterns of resource use and how these could be linked to improved local livelihoods; and field research in collaboration with local people and government institutions to compile the information needed for the development of the concept. Once established, the "Area-Capability" Concept for the Southeast Asian region, the development of which is still ongoing, would be pilot-tested in the region to assess their adaptability and acceptability.

Table 2. World's population living in coastal areas

Coastal Area Ecosystem Sub-types	Estimated Population	Share of World's Population (%)	Share of Coastal Area Population (%)
Estuaries	1,598,940,542	24	27
Coral Reefs	710,583,010	11	12
Mangroves	1,030,295,102	16	17
Sea-grass	1,146,100,829	18	19
Others	610,883,710	9	10
TOTAL	**5,996,803,193**	**78**	**85**

Source: Adapted from UNEP (2006)
Note: Estimated population in 2006: 6,555,000,000 (PRB, 2006)

Development of the Area-Capability Concept

The Area-Capability (AC) Concept has been framed with the idea that the finite nature of natural living resources requires consideration and awareness by users so that the resources could be utilized in a sustainable manner. At the onset, socio-ecological studies involving value chain research have been carried out to evaluate the linkage between natural resources and human activities, where certain resources that are commercially utilized with the particular functions of such resources as income generators, are highlighted (**Fig. 1**). Considering that people living in coastal areas utilize various types of resources for several purposes, it is necessary to improve the ecosystem health of coastal areas in order to achieve sustainable development. Such broad-scale improvement is crucial since intensive utilization of a particular living resource could deteriorate nearby and other resources through ecosystem linkages, *e.g.* felling of mangroves destroys the habitats of coastal aquatic animals creating negative impacts on the natural fishery resources. As a consequence, resource shrinkage occurs aggravating the competition and conflict among resource users, resulting in loss of sustainability of the

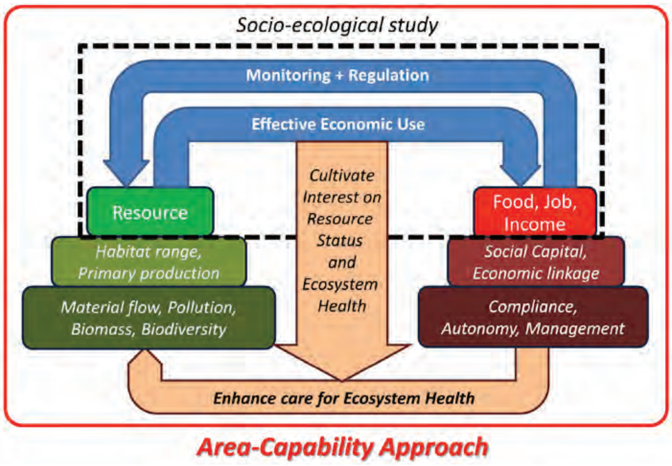


Fig. 1. Linkage between resource and food supply, income generation, and job opportunities established through socio-ecological study (black dashes) for the development of the AC Approach (the whole square) which encompasses not only the overall relationship but also the level of care for a range of habitats and the capabilities of user communities in caring the ecosystem health, including social capital and economic linkage

resources, a phenomenon which is known as the "tragedy of the commons" (Hardin, 1968).

While looking at ecosystem health in resource management, Smith and Maltby (2003) proposed an ecosystem approach in management but this entails collecting sufficient data to calculate the stock status for all species, which is an incredibly gigantic task, especially in coastal areas where the level of biodiversity is high. Moreover, determining an accurate assessment of the status of ecosystem health in an ecotone would be another challenging task due to high variability, since an ecotonal area often has higher density of organisms and greater number of species than in either flanking ecological community.

Nevertheless, in the development of the AC Concept, the main concern is to monitor the ecosystem health through the health status of habitats that comprise food webs and average trophic levels, range of the habitats, and the amount of primary production (**Fig. 1**). Furthermore, cultivating the interest and understanding of resource users on the importance of ecosystem health is another important aspect necessary for the development of the AC Concept.

