

UTILIZATION AND SUSTAINABLE DEVELOPMENT OF ISLAND MOUNTAINS IN CHINA^①

Zhang Yaoguang (张耀光) Yang Yinka (杨荫凯)

Institute of Marine Resources, Liaoning Normal University, Dalian 116029, P. R. China

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ABSTRACT: The island mountain utilization is a kind of mountain utilization. Although the islands cover little area, they can be used as the base of marine development. The sustainable development of island mountains is of significance to marine development. There are more than 6500 islands (including the South China Sea Islets) in China, and most of them are continental islands which are the extensions of continental mountains extent towards sea. For this reason, there are many hills but few mountains, the area of hills makes up more than two thirds of the whole land area. In order to keep ecological balance of islands, the utilization of island hills and mountains should take exploitation of forests as the main to conserve water source and water-sol, and forests become an important factor in keeping ecological balance and sustainable development of islands. At the same time we should make good use of forests through setting up forest nature protecting area and forest parks and developing forest tourism.

KEY WORDS: islands in China, island mountains, mountain utilization, sustainable development

There are many “high mountains” and “low hills” sticking out of sea on the continental shelf. These mountains and hills are sea islands.

There are more than 6500 islands in China, most of them are continental islands which are the extensions of continental mountain extent towards the sea. For example, Changshan Archipelagoes in Liaoning are the extension of the Changba Mountains, and Zhoushan Islands are the extension of the Tianta Mountains towards northeast to the sea. Both Taiwan Island and Hainan Island were linked with the continent during the geological period. During the period from the end of Paleozoic Era to Mesozoic Era, the Pacific Plate collided with the edge of the continent, the violently folded earth's crust stuck out of the sea, then Taiwan Island came into being. As to Hainan Island, it departed from the continent during the late Quaternary period when there happened approximate east-west tension rift.

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I. CHARACTERISTICS OF ISLAND MOUNTAINS IN CHINA

1. The Size and the Altitude of Island Mountains Being Related to the Area of Islands

At the Sea World Symposium on Man and the Biosphere of small islands held in Puerto Rico in 1986, the concept of small islands was presented. The island whose area is less than $10\,000\text{ km}^2$, and population is less than 500 000 is called small island (UNESCO, 1990.). According to that, in China, only Taiwan and Hainan Island are big islands, the others belong to small islands.

Taiwan Island is the biggest island in China, covering an area of $3.57 \times 10^5\text{ km}^2$ (Shi, 1973), its mountain area makes up two thirds of the whole island area. There are 62 mountains whose altitudes are more than 3000 m. They run through the centre of the island (where the altitude is not less than 500 m is unfit for farming, but fit for growth of all kinds of woods).

Hainan Island is the second biggest island in China. Its area is $3.39 \times 10^4\text{ km}^2$. In whole islands the mountains whose altitudes are not less than 500 m make up 25 percent, and the hills whose altitudes vary from 100 m to 500 m make up 13 percent. The Wuzh Mountain is the core of the island, and there are 667 mountain peaks being more than 1000 m on it. The height of mountains decreases from the middle part to the edge, and appears ring structure. In the middle-south there are mountains not less than 500 m, outside decreasing to 500–100 metres hills, and then to tableland and plains whose altitudes are less than 100 m.

In China, most continental islands consist of archipelagoes. There are many hills with few mountains. On the average the area of hills makes up more than two thirds of the whole island area, and the average altitude of the hills is 200–300 meters. Mountains whose peaks are more than 400 meters high include Guolao Mountain (576 m) and Dajian Mountain (587 m) of Nan'ao Island, Junshan Mountain (436 m) of Hatan Island in Pingtan. On other islands, mountain peaks are less than 400 m above sea level (see Table 1).

2. Forest Land—the Main Soil Resource of Island Mountains

Among the island soil resources of China, the area of forest land makes up 20–30 percent of land area on an average, but the proportion of the forest area to total forest land area is relatively high.

In China, the forest land area of main islands is $3.029 \times 10^4\text{ km}^2$, being about 41.1 percent of the island land area of $7.373 \times 10^4\text{ km}^2$ (the area of the whole country's islands is $8 \times 10^4\text{ km}^2$, among them, there are numerous fragmentary small islands whose area is $0.627 \times 10^4\text{ km}^2$ scatter in coastal provinces, and they don't belong to the islands of islands countes), while the forest area is $2.015 \times 10^4\text{ km}^2$, being 66.5 percent of the total forest area.

