

CHINESE-AMERICAN
JOINT COMMISSION ON RURAL RECONSTRUCTION

Forestry Series: No. 5

LAND USE CONDITIONS IN TAIWAN

By

Emile C. H. Hsia



TAIPEI, TAIWAN, CHINA

JULY, 1957

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FOREWORD

Land is the only asset that is capable of continuously producing foodstuffs and raw materials for Taiwan's teeming millions and growing industries. But this renewable resource of land will rapidly diminish unless its utilization is properly planned and carefully managed so that the capabilities and limitations of land are fully recognized and its conservation needs timely met. An intelligent and progressive program for wise land use would not be possible without first making a thorough appraisal of the physical conditions of the land and the major factors that influence its productivity.

The land use phase of the Land Use & Forest Resource Survey of Taiwan (LUFRS) is an overall study of present use conditions of land and its problem areas with reference to soil conservation needs on the main island of Taiwan. It does not cover any of the other 77 outlying islands. The data were collected primarily for the purpose of determining the relative intensity of hazards confronting the present use patterns of the limited land resource and the desirable degree of emphasis to be placed on the application of soil and water conservation practices for perpetuating production from land.

The relative importance of present use patterns and factors determining the problem areas of land may change from year to year or decade to decade, but the influence of those factors is a continuing one and they will inevitably shape the pattern of future Taiwan. In this island-wide stocktaking, the emphasis is placed on the lessons which the past, particularly the immediate past since World War II, may have for the future in the utilization and conservation of land.

The information derived from analysis of the survey findings may be of special use in dealing with the following questions concerning the promotion of food and agricultural production in Taiwan:

1. How and where on the island should and can more food be produced for its rapidly growing population?
2. Should certain land areas go back to forest or be kept in agriculture crop production with intensified measures to husband the soil?
3. What and where are the major hazards seriously affecting agricultural production?
4. Are there any non-productive lands on Taiwan? How much and where? What should be done about them?
5. What relationship does ownership of land have to the land use and soil conservation program?
6. What crops or farming practices are causing the most rapid soil deterioration? How and where?
7. Is lack of grazing ground seriously handicapping the development of livestock husbandry? How extensive are the grasslands on the island?

8. What and where are the water areas? Can productive uses be made of them?
9. How are the conditions in the vital watersheds upon which the entire island depends for power, electricity, urban and industrial water supply, farm irrigation and above all, the stability in waterflow so that minimum damage may be suffered by the nation in flash floods, drouths etc?
10. What should be the land use planning in the nonforest areas such as coastal sand flats, sand dunes, alluvial wastes and other denuded land forms?
11. What is the scope of problems confronting a progressive land use readjustment program for Taiwan?
12. How and where should similar but more intensified surveys be made at minimum cost and with maximum utility for promoting agricultural production?

This is the first time that aerial survey techniques and modern photogrammetrical methods have been employed in this part of the Orient in a combined survey of forest and land use conditions. It was only through the close cooperation and full support of the administrative, educational and research agencies on the island particularly the Taiwan Forest Administration, Provincial and National Agricultural Colleges and the Taiwan Forest and Agricultural Research Institutes and others that the Joint Commission on Rural Reconstruction could successfully conduct this survey. This island-wide land use study represents, perhaps, a typical example of the overall programming activities in postwar Taiwan needed to be jointly undertaken by these agencies just mentioned.

Technical assistance and training to the local forest and agricultural personnel participating in the survey was provided by the U. S. Forest Service, Ministry of National Defense, Chinese Air Force, Combined Service Forces and the U. S. Military Assistance Advisory Group, Taiwan rendered assistance in various ways which all greatly facilitated the survey project.

ACKNOWLEDGEMENT

The Joint Commission on Rural Reconstruction wishes to express appreciation of the cooperation lent by the Provincial Department of Agriculture and Forestry, the Taiwan Forest Administration, the Taiwan Forest Research Institute, the Taiwan Agriculture Research Institute, the National Taiwan University, the Provincial College of Agriculture in their furnishing technicians to the Survey Team, providing information and offering suggestions during the course of the work.

Special credit is due to the Chinese Ministry of National Defense and the Chinese Air Force in taking the aerial photographs on the sampling strips of Taiwan from which the basic statistics were compiled, the Combined Service Forces in printing 1/50,000 and 1/250,000 forest resource and land use maps, the Bank of Taiwan in helping card punching, sorting and tabulation for compilation work, and MAAG in furnishing the basic maps as well as in loaning camping equipment.

Grateful acknowledgement is also made to the members of various agencies from whom much helpful data and information were obtained. Special thanks are due to all those who helped in reviewing the manuscript of this report and offered suggestions of great value.

MEMBERS OF LAND USE & FOREST RESOURCE SURVEY TEAM

George E. Doverspike, Project Leader
Earl J. Rogers, Assistant Project Leader

<u>Agency</u>	<u>Forest Inventory</u>	<u>Land Use Inventory</u>	<u>Cartography</u>	<u>Compilation</u>
<u>U.S. Forest Service</u>	M. B. Bryan		S. E. Webb	S. R. Johnson
<u>Joint Commission on Rural Reconstruction</u>		E. C. H. Hsia	C. W. Yang C. H. Liao	
<u>Taiwan Forest Administration</u>	S. S. Chang J. P. Hsu K. L. Lai T. N. Liao T. L. Lin Y. H. Lin L. Y. Liu T. T. Shih T. Y. Wang H. C. Yuan	M. H. Tsou	C. Y. Hsu C. L. Huang C. S. Lai C. T. Lin	(L. Y. Liu)
<u>Taiwan Forest Research Institute</u>	C. C. Koh C. K. Wang B. Y. Yang			P. L. Yang
<u>Taiwan Agriculture Research Institute</u>		Y. S. Puh		
<u>Provincial Department of Agriculture and Forestry</u>		J. M. Huang		
<u>National Taiwan University</u>	K. Y. Tai K. M. Tsai T. C. Wang			(T. C. Wang)
<u>Provincial College of Agriculture</u>		M. C. Tsai		
<u>Chinese Air Force</u>		C. C. Hsieh		
<u>Chinese Combined Service Forces</u>		C. Y. Chen K. C. Chen Y. J. Kuan S. S. Shuai		
<u>Taichung Hsien Government</u>		M. C. Liao		

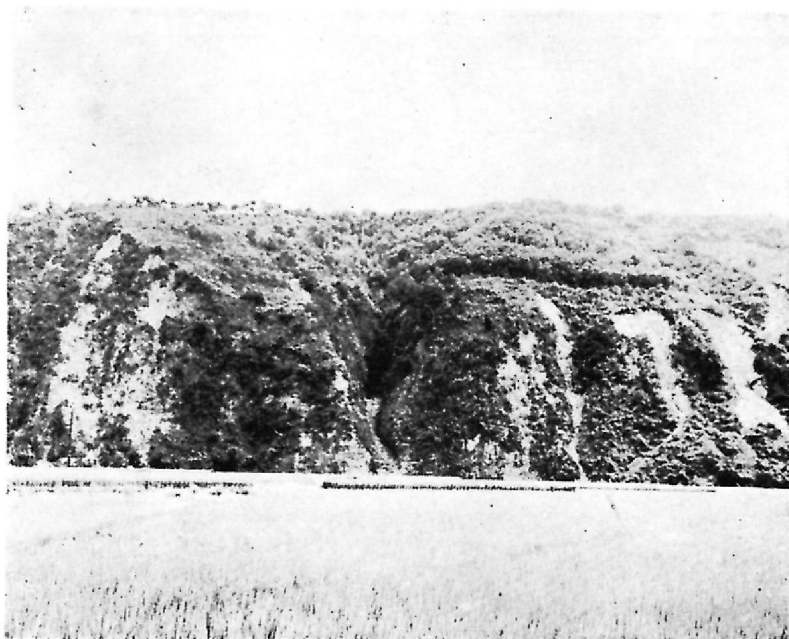


Roots of tea plants are exposed after soil is depleted.

Banana plantations and big gully above highway near Shui-li, Nanton Hsien.