Development of Socio-ecological Linkage

In order to establish the linkage between natural resources and people's livelihoods, the capabilities of user communities are evaluated. As community capability usually involves various functions, the various means of resource utilization, social capital related to compliance of management rules and regulations, and development of autonomous management skills are important factors considered in the design of the AC Concept. Based on the data and information collected, the kinds of "care" activities that are indispensable for maintaining and/or enhancing ecosystem health are generated, and the ways on how such activities should be undertaken to enhance the level of "care" in the minds and activities of resource users are crafted. The AC Concept recognizes the role of natural resources utilization because in a coastal area with high biodiversity (*i.e.* one that contains many target resources), resource users are able to monitor and obtain data regarding the status of the resources with respect to users' daily lives, and only the resource users could conduct activities with sustained care for protecting the resources.

Therefore, the ways and means of effectively monitoring the status of resources are required for the development of the AC Concept. In addition, using the results of monitoring and/or data collection, management systems could be established and/or improved in order that the resource users' compliance with regulations on management of the resources is enhanced. In this regard, participatory approach is highly required for the effective management of resources, especially in Southeast Asia which harbor high bio-cultural diversity. In the participatory approach, dwellers in coastal areas could use several resources and conduct care activities. However, preventing the over-utilization and abuse of the natural resources, and achieving a good balance between appropriate utilization of living resources and habitat protection should be given high priority.

Scientific Evaluation as a Collaborative Activity

In order to appropriately appraise the utilization of aquatic resources, especially those that show high levels of fluctuation, a detailed scientific evaluation is required. In this regard, collaboration between concerned rural communities and researchers is important in establishing the scientific evidence of sustainable development (**Fig. 2**).

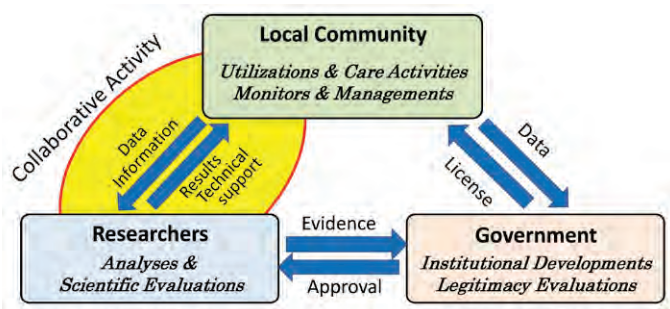


Fig. 2. Relationship between scientific evaluations by researchers and government support for community activities which is indispensable for the effective utilization of ecosystems services and fostering the care for ecosystem health by local communities

Moreover, considering that plans for expanding resource utilization and improving some commercial aspects of aquatic products would require approval and/or licenses, therefore, government support is also indispensable to promote and implement the participatory approach required for the AC Concept.

Thus, collaboration among the community, researchers, and government is another fundamental condition necessary for the development of the AC Concept (**Fig. 2**). The AC Approach focuses on the ripple effects of habitat health and community capability derived from communities' particular modes of utilizing the ecosystem services and/or conducting care activities for the natural resources to enhance ecosystem health.

If utilization of the ecosystem services is well balanced with user communities' care for ecosystem health, such utilization could be sustainable. The well-balanced linkage between utilization and care of resources is known as the AC Cycle, where researchers should also take the responsibility of evaluating the impacts of utilization and care activities on the habitat health as well as on social sustainability. Therefore, strategies aimed at facilitating spiritual and/or mind-set change of the users, including strengthening their pride and prospects of rural life, are equally important driving forces that would enable the AC Cycle to attain sustainable ecosystem service utilization (**Fig. 3**). If users do not foresee a future for themselves in rural areas for the long-term, they would not be able to recognize the importance of caring for the ecosystem health and achieving the sustainability of resources.