Both Taiwan Island and Hainan Island are the main distribution region of island forest land

Table 1 General situation and forest land area of island mountains in China

Island	Forest land area (km ²)	Proportion of forest land area to total land area (%)	Forest area (km ²)	Proportion of forest area to total forest land area (%)	General situation of island mountains	Altitude of the highest mountain peak
Taiwan	18700.0	52.4	10752.5	57.5	Mountainous area takes 2/3, and there are 23 mountain peaks being more than 3500 m above sea level.	The main peak of Yushan mountains—3950 m, the highest peak in the east of China.
Hainan	10727.0	31.6	8666.7	80.8	Mountains (higher than 500m) takes 25 percent	Wuzh Mountain—1867 m
Minor total	29427.0	42.3	19419.2	66.0		
Zhoushan Islands	463.5	33.6	423.0	91.3	Mostly hills, taking 70 percent.	Huangyang Mountain—504 m
Changshan Islands	54.3	28.3	40.7	75.0	Average altitudes 200 m, and hills takes 70 percent of the whole island area.	Kunangding of Ha yang Island—379 m.
Mao dao Islands	23.1	41.3	14.8	64.1	Average altitudes 100–200 m, hills take 70–80 percent.	The main peak of Daqan Island—202 m, the main peak of Gaoshan Island—203 m.
Dongtou	46.2	32.2	35.1	76.0	Mountainous land and hilly area takes 90 percent, average altitudes less than 200 m.	Yandun Mountain on Damen Island—392m, the main peak of Nyu—332m.
Yuhuan Island	56.3	24.2	43.7	77.6	Average altitudes 200 m. Mountain land and hilly area takes 52 percent.	The main peak of Tanluo Mountain—361 m.
Haitan Island	82.0	22.0	76.8	93.7	Average altitudes 200 m, high hilly area takes 51 percent.	The main peak of Junshan Mountain—436 m.
Dongshan Island	60.7	24.6	52.3	86.2	Average altitudes over 100 m, and hilly area takes 50 percent.	The main peak of Sufeng Mountain—274 m.
Nan'ao Island	74.4	68.0	44.3	59.5	Altitudes 200–300 m, and hilly area takes more than 80 percent.	Guolao Mountain in the east—576 m, and Dajian Mountain in the west—587 m.
Minor total	860.5	31.5	730.7	84.9		
Total	30287.5	41.1	20149.9	66.5		

Based on the relevant data of literatures (Ma, 1987; Wu, 1993) and county annals of island counties.

resource. In the early years, the forest area of Ta wan made up two thirds of that of the whole island. In the 1970s, the forest area was still 55 percent of the whole island area, and timber storage reached $1.8 \times 10^9 \text{ m}^3$. This island is one of the important wood growing areas.

Among the forest land of Ha nan Island, there are 5820 km^2 of natural forests, being 67 percent of the forest land area, and 2847 km^2 planted forests being 33 percent of the forest land area. Natural forests are mainly distributed over mountains and valleys 500–1500 m above sea level. The forest land being less than 500 m has been damaged seriously, and mostly has developed into hillsides covered with bush and grass. Low forests at the height of 1500 m on mountain peaks only have the effect of water and soil conservation. Ha nan Island basically belongs to the tropical monsoon forest region, so the rainfall varies with the season obviously, and rainstorms happen frequently. Once forests are damaged, it is very difficult to recover them for the re-ecosystems.

Both Ta wan Island and Ha nan Island have high altitude, and forest distribution presents vertical change. But Zhoushan Archipelagoes and other islands are low, so forest distribution mainly presents horizontal variation among islands. From Nan'ao Island of Guangdong eastward and northward to M aodao Archipelagoes and Changshan Archipelagoes, in the north part, the climate appropriately varies from the tropics, the subtropics and the warm temperate zone. Simultaneously, the amount of precipitation decreases from 1300–1400 mm to 500–600 mm. The average annual temperature drops from $21.0 \text{ }^\circ\text{C}$ to $10.5 \text{ }^\circ\text{C}$, and the main forest type varies from the transitional tropical monsoon to deciduous broad-leaved forest of warm temperate zone. Among them there are both the trees acclimating to fit for local climate and those widely distributed. Now they are mostly planted forests, with only a few natural forests.