*Land slides and gullies
on tableland.*



*Gully forming in citronella
plantation, Miaoli Hsien.*

IV. LAND USE CHANGES IN RECENT YEARS.

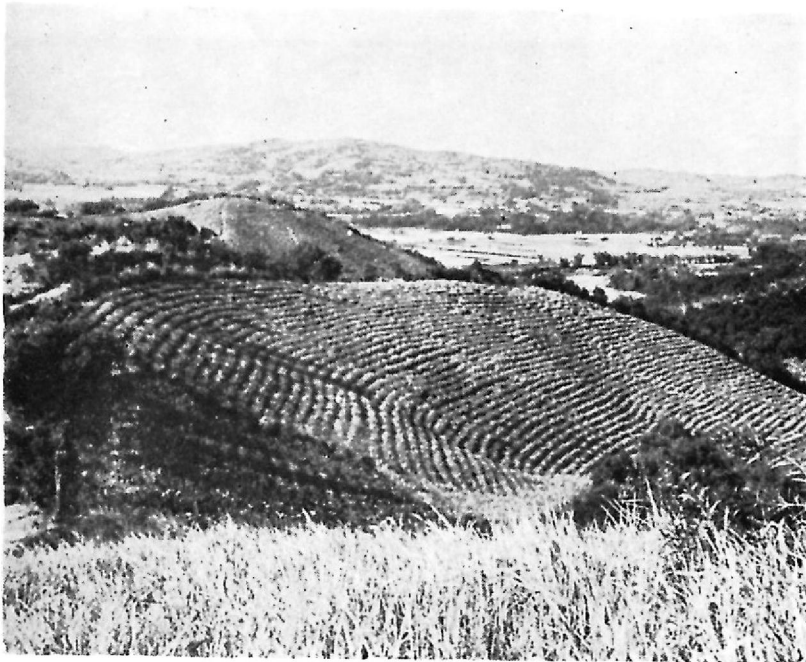


Cash and food crops invading forest land is one of the significant land use changes in recent years of Taiwan.

From brush land to dry farming: Native tea plantation.



*Hardwoods changing to
bamboo stands is one
of the recent land use
trends.*



*From grassland to
citronella plantation.*

V. GOLDEN DAWN OF WISE LAND USE AND SOIL CONSERVATION WORK



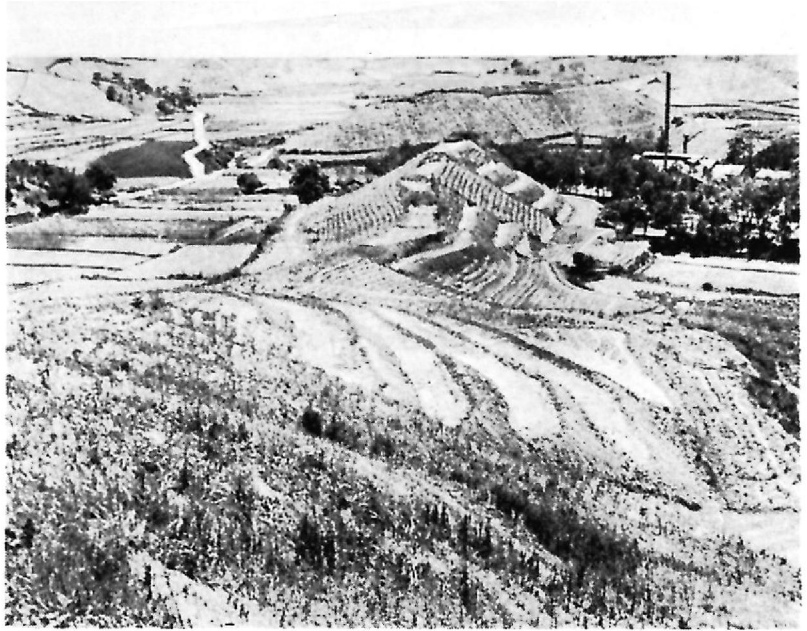
Young tree plantation on slopes. Rice and other crops on terraced land. Showing good land use.

A typical view of good land use.

Note the hillsides fully covered with trees and productive plain well protected by windbreaks.



More bench terraces are being built for growing upland crops.



Pineapple soil conservation demonstration plantation in Ta-shu, Kaohsiung Hsien.



*Hillside ditch and mulching
in young pineapple planta-
tion at Taitung*

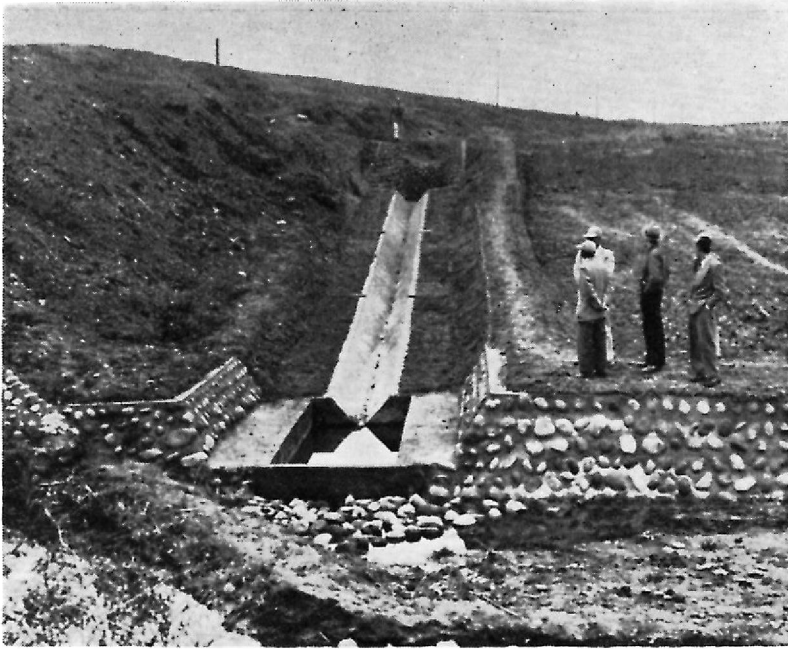
*Terraced land, if irrigation
water is available, can
produce more rice for the
increasing population.*



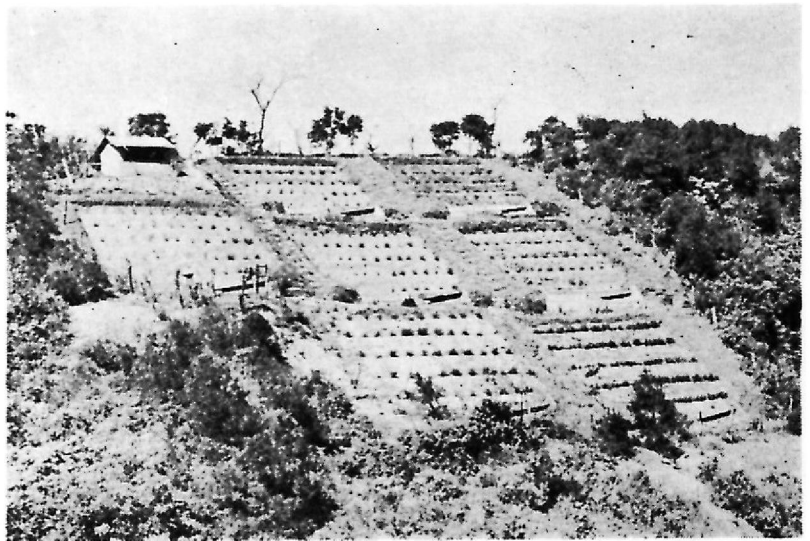
Soil conservation trainee demonstrates "Fresno Scraper" for terracing on gentle slopes.



Drop structures made to control the run-off water.



Close-up view of water disposal chute.



Soil and water run-off plots at tea experiment station.

*Erosive hills are being
planted back to forest.*



*Trees growing on steep
slopes not only protect
the soil from erosion but
also give considerable
cash return in the near
future.*