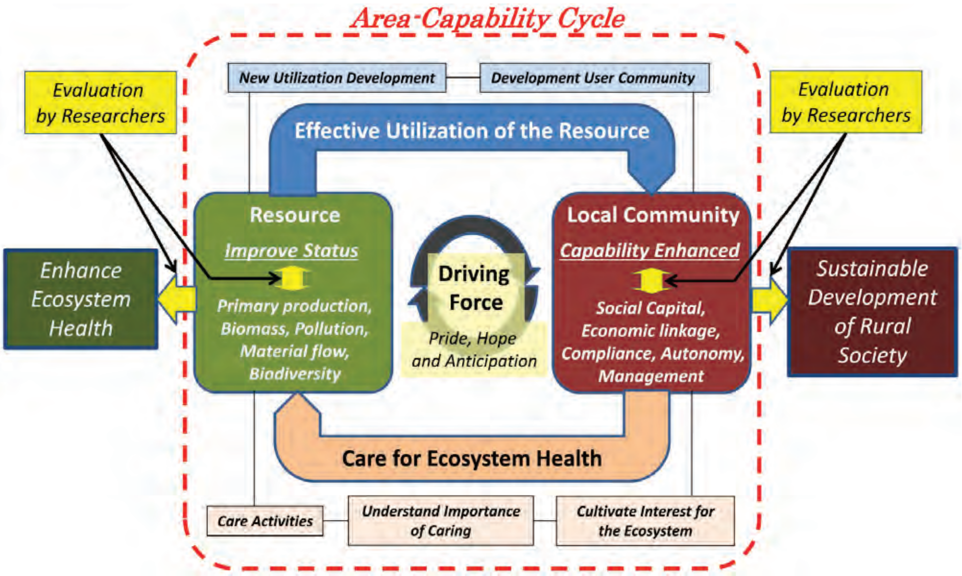
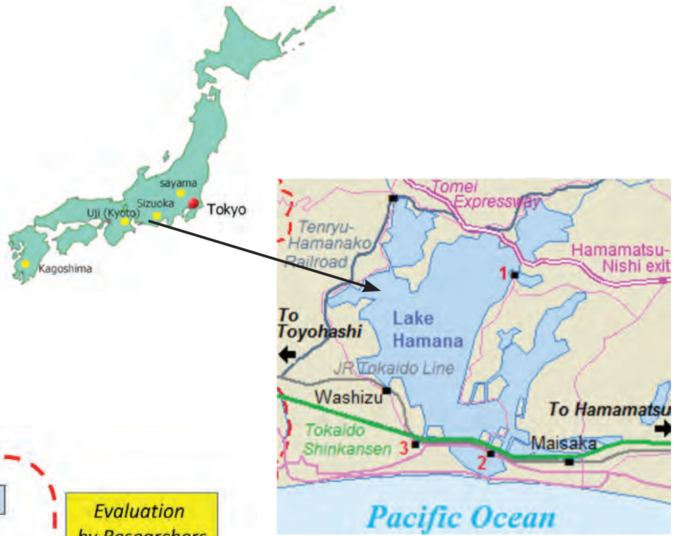


Fig. 3. Development of Area-Capability Cycle comprising the processes of finding new resource, effectively utilizing the resource, developing user community, enhancing users' capability, cultivating the interest of users on ecosystem health, understanding the importance of caring, promoting care activities for habitat and primary production of the resource, and fostering the pride and hope of users on their means of utilization and care of the ecosystem services

Applicability of AC Cycle: Case Studies

In an area around Hamana Lake in Shizuoka Prefecture of Japan, the collaborative activities of community members, researchers, and government have resulted not only in enhanced prawn stock but also cultivated social capital resulting in novel utilization of the ecosystem services. Hamana Lake was once well known for its rich and productive fisheries several hundred of years ago, but since the mid-1960s, the coastal environment had been drastically changed owing to infrastructure development following the change of the economic system of Japan. Since such environmental changes had consequent negative impacts on the fishery resources, and as one of the countermeasures to address the protests of affected fishers, the Government of Japan initiated a stock enhancement project and established a stock enhancement center in each prefecture, where each Prefectural Government was given a budget to conduct artificial breeding of juveniles and larvae for release and stock enhancement (Shigen Kyokai, 1983).