3. The Problem of Soil Erosion of Island Mountains

There is also improper utilization of island mountains. Taking Ta wan Island as an example, now the utilization of mountains is developing from the situation taking forests as the main to diversify utilization, and excessive reclamation and building on hillsides has resulted in serious soil erosion. Besides, there are plenty of rain, high mountains, and precipitous hillsides, so soils are washed out seriously. Without conservation of forests water and soil would be washed away heavily. The area of natural forests in Ha nan Island has been decreased by two thirds because of continuous cutting.

Although a number of planted forests and rubber forest are planted on the spot, the effect on ecology isn't so good as that of natural forests. The main reason is that mountains in the middle part, where forest once scattered, are the source of main rivers of islands. Once these water conservation forests are damaged, soil erosion will undoubtedly be aggravated.

Other islands are also facing with the problem of soil erosion resulted from the decreasing of forest area.

II. SUSTAINABLE DEVELOPMENT OF THE EXPLOITATION OF ISLAND MOUNTAINS

1. Island—the Confluence of Two Large Fragile Ecosystems

This refers to the confluence of the fragility of island mountain ecosystems and island's ecotope itself.

Islands (especially islets) feature small area, simple geographic structure, lower index of diversity of organism, and poor stability (Zhang *et al.*, 1993). Consequently the scope we can choose for the sustainable development in ecology and economics has some limits. For example, on islands even a small amount of felling forest can lead to soil erosion; if the population increases a little, that will make influence on ecological and social aspects. Therefore the sustainable development of island mountains is integrated with that of islets themselves.

2. Diving Mountain Utilization Area in Line with The Characteristics of Island Mountains

Through diving mountain utilization areas, we can rationally use island mountains in the light of the local conditions. Taiwan and Hainan, these two islands can be divided according to the regional factors, utilizing characteristics and development tendency because their areas of mountainous region are very large.

2.1 Mountain Utilization of Taiwan Island

1) Middle mountain area—forests, fruits and vegetable base. This area mainly comprises the mountain and hilly land in Taichung, Nantou, Gaoxiong and Pingtung counties, in the most tropical or subtropical climatic zones. The proportion of its mountain area to the land area of the total island is 45 percent. So it is suitable for growth of forests. According to the principle of “depending on mountains and forests, being suitable for local conditions and trees”, in order to increase the production efficiency of woodland we should select some regions to set up a number of forest, especially quick grown high-yield forest. Moreover, with the purpose of increasing the integrated development benefit, we should take advantage of vertical variations in this area, and establish the base of spruce vegetable and fruit-trees (Wu, 1993).

2) The east mountainous and hilly land—dry farming and forest region. This region comprises Yilan, Hualien and Taidong counties etc. These mountains run from south to north. Its length is about 170 km, and broadness is 15 km or so, but hills and longitudinal valleys distribute here and there. Most of the forests are broad-leaved forest, mixed with some bamboo groves occasionally. Management of farmland is mainly dry-farming. This region still has certain exploiting potential, so we should add some water irrigation facilities, reinforce water and soil conservation, devote major efforts to developing cultivation of fruit-tree, and take the road of integrated development of forests, farming and fruits (Wu, 1993).

2.2 Mount in utilization re of H in n Isl nd

1) The area of middle-low mountains and higher hills in the middle island——valuable timber forest nature protecting area. This region includes mountains and hills whose altitudes are not less than 300 m. Its area makes up 30–35 percent of the total island area. In the past it was covered with tropical natural forest, mostly Selva or Monsoon forest. Now, here is one of the few tropical forest bases in China. In this region plant species are abundant, including about 550 kinds of endemic species, 40 species of precious trees, over 160 species of other high commercial value trees, more than 1000 species of medicinal plants, 70 species of world plants, and about 105 species of wild animals, among which 23 species lives only in Hainan Island (e.g. *Hylobatid egibbons*), which is playing a great role in keeping the whole island's ecological balance, and in safeguarding the production of agriculture, rubber and tropical crops. From today on we should make closed forest and keep the ecological balance of tropical forests (Wu, 1993).

2) Lower mountain and tableland area for rubber, tropical crops, elementary crops, cash crops and commercial forests. Its area makes up 38 to 40 percent of that of Hainan Island, most are secondary forest land. For the altitude less than 300 m, basins, valleys and tablelands interleave. Uncultivated land resource is rich. Soil is fertile and easy to reclaim, and suitable for the growth of rubber or tropical crops. Therefore it is the key area for exploiting land resource. Now in Hainan Island, over 80 percent of rubber land is distributed in this region, and it will be the main base of rubber in the future (Wu, 1993).