I. INTENSIVE LAND USE IN TAIWAN

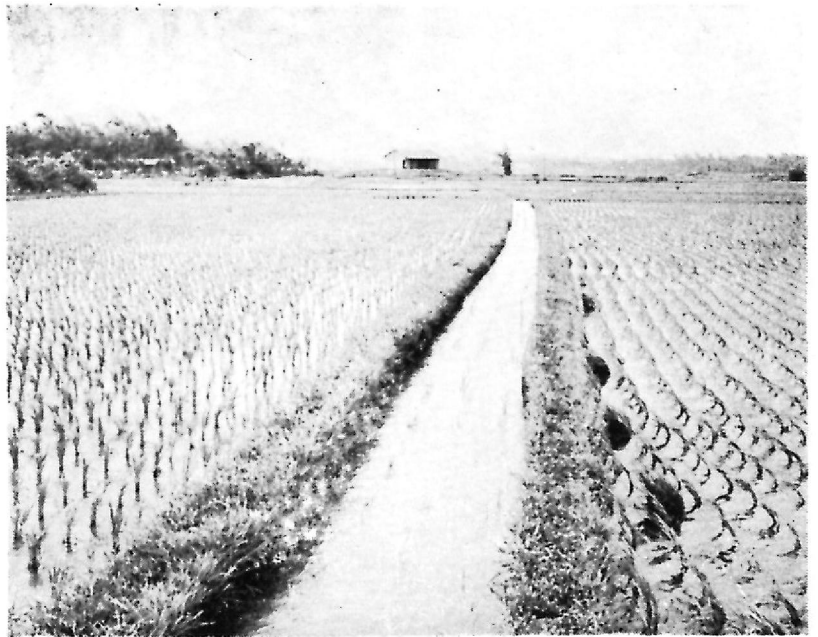


*Farming in the river bed
to feed the fast growing
population.*

*All possible land is
used for food pro-
duction.*

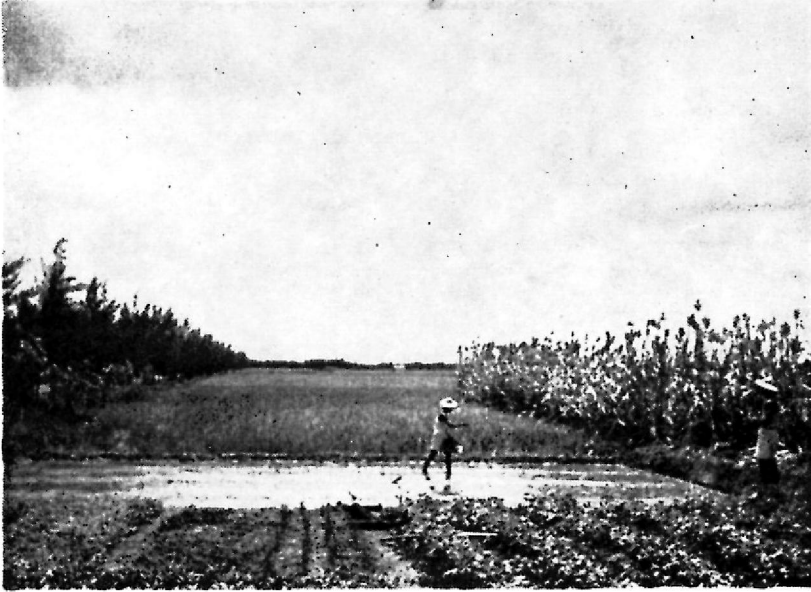


*Drainage ditch with
rice planted.*



*Agricultural crops along
the unstable stream banks
are usually damaged by
overflow after a heavy
shower.*

II. MAJOR LAND USE TYPE IN TAIWAN

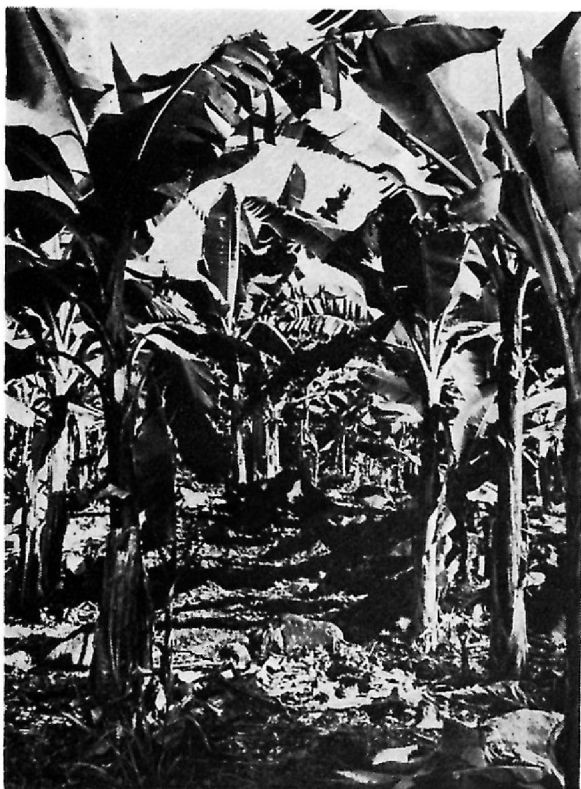


*Cropland is well protected
by windbreaks in coastal
plain*



*Terraced valley: paddy
field at Taipei basin*

Upland cultivation with cash crop: Assam tea plantation.



Upland cultivation with cash crop: Banana plantation on rocky site.



Mountain area is well covered by young tree plantation.

Note the tree nursery at the middle.

Bamboo grows on hillside.



*Fish pond protected by
windbreaks at Southern
Taiwan*



*Pasture in mountain area
at Central Taiwan.*

III. SEVERE EROSION ON WATERSHEDS, HILLSIDES AND TABLELANDS.



Land slides in Wan-ta-chi watershed, the head-water area of the Sun-Moon Lake.

Reservoir silted full with up-stream rocks and debris.



Shifting cultivation on steep slopes causes severe soil erosion.



Active gullies in cultivated hillsides.

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SUMMARY

Over 600,000 hectares of nonforest areas of Taiwan are undergoing from severe to extremely severe soil erosion. The total cultivated area increased from about 858,000 ha. in 1948 to 1,042,800 ha. in 1955. Most of this increase was in the cultivation of the uplands. There were 290,000 ha. of upland farming in 1955 using lands beyond their physical limitations or capabilities. Whatever soil conservation practices have been applied on such land are very inadequate.

Rapid land use changes were found to be taking place in the postwar years, frequently from brush, grassland, hardwood forest to upland farming, bamboo groves, or banana, tea, cassava, citronella plantations; from tidal flats or sand beaches to fish ponds, salt flats or some crop field; and from crop field to urban or industrial uses.

In spite of continuing efforts on the part of the government and farmers to produce more food for fast growing population, the addition of new paddy fields to the old has been negligible. It is hardly enough to compensate the annual losses suffered from inundation silting, sand-blowing, dune encroachment and other destructive hazards.

Deterioration of protective cover condition is widespread, particularly in the headwater areas of the Island's major watersheds.

Over 300,000 ha. of grassland scattered all over the Island but mostly in mountainous areas, present serious problems of proper land use, fire control, effective reforestation and aforestation on account of their relative inaccessibility, steep slopes and general lack of stock or irrigation water. In addition to these areas there are 20,000 or more hectares of denuded land in the nonforest area plantable to trees and over a million hectares in the forest areas having less than 50 cubic meters of timber volume per hectare. Most of these lands represent areas that need to be quickly planted to trees for protection and economic returns.

Total forested areas were found to be much less than estimated in past reports. Hardwood and bamboo types occupy nearly 80 percent of them. Of the accessible land 62 percent has timber volume less than 50 cubic meters per hectare and nearly 80 percent has volume less than 100 cubic meters per hectare.

Only about 10 percent of the 300,000 odd ha. nonforested areas, mostly scattered and inaccessible, within the nationally owned land has some limited agricultural potentialities. Much remains to be desired in the development of non-arable uses and in the implementation of soil and water conservation in arable uses of land on Taiwan.

GENERAL DESCRIPTION OF TAIWAN

Taiwan, better known to the outside world as Formosa¹ is the name of the largest islands in 2 groups of 78 islands, about 150 kilometers² off the coast of the South China mainland. (Fig. 1) It resembles a tobacco leaf in shape, measuring about 384 kilometers³ long from north to south and 144 kilometers⁴ wide at its widest. The terrain is dominated by rugged hills and high mountains. The entire island is severely dissected by many short and steep streams.

FAST POPULATION GROWTH

Population on the island has increased rapidly during the past 3 centuries, the increase consisting largely of migrants from mainland China, particularly in times of war and famine. At every influx of these migrants from the mainland there was usually a renewed impetus in the drive for opening up new tracts of land for cultivation. By the end of 1955 the island's population reportedly reached 10 million⁵, approximating a 50 percent increase over the population