Map of Japan showing Hamana Lake in Shizuoka Prefecture

For Hamana Lake, kuruma prawn (*Penaeus japonicus*) was selected as the target species for stock enhancement, and a stocking center was established near the Lake. However, since there was no aquaculture technology for kuruma prawn established in the center while environmental data of the Lake was not available, the center was unable to determine the optimal release sites and time. Moreover, competitive fishing which was standard among the villages at that time prevented the sharing of information and development of collaborative mechanisms, so that statistical data on prawn catch rates was insufficient to start the stock enhancement project (Ogata, 2015).

Given such a situation, the intermediate aquaculture technology for the kuruma prawn was modified by adjusting it to the environment of Hamana Lake while information on the environmental and stock aspects of the Lake was compiled. During the first year of the prawn stock enhancement project, about one hundred thousand prawn larvae was released (Ogata, 2015), and on the second year, fishers from Shirasu Village located near the intermediate aquaculture site on the west side of Hamana Lake collaborated with researchers of the center and together released approximately three million larvae (Nippon Saibai Gyogyo Kyokai, 1986). The released prawns contributed to the increasing catch of fishers living in villages other than Shirasu, allowing them to recognize the importance of this type of release program for their livelihood. As a consequence, many fishers from all villages surrounding Hamana Lake joined the government stock enhancement project (Ogata, 2015).

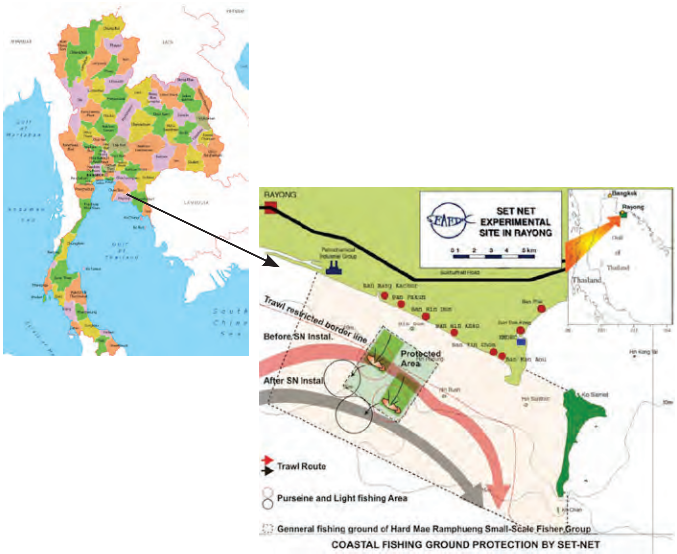


Fig 5. Map of Thailand showing the set-net site in Mae Ram Phueng Beach, Rayong Province (Adapted from Munprasit, 2010)

The project had succeeded in releasing 10 million larvae per year during the five-year project period, and the fishers participating in this project had reported increases in their catches, thus, ending the practice of catching small prawns from the wild (Ogata, 2015). Furthermore, the fishers also improved the system of selling prawns on their own, and after the Government's project was terminated, the fishers started their own prawn stock enhancement program, including intermediate aquaculture and release of prawn juveniles (Ogata, 2015). The linkage between the stock enhancement project and sequential changes of the community and resources, including the ripple effects based on the AC Cycle model is shown in **Fig. 4**.

Another case related to the development of the AC Cycle could be gleaned from the establishment of a community-based set-net fishery project in Rayong Province, Thailand by the Training Department (TD) of SEAFDEC. Since 2003, SEAFDEC/TD had been promoting the establishment of community-based set-net fishery as a tool for monitoring the resource status and management of fisheries in Rayong Province (SEAFDEC/TD, 2005; SEAFDEC/TD, 2008).