2.3 Zhoushan Islands, Chongshanshan Islands and other islands ——water-source protecting and water-soil conservation forest re .

These islands are narrow and small, with little catchment area and short streams. Consequently precipitation will run into the sea quickly, and rain water reserves becomes much less. For example, Nan'ao Island, the area of mountain and hill are near, with a slope of 25° – 35° . There are many valleys, but mountains are high, and rivers are short, valleys whose catchment area is not less than 5 km^2 are few. So it is difficult to intercept runoff. Therefore water resource becomes a constrained element in exploiting and developing islands. This demands to develop water-source protecting forest and water-conservation forest to solve this problem. These islands are not mainly for cutting forest and farming, but should be used for properly developing economic forests such as fruit trees.

3. Forest ——An Important Element of the Ecological Balance and Sustainable Development of Islands

Forest is a principal part of island mountain ecosystem. In islands the catchment area is small and fresh water is short, so forest plays an important role in conserving water source. Therefore we should set up large area of island water-source conservation forest, water conservation forest, shelter forest and economic forest to make a multilayer organic system and reach

the un son of ecō-benef t, soc al benef t and econom c benef t.

In forests ra nwater s ma nly caught by tree-crown. At a certa n ra n fall ntens ty, ra nfall caught by tree- crown of oak s 31. 1 percent, that of acac a s 30. 1 percent, wyxhelm 23. 0 percent, and Ch nese p ne 22. 4 percent. Bes des the l tter can protect the earth' s surface, reduce or control surface runoff, play ng the role of conserv ng water source and of preserv ng water-so l. Generally speak ng forests can make 50- 80 percent of ra nfall soak nto the ground and be stored. The water stored by a forest w th an area of 3000 ha s equal to that stored by a reservo r w th a storage capac ty of $100 \times 10^4 \text{ m}^3$. The average water amount caught by forests s $5 \times 10^4 - 20 \times 10^4 \text{ t/km}^2$.

Therefore, the forests have a great effect on solv ng the problem of the shortage of fresh water on slands.

4. Sett ng up Forest Protect ng Area, Forest Park and Develop ng Forest Tour sm

In the past the conservat on of pr meval forests of slands s rather perfect. But because of deforestat on the reserves s very few now. The value for tour sm, wh ch s prov ded by sland forests, w ll far exceed ts value as t mber. Therefore, we should keep certa n areas of secondary forests as nature protect ng area at d fferent alt tudes n a planned way. The product ve value wh ch s d rectly prov ded by these secondary forests may be not very great, but these secondary forests have the cond t ons on wh ch t can evolve nto near pr meval forests, and makes advantages for the protect on and development of some endangered spec es. On the contrary, f these secondary forests are all recla med to cult vated land, plantat on and planted forest, th s poss b l ty w ll disappear.

Nature protect ng area of forest or w ld an mals s often set up n typ cal forest ecosystem reg ons, the hab tat and breed ng place of rare spec es, and those accentedly protected by nat on n d fferent zones. It has been proved by pract ce that where the nature protect ng area s set up, where the natural env ronment and resources are effect vely protected.

Accord ng to the gross stat st cs of 1993, there are 97 nature protect ng areas (ma nly mu t ple-type) n ma n slands of Ch na, cover ng an area of 560 243 ha or so (see Table 2). These nature protect ng areas are mostly d str buted n Ta wan and Ha nan Island. In Ta wan Island the area of nature protect ng reg ons s 425 083 ha, mak ng up 75. 9 percent of nature protect ng area on slands, and Ha nan Island takes 18. 5 percent. As to protect ng type, the area of nat onal forest parks s 327 782 ha, mak ng up 58. 5 percent, that of forest conservat on area s 130 864 ha, mak ng up 23. 4 percent. In fact these two types both belong to forest protect ng system. From th s po nt we can see the mportance of forests n sea slands.