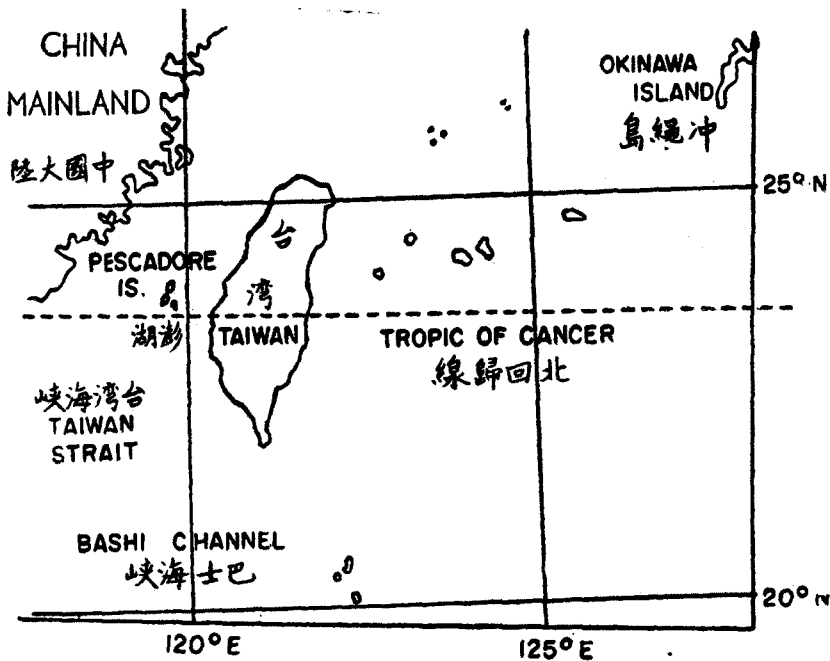


Fig. 1. Geographical position of Taiwan

- 1 The island was first given the name of Il de Formosa by early Portugese sea-farers in 1590 because of its beautiful virgin forests and sub-tropical vegetation existing all over the island then.
- 2 About 100 miles.
- 3 About 235 miles.
- 4 About 88 miles.
- 5 Hsin Shen Pao: Population figure released by PDCA at end of November 1955 was 9,020,938 (including 84,501 in Pescadores) Plus moving population and military personnel & dependents.

reported at the time of retrocession, 1955. (Fig. 2) The annual natural increase rate of population was variously estimated from 2.5 percent to 4.1 percent in the last five years. Few countries in the world today have as dense a population per unit of land area and as rapid a rate of increase as Taiwan.

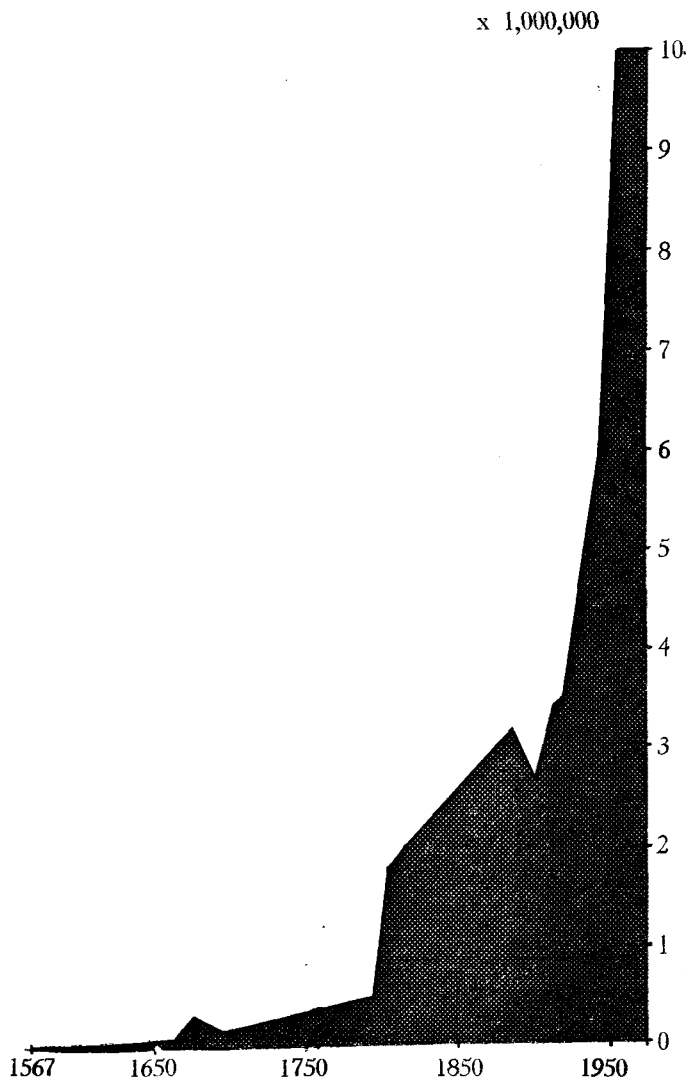


Fig. 2. Population changes in Taiwan 1567-1955

CLIMATE

The climate of Taiwan is well suited to growing a wide variety of agricultural and forest crops. It has a long growing season, mild temperatures, abundant rainfall and a range in elevation from sea level to over 13,000 feet.

Temperature seldom exceeds 100°F or goes below 32°F. Summer temperature averages 75° to 85°F which is close to the optimum for the growth of tropical and subtropical plants.

Rainfall varies from 1,235 millimeters⁶ per year in the southwest to over 4,940 millimeters⁷ per year in the northeast. The extreme range of mountains accounts for the great range in rainfall. Northern Taiwan has rainfall of 120 millimeters or more in the driest months. Relative humidity remains high (80 percent or more) all year round.

The range in elevation and rainfall provides a diversity of weather varying from cool winters good for the development of citrus fruit in northern Taiwan to a dry season suitable for crop ripening and for the concentration of sugar cane juice in southwest Taiwan.

Typhoons and strong winds along with occasional excessively cloudy winters in the north or infrequent droughts in the southwest plains do occasionally restrict agriculture production.

6 About 50 inches

7 About 200 inches

LAND RESOURCES AND PRESENT LAND USE CONDITIONS

MAJOR LAND FORMS

Basically agricultural in its economy, Taiwan is handicapped by very limited arable land on the one hand and on the other a lag in the development of land resources other than farm crop production. This condition is, in part, dictated by the physical make-up of the island's typical land forms.

Physiographically Taiwan is dominated by four groups of land forms, namely (a) mountains, (b) plains, (c) hills and tablelands and (d) dunes and reefs. (Table 1 and Fig. 3)

Table 1.—Major land forms in Taiwan

Land form	Area in square kilometers
Mountains	22,984
Plains	8,120
Hills & tablelands	4,386
Dunes and reefs	269
Total	35,759

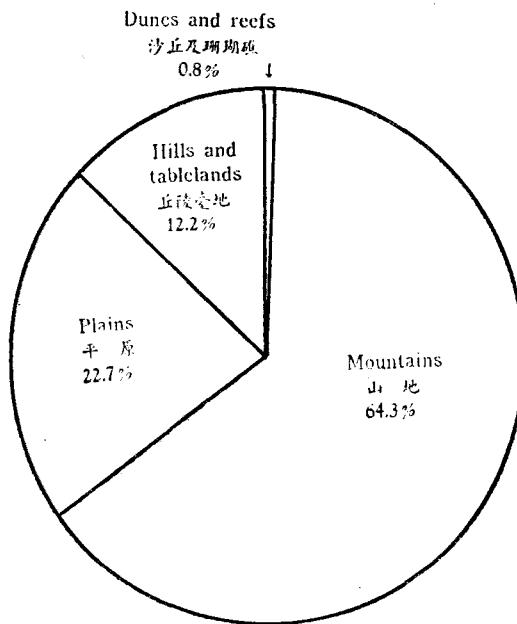


Fig. 3. Major land forms in percentage of total land area

MOUNTAINS

Highly unstable and readily disintegrable, the mountains of Taiwan are mostly of sedimentary rocks such as sandbeds, sandy shales, fissile slates, shaly sandstones and some partly metamorphosed limestones. Their typically high and continuous ridgelines are generally parallel to the lengthwise coast lines of the island.

Active soil erosion resulting in landslides, rockfalls and mudflows is common on steep slopes and in deep, narrow stream valleys. Heavy silting and flash floods are frequent and widespread in the broad lowlands. They are often aggravated by earthquakes, typhoons, rain and thunderstorms common in this sub-tropical

and tropical area. The economical utilization of land both on the mountains themselves and in the wide expanse of lowlands of Taiwan is influenced by these high mountains in more than one way:

1. They form a high N-S land barrier with elevations from 3,000 to about 4,000 meters above sea level. They hinder the monsoon air currents and catch enormous amounts of moisture in the form of rainfall, averaging over 2,500 millimeters annually over an area of more than 10,000 square kilometers. With proper vegetative cover these highlands can provide more dependable supply of usable water for generating hydro-electric power, and for irrigation, urban and industrial uses.

2. Optimum rainfall and wide range of elevations offer excellent conditions for the growth of useful forest trees. Without forest cover, the mountains would be vulnerable to the destructive erosive forces of rainwater so heavily concentrated in these highland areas.

3. By shielding the seasonal northeastern winds, the mountains make possible a dry winter season in the south western plains where sugar cane and other field crops require a dry spell for concentrating sugar and maturing of seeds.