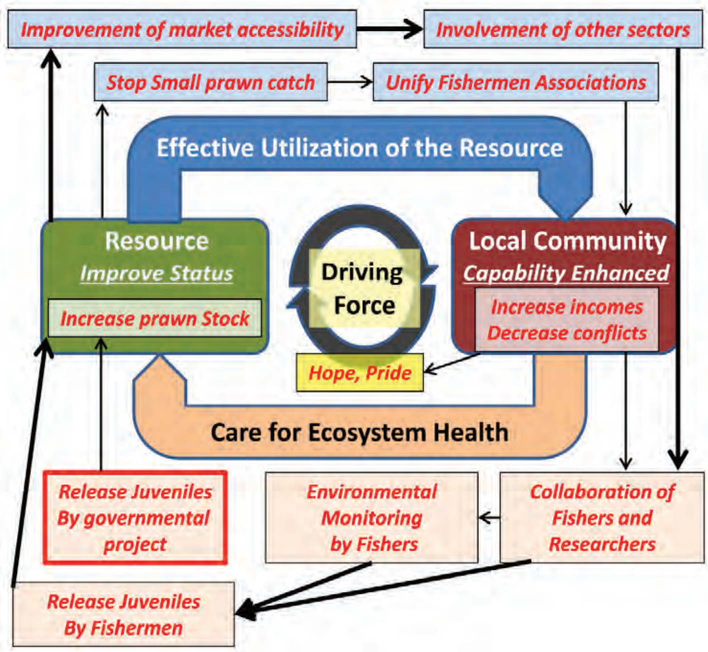


Fig. 4. AC Cycle model adopted for stock enhancement of kuruma prawns in Hamana Lake, Japan: from release of artificial larvae of kuruma prawns under a Government-sponsored project until the ultimate take over by fishermen's association after the Government-sponsored project had been phased out

In 2003, a new community was established through the SEAFDEC set-net project, to operate a set-net fishery, and the community has been distributing their fish catch at a community fish market at the beach adjacent to the set-net installations (**Fig. 5**). By pooling the receipts from their sales of fish, information and data on fish catch, sales, and operation costs had been precisely recorded. After launching the set-net fishery in Rayong Province, Thailand, the local fishers were able to catch a much wider variety of fish using a set-net than before. Starting in 2006, the fishers' groups were able to obtain complete independence in the operation and management of the set-net fishery and in selling their fish catch (Munprasit, 2010).

The skills acquired by fishers in fishery management and operations were then transferred to new community members. The impacts of set-net installations on the habitat health have been examined by assessing the water and sediment quality, fish catch compositions, and the average trophic level of each catch, and the results suggested no particular deterioration of habitat health (Khrueniam *et al*., 2014; Kon *et al*., 2014). In addition, a socio-economic study of the set-net fishery suggested a constant increase in the quality of the catches and incomes of fishers without notable increase in the fish catch (Manajit *et al*., 2011). Nevertheless, the AC Cycle of this particular set-net fishery was observed to have a weak linkage between care activity and improvement of status of fish stock, as there is no direct care activity for the resources and habitat health by the community. However, since set-net could act as nursery and refuge for juveniles and larvae for many aquatic organisms, and if this function is proven to be valid, then the set-net installation itself could be an example of good care activity for stock status.

In this regard, researchers should collaborate with fishers in the community and prove that set-net could function as nursery and refuge of fish stocks. If the set-net could take on the function of conserving the ecosystem, the AC Cycle of the set-net fishery would be completed as shown in **Fig. 6**. More importantly, it should be noted that the AC Cycle as indicated in **Fig. 4** and **Fig. 6**, could easily illustrate the compilation of all aspects of community activities including those activities that are still required in order to achieve sustainable utilization of the ecosystem services for rural development, in addition to the respective roles and responsibilities of each player (*e.g.* community members, researchers) in achieving the desired goal.