Forest conservat on areas of Ta wan mostly are that of broad-leaved forest, such as *Cyc s t iw ni n*, *Keteleeri formos n*, *Amentot xus formos n*, *S ss fr s r nd iensis*, Or g nal masson p ne and Or g nal fragrant cypress as well. Some of them have comprehens ve features, nclud ng the protect on of w ld an mals, rare an mals and some natural landscape. On

the other hand, Songtao water-resource nature protect ng area, Shahe water-resource nature protect ng area, pr imeval forest nature protect ng area and protect ng area of mangrove forest ecosystem as well have been set up n Zhanzhou of Ha nan Island.

Table 2 The nature protect ng areas of ma n slands n Ch na

Region	Nat onal forest park (ha)	Forest conservat on (ha)	Birds conservat on (ha)	Others (ha)	Total (ha)	Protect ng area (number)
Total	327782	130864	32417	69180	560243	97
Ta wan	318427	98242		8414	425083	51
Ha nan		32622	10156	60690	103468	39
Nan' ao	1200				1200	1
Dongshan	780				780	1
Yuhuan	175				175	1
Zhoushan			17		17	1
Changdao			5320		5320	1
Changha	7200				7200	1
Shedao						
Laot eshan			16924	76	17000	1

Note: Based on the data of on-the-spot invest gat on on sland count es n Ch na and the Name Index of nature protect ng areas n Ch na, *N ture*, 1995, (1- 5).

Many nature protect ng area of birds are set up on slands, espec ally Changdao-Shedao, Laot eshan nature protect ng area. Some sland migratory birds, wh ch dwell at the Changba Mounta ns, the X ao H nggan Mounta ns, grasslands of Inner Mongol a and S ber a, w ll fly across Shedao, Laot eshan and M aodao slands to the Yunnan-Gu zhou Plateau dur ng September and October every year. And they w ll fly across these areas to the north dur ng March and Apr l the next year. These sland migratory birds can be d v ded nto two types. One s the bird of prey wh ch migrates dayt me and perches n ghtt me. The other s the bird of sparrow wh ch migrates n ghtt me and perches dayt me. These birds totally conta n 18 orders, 54 fam les, 60 species, and amount to 100 000 or so, mainly are *Grus japonensis*, *H li eetus lbicill*, *Aquil heli c*, *Cygnus*, *P ndion h li etus*. Human, birds and forests have a close relat on —“People love birds, birds protect forests, forests conserve water, and water benef ts people”.

Tour st resources of sea slands themselves are very r ch, espec ally landforms of mar ne abras on, mar ne deposit and gran te eolat on of Nan' ao, P ngtan and Putuo Mounta n are more typ cal. If they comb ne w th the oas s n the sea, the scenery w ll become more fasc nat ng.

Forest parks of slands have d fferent ranks. Changshan slands forest park s a nat onal forest park tak ng the whole county as ts scope. Huanghua Mounta n forest park of Nan' ao Island s only one part of the sland. The forest park of Ch shan forestry centre n Dongshan county and Dalu Island forest park n Yuhuan county only take an slet as scope. And there are

Kend ng, Yushan, Yangm ng mounta n and Taluge park n Taiwan.

Forest tourism which has some ecological features has made great development all over the world in recent years. According to the statistics, through the whole world the person-times visiting forest parks reached 3.9×10^8 in 1993, and might break 5.0×10^8 in 2000. The income of forest tourism in Latin America, where forest tourism started much earlier, has taken 90 percent of the total tourism income. In Brazil there are 13 national organism protecting areas and 23 national parks. Now they have been developed as tourist attractions. In China forest tourism now appears as an upsurge. It is reported that tourists received by forest park increased from over 1.0×10^6 person-times in the early 1980s to 1.0×10^7 person-times in the late 1980s, and hit 3×10^7 person-times by 1994.

There are not only plentiful nature scenic resources, but also many human resources of islands in China. Most islands have mountain-sea or mountain-forest scenic spots with a unique style in boundless ocean and blue waves. We can develop healthy and free tourism of "Sunshine, Sandy beach, Sea water", and many ecological touring activities, such as forest sightseeing, forest hunting, forest exploring and scientific inspection as well, can be organized on islands too. This kind of tourism can not only make people "return to nature", but also protect island forest ecological system.

From all these mentioned above, we can see that island mountains are only a small part of vast mountainous regions in China, but they are also one type of mountain utilization patterns. Because of the special geographical position of islands, which will be regarded as an important base in the future process of exploiting marine resources. It goes without saying that it is very important to keep the integrity and sustainable development of island mountain ecosystem, which is looked as the heart of islands.

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