4. Every change in the land conditions of high mountainous areas affects the land use in many lower parts of the watershed area. This is true for each of the major watersheds on the island. As the gradient of stream is steepened by the upward-lifting of mountains, more and more rock debris and dislocated gravels, silt and sand are flushed downhill by torrential rains and runoff water and deposited on the otherwise productive lowlands. Every year heavy damages are done to hundreds of hectares of farms and villages, miles and miles of railroads, highways, irrigation canals, and a great many other public and private properties. Time and again costly and temporary repairs have to be made because of such recurring damages over the low plains while the causes are in the mountainous highlands.

5. The mountains offer small deposits of gold, copper, manganese, sulphur, pyrites, mica, asbestos, and some gas and oil. The tapping of these meagre mineral resources often lacks coordination with conservation practices to stabilize upper watershed conditions.

Aside from cutting of timber and sporadic clearing of mountain slopes for cultivation, the mountains receive relatively little attention from the general public. Hardly any conservation management program has received whole-hearted support in the past. Over half of this vast mountainous area is now in an economically unproductive state.⁸

PLAINS

Upon the vast expanse of alluvial and coastal plains, mostly on its west coast, depends the bulk of Taiwan's agricultural production. Stream alluvium constitutes about 1/4 of the island's land area (about 800,000 hectares). Coastal sand plains only fringe the island's coast lines in separate sections. These are separable from the stream alluvium generally in two ways: (a) the former deposits are characterized by wind-blown sands with distinctive, irregular hummocky topography of low swells and ridges with intervening depressions and (b) that the later formations include all alluvial deposits built seaward from higher lands generally

⁸ LUFFS Reports: "Basic Land Use and Forest Statistics for Taiwan" as of 1955 P. 14 and "Forest Resources of Taiwan" P. 1.

dominated by light textured soils or sandy loams.

Over all other land forms, the plains have many advantages economically in general and agriculturally in particular: Constituted largely of fine grained sediments washed down from adjacent mountains and hills, alluvial soils have higher fertility than most others. Adequate water supplies, both surface and underground, are normally present in plain areas. Readily accessible to urban, cultural, administrative centers and in particular to transportation routes and potential markets, the plains support the largest number of people per unit area. (Fig. 4)

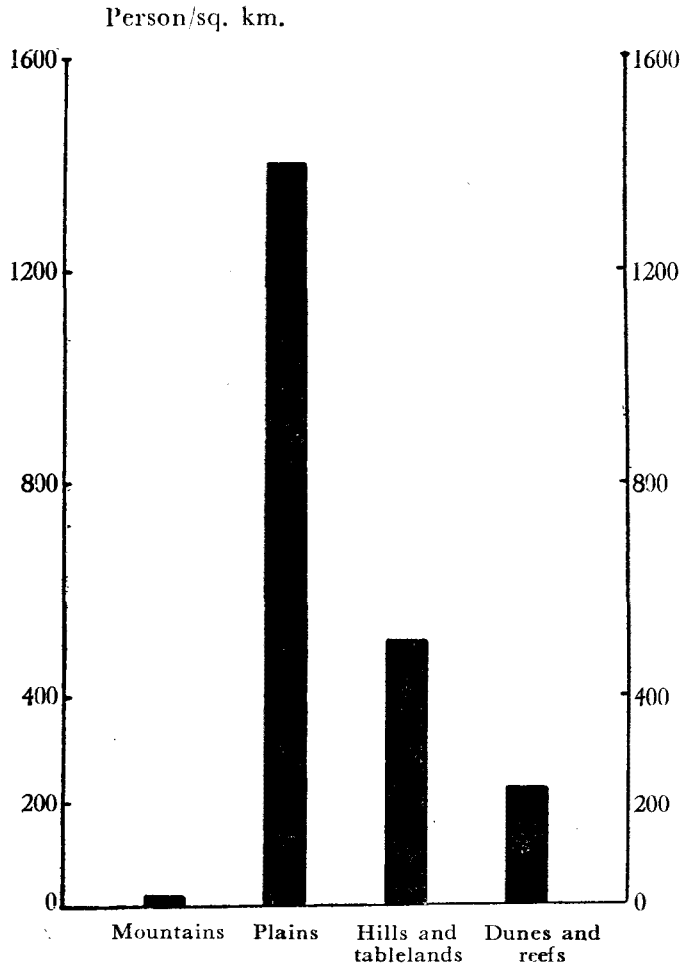


Fig. 4. Population density by major land forms

HILLS AND TABLELANDS

Between the mountains and the plains, there lies a complex zone of dissected foothills, uplifted marine plateaus, pleistocene gravel tablelands, remnants of older river gravel in the form of gently sloping plateaus and terraces. From the mountains to the east, these are separated by a line where steeply dipping mountains rocks disappear beneath less compactly folded younger sediments. And from the recent alluvium along the coast to the west, they are marked out by the spectacular scarps of diluvial terraces and the pleistocene tablelands consist-

ing of unconsolidated materials mostly gravels and boulders.

The economic role of these hills and tableland-plateaus in the land use development of Taiwan is conditioned by many factors including the following ones:

1. High dispersion ratio of the clayey, lateritic soils on top of the gravel bed is highly conducive to water erosion.

2. The plateau-tablelands are usually not directly connected with any higher lands wherefrom irrigation water supplies can be readily developed.

3. Depending for the most part on seasonal rainfall, agricultural production in these areas often suffers setbacks resulting from unpredictable rains or unreliable irrigation water supply.

4. Surface reservoirs occasionally supplemented by canals leading from a few higher sources can only serve as intermittent piscicultural ponds.

5. Because of prolonged exposure and desiccation of land surface resulting from denudation and cultivation since early settlement days, these areas are marked by an exceedingly low organic matter content and consequently low fertility level.

6. Closer to the plains and more accessible than the mountains, the hills and tablelands are ever increasing targets of agricultural expansion, despite a high proportion of slopes, deeply incised stream valleys and active soil erosion.

DUNES AND REEFS

Along Taiwan's western coast, there are found many sections of tidal sand flats and actively migrating dunes. These are developed under the strong seasonal NNW winds from September to April and SSE winds from May to August every year. The periodically receding tidal or stream waters expose the otherwise submerged sand along the beach, in the stream bed or from the river banks. The wind blows and transports the quickly dried-up sand particles to distances often as far as 5 kilometers. Thus, the adversely affected area is much greater than the areas actually covered by the moving dunes and drifting sands themselves, although the widths of the dune belt may be variable. Differing from soil erosion by water, the erosive forces of wind in the dune areas have much wider implications upon agricultural production because they inflict damages not only upon the soil, but also directly on the crops, on the irrigation and drainage facilities and on the health and normal activities of man and livestock.

Though limited in areal distribution, the uplifted reef limestone formations in the vicinity of Kangshan, Panbienshan, Maopitou and Oluampi areas present peculiar problems of land use. Steeply sloping and very rugged in microrelief, the sharply lifted and tilted coral reefs are only thinly covered with lithosols, often of high susceptibility to water erosion.

SOILS

The potentialities of Taiwan's land resources are principally conditioned by the dominant properties and limitations of its major soils. If one proceeds from the west coast toward the central mountains, one would with all probability come upon soils of the island in the order as appears in Table 2. The major soils and their approximate areas in hectares are shown in the table under broad use types, namely agricultural, forestry and transitional:

Table 2.—Soil areas of Taiwan by major uses

Soils	Agricultural	Transitional	Forest	Approximate area x 1,000 ha.	Percent
1. Dune or eolian	*	*	*	9.3	0.3
2. Saline	*	*		136.5	3.8
3. Claypan	*			91.8	2.6
4. Alluvial	*	*		255.0	7.1
5. Paddy	*			230.0	6.4
6. Red earths	*	*		550.0	15.4
7. Yellow earths		*	*	322.5	9.0
8. Grey brown podzolic			*	292.0	8.2
9. Mountain humus			*	45.2	1.2
10. Podzols			*	2.5	0.1
11. Purplish brown & brown			*	10.0	0.3
12. Miscellaneous	*	*	*	21.2	0.6
13. Lithosols			*	1,610.0	45.0
Total				3,576.0	100.0

For practical purposes the agricultural soils appearing in table 2 under numbers 2, 3, 4, 5, 6, 7 and 12 may be consolidated into four groups in the order of their agricultural importance as follows:

1. Paddy and alluvial soils:

Farming in Taiwan has been developed first in the coastal plain areas and extended gradually toward the central mountains. This is so perhaps because of the fact that the most productive soils, namely paddy, alluvial and associate soils are concentrated in the plains, namely, (1) West and Southwest Plains, (2) Ilan Delta, (3) Pingtung Alluvial Plain, (4) East-Taiwan Rift Valley, and (5) Taipei Basin. (Figs 5 and 6)

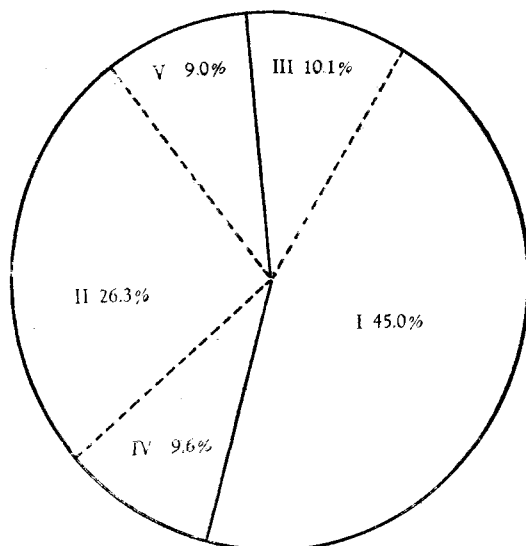
Cultivation of land in these areas dates back from 70 to 200 years ago. Artificial irrigation has been established for most of the fertile plain areas. Typical profile of wet soils particularly those of the paddy soils have been developed. In places of unusual stoniness, light soil texture, excessive internal drainage and inadequate supply of irrigation water, land is commonly used for the production of dry-farming crops. In the latter cases, soils, as a rule, preserve their distinctive features of alluvial origin.