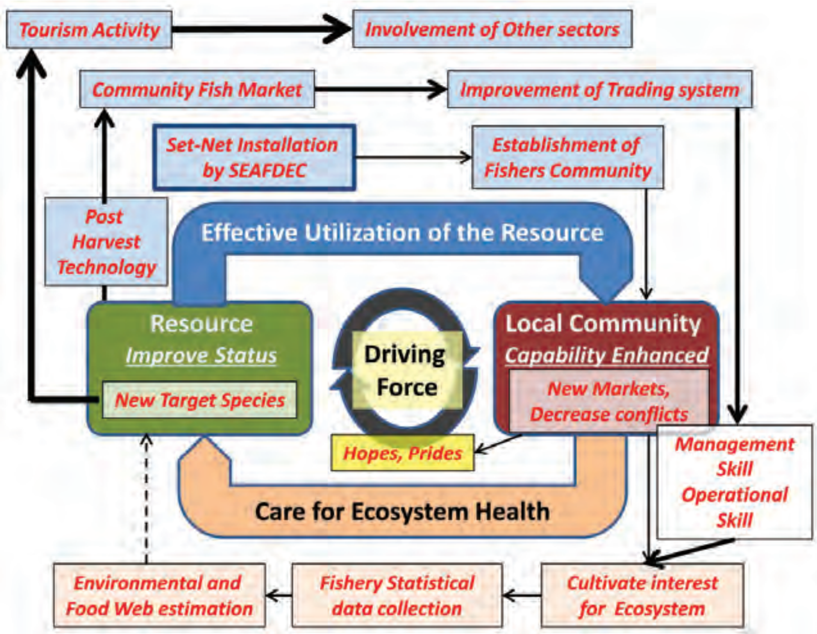


Fig. 6. AC Cycle of a community-based set-net fishery in Rayong Province, Thailand which started with installation of set-net by SEAFDEC/TD but since it does not show clear linkage between care for habitat health and resources, this case has been targeted for improvement through the adoption of the AC Approach

Way Forward

Based on several case studies, including stock enhancement at Hamana Lake, set-net fishery at Rayong Province, and other sites of the SEAFDEC-RIHN collaborative research project (*e.g.* eco-tourism at Ishigaki Island and Mikawa Bay, Japan, and stock enhancement in Batan Bay, Philippines), eight key elements and conditions would be necessary for the successful adoption of the AC Cycle (**Box 1**). These key elements should be treated as essential items for any rural development planning and activities, in order to achieve a sustainable future.

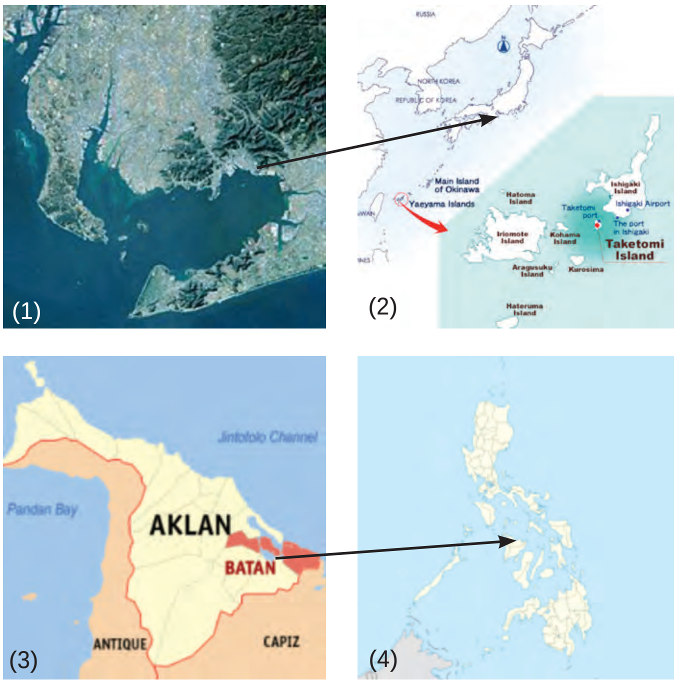
The unique features of coastal fisheries in tropical zones including Southeast Asia are their multiple species and