These soils form the backbone of the island's agriculture and generally present only minor to moderate conservation problems. Their slow deterioration, however, may occasionally be aggravated by flash floods, silting and deposition of inert materials washed down from other soil areas of the highlands.

2. Red earth:

Characteristically acid to strongly acid in reaction, the red earths are examples of soil material which has undergone processes of prolonged leaching, excessive surface run-off and water erosion. They are generally very thin in the top or "A" layer, if any, underlain with a reddish to brownish heavy-textured sub-layer ranging from 0.3-2 meters in depth, often lined with gravel, boulders or rock fragments of sandstone, shales and others.

The high dispersion ratio of their colloids, infrequent accessibility to irri-



- I Soils (Lithosols) dominantly under some forest cover with sporadical areas under brush or bare.
- II Soils (alluvial, saline, red earths) dominantly in agricultural uses, some in other NF uses.
- III Soils (Mountain humus, podozols, brown, and purplish brown earths) dominantly under forest.
- IV Soils (Yellow earth, misc.) dominantly in other NF uses.
- V Soils (paddy, claypan soils) long under Agricultural crops.

Fig. 5. Percentage areal distribution of soils in Taiwan by major use

gation water, low organic matter content, high rate of fixation of potash and phosphate by the clay complex make these soils very expensive to manage for general crop production.

3. Saline and claypan soils:

The saline and claypan soils also present hazards chemically, physically and otherwise. Because of prevailing seasonal winds of sufficiently damaging strength throughout the growing seasons in these plain areas, crop production has been seriously suffering from wind-induced drouth, salt toxicity, shallowness of top soil and high impermeability of some subsoils.

4. The yellow earths:

The yellow earths are mostly interlocked with red earths on uplifted marine plateaus and in foothill areas. There are however a few distinctive profiles with leached horizons in places ranging from 1,000-2,500 meters above sea level. Considerable portions of the yellow soil area are generally better suited for forest or timber production than for agricultural use. Yet cultivation has already found its way into these areas in numerous places.

With few exceptions these agricultural soils are relatively low in their organic matter content, generally unstable in the presence of water so far as their structural aggregates are concerned, predominatingly shallow in effective depth. The red and yellow earths are often found on sloping sites ranging from steep to precipitous angles. As a rule all soils have high susceptibility to water erosion particularly when deprived of their protective cover. Upon being used for produc-

ing crops, man exposes these soils usually in the most vulnerable seasons and under the least protected conditions.

Under the rugged physiographic conditions of the island, soil erosion processes proceed at much faster rates than the soil forming processes. Few virgin soil profiles have been fully developed and preserved for any length of time.

LAND USE UNDER SOIL DEPLETING CROPS

Severe soil erosion invariably results from any one of three sets of man-made conditions on any land form in Taiwan, namely (1) using land far beyond its capability, (2) inadequate conservation treatment on land where use is beyond its capability and (3) inadequate or improper maintenance practices although land use may be within its capability. All these conditions are commonplace phenomena, particularly in the areas adjacent to the foot hills. Field instances can be found in the recent expansion of citronella and tea plantations and other soil depleting crops.

CITRONELLA PLANTATIONS

There were only 57 hectares under citronella grass in 1945 when the island was restored to the Republic of China. By the Fall of 1951 the area under this crop had increased to 18,000 hectares, practically all from lands suitable only for, or originally under, forest use but cleared and denuded during this 6 year period. This happened mostly in the foothills of Miaoli, Taichung, Nantou and scattered hilly sections of Hsinchu and Taoyuan Hsien. In the years following 1951, the price of citronella oil dropped from NT\$40 per catty to below NT\$10. But the hilly areas already cleared of their forest cover could not be restored quickly to timber production. In fact some abandoned hillside citronella plantations were converted to emergency food crops such as peanut, sweet potato, corn, cassava or others, almost all of which require clean cultivation following planting and soil excavation during harvest. The need for controlling accelerated soil erosion on these citronella hillsides is ever more urgent as a result of an all time high price (NT\$52/lb or higher) being offered in the export market again since early 1955.

Deeply affected by the frequent price fluctuations in the local and export markets, citronella growers did not have the time, labor nor incentive to establish soil conservation measures such as terracing, contour planting, strip cropping, protected waterways. Concentrated runoff in numerous rills breaking through the discontinuous citronella clumps rapidly carries away the surface soil from the hillsides. This usually begins at the year's first few rain storms. In the short span of from 2-6 years, extensive areas were thus depleted and desiccated, aggravating profound drought hazards on both upland and paddy farms in Taoyuan, Hsinchu, Miaoli and Taichung Hsien is during the summers of 1952, 1953 and 1954.

TEA PLANTATIONS

Similarly new tea plantations to a total of over 10,000 hectares were either restored from abandoned prewar tea gardens or expanded into newly cleared hilly lands within 8 years (1945-1953) after restoration.

The manner in which the cultivation of tea accelerates soil erosion can be summed up as follows:

1. Over 80 percent of tea plantations are situated on rather steep hillsides with slopes of from 20° to 40°.

2. The tea plants require clean weeding and cultivation from 3 to 10 times a year to depths varying from 10-15 centimeters. Usually one sub-soiling or deep plowing of tea soil to depths of 20-30 centimeters is necessary following the harvest of fall leaf crop.

3. It takes from 3 to 4 years before newly planted tea seedlings to develop full crown canopy.

4. With the exception of Assam Tea, which constitutes only about 3 percent and which needs to be replaced once every 15 years or longer, the native tea varieties need to be renewed once every ten years. In other words, during 4 out of the 10 growing years of native tea varieties there is soil erosion due to the clean cultivation required and huge amounts of soil disturbed or exposed. The magnitude of widespread soil erosion can be comprehended when one recognizes the fact that the native tea varieties still constitute over 96 percent of the total crop.

5. The common practice of working-in the green manure crops is to lift the entire plants, roots and all, lay them near the roots of the tea plant and cover them with a very thin, loose layer of broken soil, and leave them to the mercy of rain drops and runoff water.

6. Tea farmers do not like to see water standing on their tea plantations. Painstakingly they will excavate vertical or up-and-down hill drainage ditches which very often develop into gullies as a result of concentrated runoff.

7. Whenever a hillside is cultivated to tea, clean cultivation extends from the very top down to the foot of the hill, all planted to this one crop. This not only exposes most of the vulnerable soil but also prolongs the continuous slope and accelerates the erosive action of runoff water.

8. With limited access to technical education and modern soil conservation technique and equipment, tea farmers are very backward in managing their plantations mostly on marginal land.

As soil erosion damages on these lands are irreparable in many cases, the losses suffered by the nation as a whole become much greater than the meagre income temporarily realized by the individual tea or citronella farmers from their soil impoverishing crops.

HILLSIDES UNDER BANANA AND CASSAVA

The evils of misusing land are at their worst in the recently expanded cultivation of banana and cassava on steep hilly lands originally under brush or forest in many parts of central Taiwan. Not only has much of the soil material been eroded away from most of such cultivated slopes due to tillage and harvest operations, but also the excessive runoff waters have exposed and moved rock boulders of all sizes and caused frequent damages on highways, railroads, irrigation channels and productive paddy fields in the lower areas.

DETERIORATING WATERSHED CONDITIONS

The deterioration of land conditions has been reported on the Chushuichi, Taanchi and other watersheds. For instance, against every hectare of the Wushuhchi watershed land that might be stabilized by the protection of natural vegetative regeneration after burning or suspending cultivation, there were 4 hectares of original brush or forest land seriously deteriorated or ruined forever by misuse and lack of protection/management measures within the ten year period from

1943 to 1953.

Recent trends of urbanization have converted hundreds of hectares of good paddy land in the plains or near big cities into various urban uses. On the other hand, laborious grubbing and clearing, expensive levelling and terracing were often carried out on hillsides or at river bottoms either too steep, too stony or too unstable to be farmed. Costly and temporary establishments, such as special crop plantations, roads, dykes, canals, embankments, levees, are often built in places where unchecked runoff, soil erosion or flash floods repeatedly take heavy tolls of crops and land, life and property.

SHIFTING CULTIVATION

Shifting cultivation as widely practised by the aborigines in 12 out of Taiwan's 15 Hsiens⁹ on steep mountainous slopes 1,000 meters or higher above sea level is as destructive to the land and water resources of Taiwan as the illegal expansion of soil depleting crops in the foot-hill areas just described. Within the limits of the aborigine reservation it is often difficult for the aborigine villager to spot any steep mountain side that has not been farmed at one time or other, particularly in the vicinity of their villages. Cultivation is done with very primitive hoes after the trees, slash or grass is burned by fire. At the end of two or three year's cultivation to millet, sweet potatoes, corn or peanuts, the tract of land is abandoned and new site for such primitive farming is sought. In return for his cultivating the steep mountain slopes, the aborigine farmer can seldom

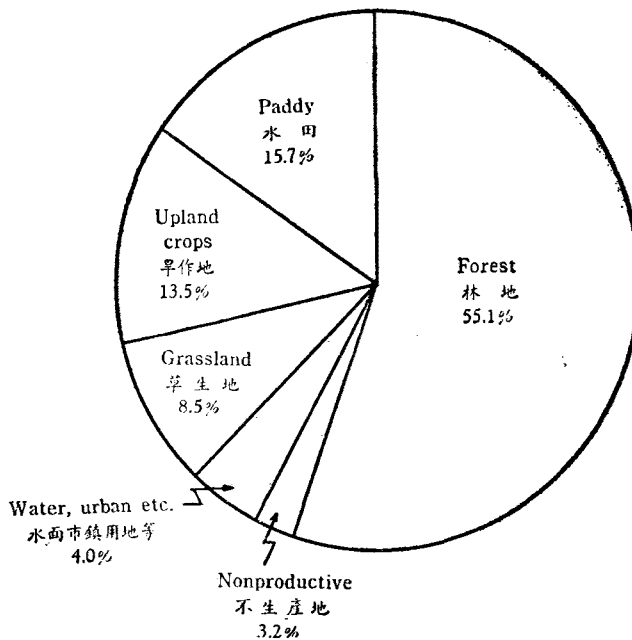


Fig. 6. Percentage areal distribution of present land use types in Taiwan, 1955, based on LUFs data (Compare with Fig. 9)

9. The 12 Hsiens with large and exclusive townships of aborigine reservations are Ilan, Taipei, Taoyuan, Hsinchu, Miaoli, Taichung, Nantou, Chiayi, Kaohsiung, Pingtung, Taitung and Hualien.

earn an annual income from farming more than US\$11 as reported in a recent Wushechi watershed survey. On the other hand, gullies, land slides and rock falls eventually result from such denudation practices. Examples may be found at Lushan, Tengyuen, Hoping, on the Wushechi watershed; Gihensha, Uraisha, and Kyopansha on the upper Tanshuiho watershed, and on many others.

This continuous drive by the mountain dwelling tribesmen for more arable land regardless of its capability and limitations has led to the fast expansion of areas marred by grass burning and forest fires. The grassland and denuded mountain slopes increased to 8.5 percent of total land area by 1955 from a reported 5.7 percent prior to 1948. This means over 100,000 hectares increase of these nonprofitable use types in less than 10 years. (Figs. 6, 7 and 19).

PRESENT LAND USE

The distribution of present land use types is shown in 1:50,000 and 1:250,000 topographic maps and summarized in figures 6 and 7. There are slight modifications in the grouping of land use types in the L.U.F.S. The classified headings of land use types as conventionally used in the Taiwan Agricultural Yearbooks are found overlapping and not well defined for the survey work. It was necessary that a much simplified classification be adopted. Aside from forest cover types which are discussed in a separate report, the nonforest land use types are so defined as to cover the following headings conventionally used in past reports:

Land Use Types (L.U.F.S)	Use Types as Classified in Past Reports (T.A.Y. & others)
Cp (Paddy)	1. Paddy field. Both double and single cropping. 2. Two or three year rotation dry land farms. (so terraced and leveed as capable of producing one crop of paddy rice in two or three years.)
Cd (Dry-farming)	1. Dry land 2. Miscellaneous plantations
G (Grassland)	1. Pastures 2. Land under tall or short grasses excluding commercial bamboo.
U (Urban or industrial)	1. Building sites in villages, towns and cities. 2. Salt fields. 3. Mineral quarry or mining areas. 4. Temples and graveyards. 5. Railroads, highways, wharves and their associated establishments.
W (Water)	1. Piscicultural ponds. 2. Swamps. 3. Pool. 4. Drains. 5. Waterways.
Lp and Lu (Denuded land plantable and unplatable)	1. Other lands including prairie, parks, dikes and river bottoms.

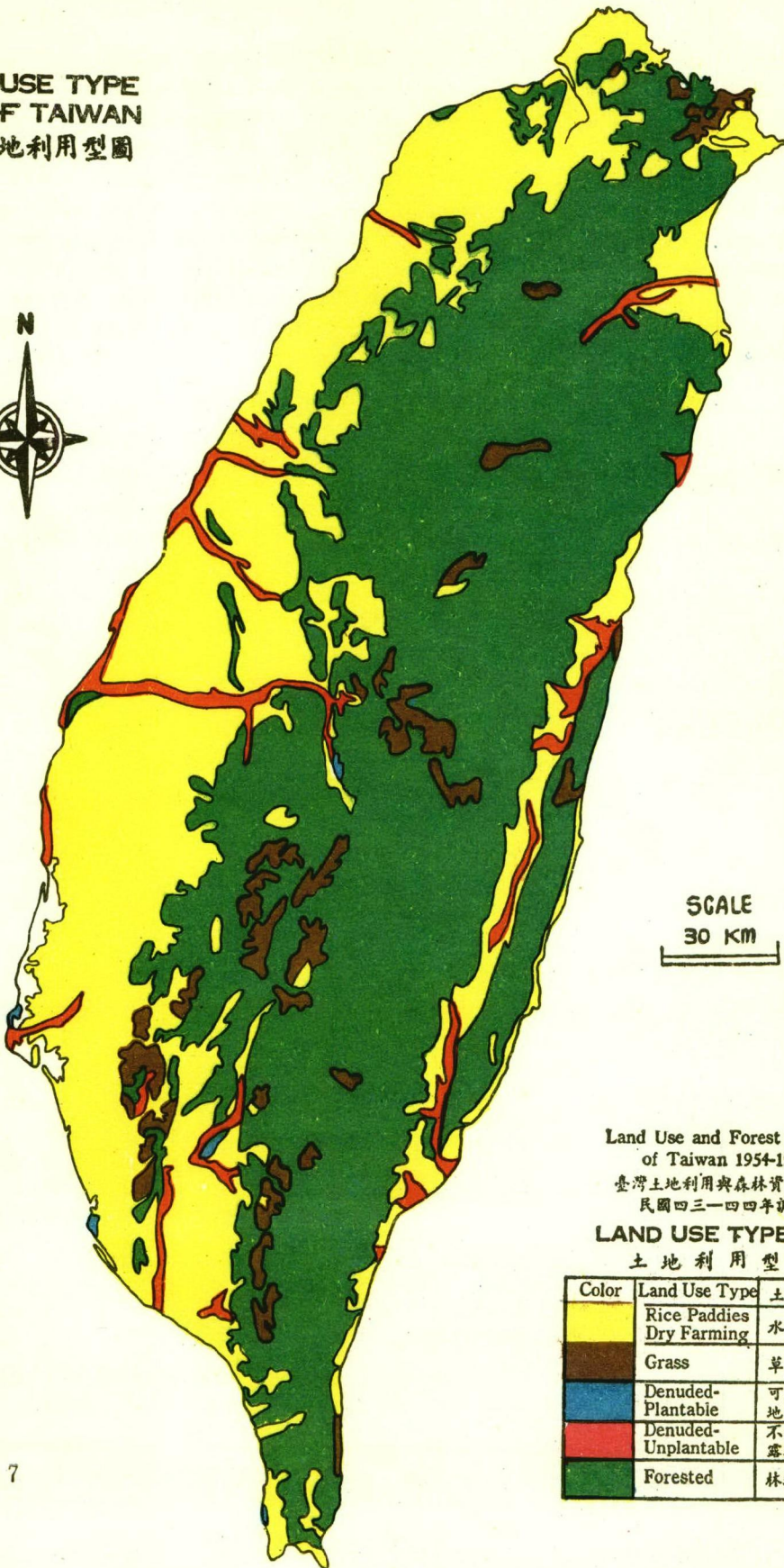
The attention of the reader is invited to the section in the appendix on the definition of terms used in the present survey.