Box 1. Key elements and conditions to be considered in adopting the AC Cycle

1. Improvement and/or invention of utilization technology for ecosystem services
2. Development and strengthening of the community as a user group of the technology
3. Capability enhancement of community members through the utilization of ecosystem services
4. Cultivation of community interest for habitat health
5. Recognition of the importance and effectiveness of the care for ecosystem health
6. Promotion of care activities by the community with scientific evaluation
7. Improvement of stock status through the care activities conducted by the community
8. Strengthening the will of dwellers to remain in the area long-term while preserving nature

multiple fishing gears by nature, and are small-scale. This situation has been fostered by high level of bio-cultural diversity in the region, while the small stock size of each species also increases their vulnerability to intensive utilization. In addition, while human impacts on the environment had been increasing in recent years already affecting the global ecological system, any living resource is at risk of depletion due to regime shifts, even if placed under management and/or a traditional system of maintenance (Future Earth, 2013).

Therefore, adaptive utilization of natural resources, including changing methodologies and routine monitoring, with deep consideration of the ecosystem and its utilization features are required immediately and in the future. In this regard, the AC Cycle could serve as a concrete measurement tool. By applying the AC Cycle to each activity, it would be easy to examine whether or not an activity shows a good balance between utilization and care of resources. In other words, a specific activity and/or action that do not seem to achieve sustainable development could be revisited and revised by adopting the AC Cycle measurement, as exemplified in the set-net fishery system of Rayong Province of Thailand. Under conditions of high environmental variation and unexpected climate changes, increasing the potential of various ecosystem service utilization activities can help in supporting sustainable development in rural areas. In this regard, increasing the number of AC Cycles in each area is more important than establishing a system of monetary economic-scale expansion.



Other project sites of the SEAFDEC-RIHN collaborative project: (1) Mikawa Bay and (2) Ishigaki Island in Japan promoting ecotourism where environmental and ecosystem health assessments are undertaken based on the AC Cycle model; and (3) and (4) Batan Bay in the Philippines promoting stock enhancement where resource rehabilitation is carried out for sustainable coastal management and rural development in accordance with the AC Concept

The AC Concept and Approach are being developed by researchers from Japan and the Southeast Asian countries through this collaborative project spearheaded by SEAFDEC and RIHN. From the many case studies showing good practices of community activities in Japan and Southeast Asia, experiences could be gained and shared to help in extending the AC Concept for possible application in the region or even worldwide. Based on this collaborative project, it is expected that a balance could be struck between fishery resource utilization and conservation in order to achieve environmental sustainability and socio-economic stability. As soon as the SEAFDEC-RIHN collaborative project is completed in 2017, outputs useful for the Southeast Asian region could be generated as shown in **Box 2**.

Box 2. Outputs that could be generated from the SEAFDEC-RIHN collaborative project

- Inventory database and reference books on coastal fishery in Southeast Asia
- Inventory database and taxonomic field guide books on coastal resources in Southeast Asia, and population structure map of major marine fisheries target species in Southeast Asia
- Research protocol guidelines and reference books on ecosystem health assessment of coastal areas
- Research protocol guidelines and reference books on social aspects assessment of coastal areas
- Acoustic survey methodology and analysis systems for coastal areas
- Guidelines on community-based set-net fishery installation and utilization for coastal management
- Guidelines on community-based restocking activities for co-management of coastal resources
- Guidelines for Establishment of "Area-Capability Approach", through the human networking among SEAFDEC Member Countries

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