120°

121°

122°

LAND USE TYPE
MAP OF TAIWAN
臺灣土地利用型圖



SCALE
30 KM

Land Use and Forest Survey
of Taiwan 1954-1955
臺灣土地利用與森林資源調查
民國四三-四四年調查

LAND USE TYPE MAP
土地利用型圖

Color	Land Use Type	土地利用型
Yellow	Rice Paddies Dry Farming	水稻田旱作地
Brown	Grass	草地
Blue	Denuded-Plantable	可造林之裸露地
Red	Denuded-Unplantable	不能造林之裸露地
Green	Forested	林地

Fig. 7

120°

121°

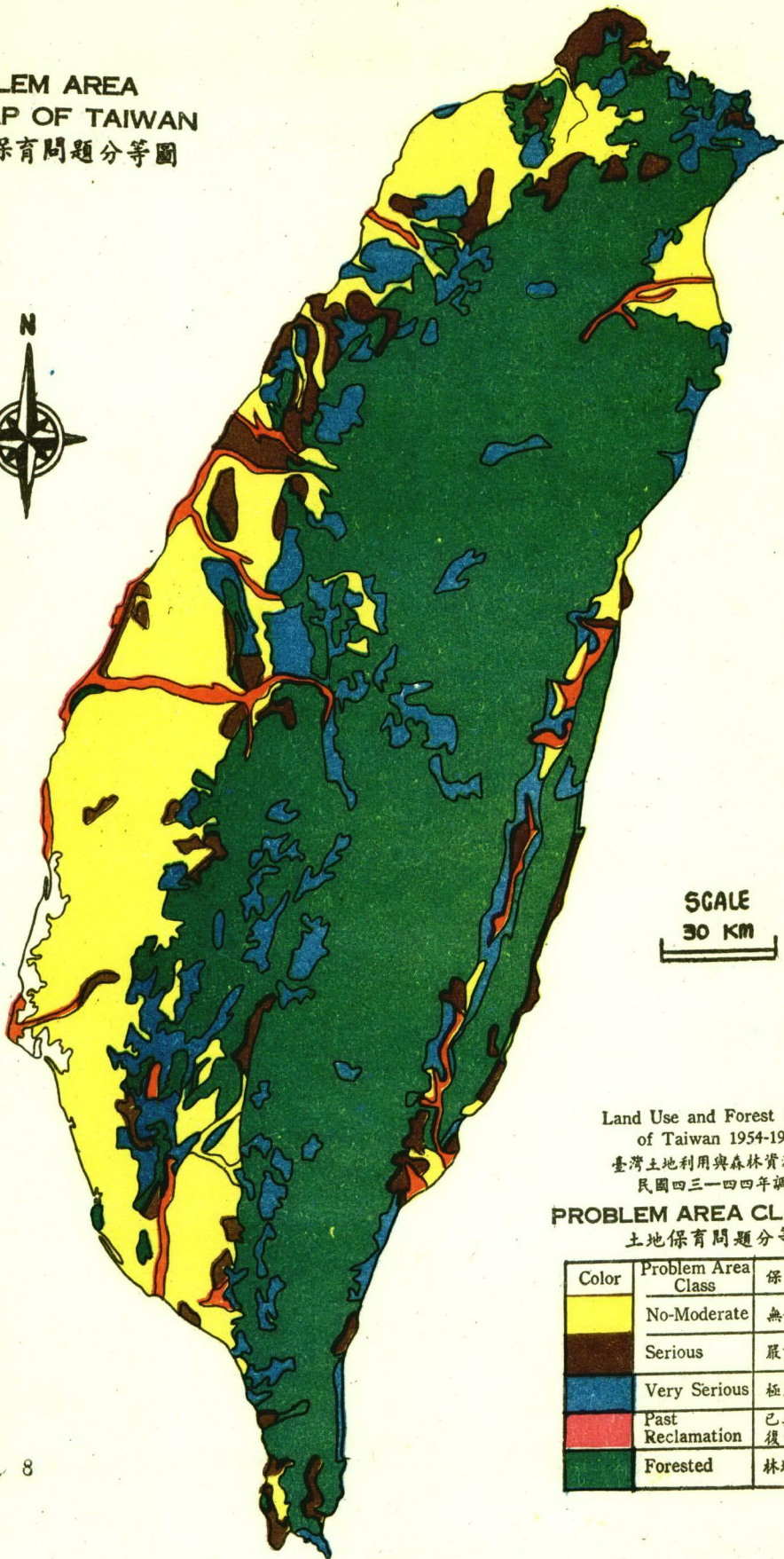
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PROBLEM AREA
CLASS MAP OF TAIWAN
臺灣土地保育問題分等圖



SCALE
30 KM

Land Use and Forest Survey
of Taiwan 1954-1955

臺灣土地利用與森林資源調查
民國四三—四四年調查

PROBLEM AREA CLASS MAP
土地保育問題分等圖

Color	Problem Area Class	保育問題分等
Yellow	No-Moderate	無—中等
Brown	Serious	嚴重
Blue	Very Serious	極嚴重
Red	Past Reclamation	已無改良 復舊可能
Green	Forested	林地

Fig. 8

120°

121°

122°

TREND OF LAND USE AND PROBLEM AREAS

RAPID LAND USE CHANGES

On numerous occasions during the present survey, cover and land use changes have been discovered. Where aerial photos taken from 1947 to 1951 showed one cover type, ground checking showed another. Most common cases include: from brush land to dry farming; from grassland to banana, tea, cassava or castor bean plantations; from tropical and subtropical hardwood forest to bamboo groves; from sand flats or shallow sea beaches to fish ponds, salt field or to a limited extent some paddy farms; and from paddy fields to urban or industrial uses. This unstable pattern of land use indicates increasing demand for land for more intensive uses by the rapidly growing population. The general tendency seems to be that soil depleting cover types increase in acreage at much faster rates than do crops or vegetation which may help conserve soil and water. (Figs. 6, 9, 10, 11).

A comparison of the percentages in Fig. 6 with those in Fig. 9, shows that cultivated upland fields increased by 4 percent since 1948 with respect to total land area. To a small extent this increase is due to the broader sense of the definition for the cultivated upland farm as used in the present survey¹⁰. The slight increase of about 1 percent each in paddy fields, water and urban areas are perhaps more matters of definition in land classification than significant land use changes. Despite slight variations in classification and definition, the sharp decrease of forested area from the hitherto reported 63.6^x percent of the total land area to 55.1 percent in 1955 should be considered very significant in regard to the conservation of land, water and forest resources.

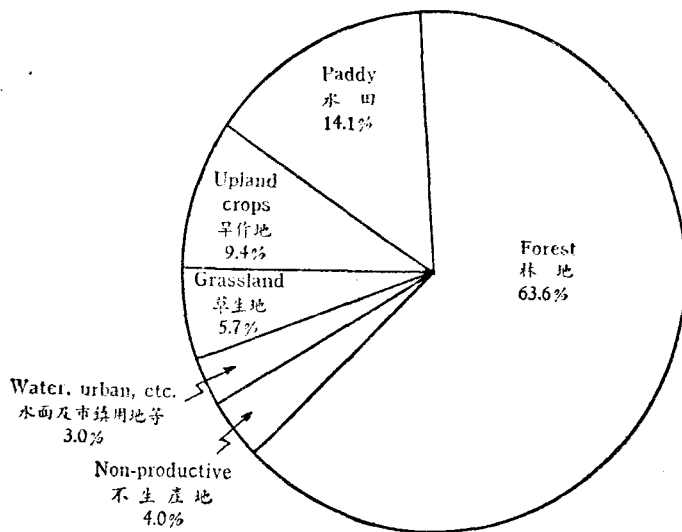


Fig. 9. Estimated percentage areal distribution of land use in Taiwan, prior to 1948
(Compare with Fig. 6)

10. cf. Definition of Terms, in the appendix.

* A total of 2,278,956 ha. of forest areas were reported by Taiwan Forest Administration. This estimate includes 381,431 ha. of non-forest areas.

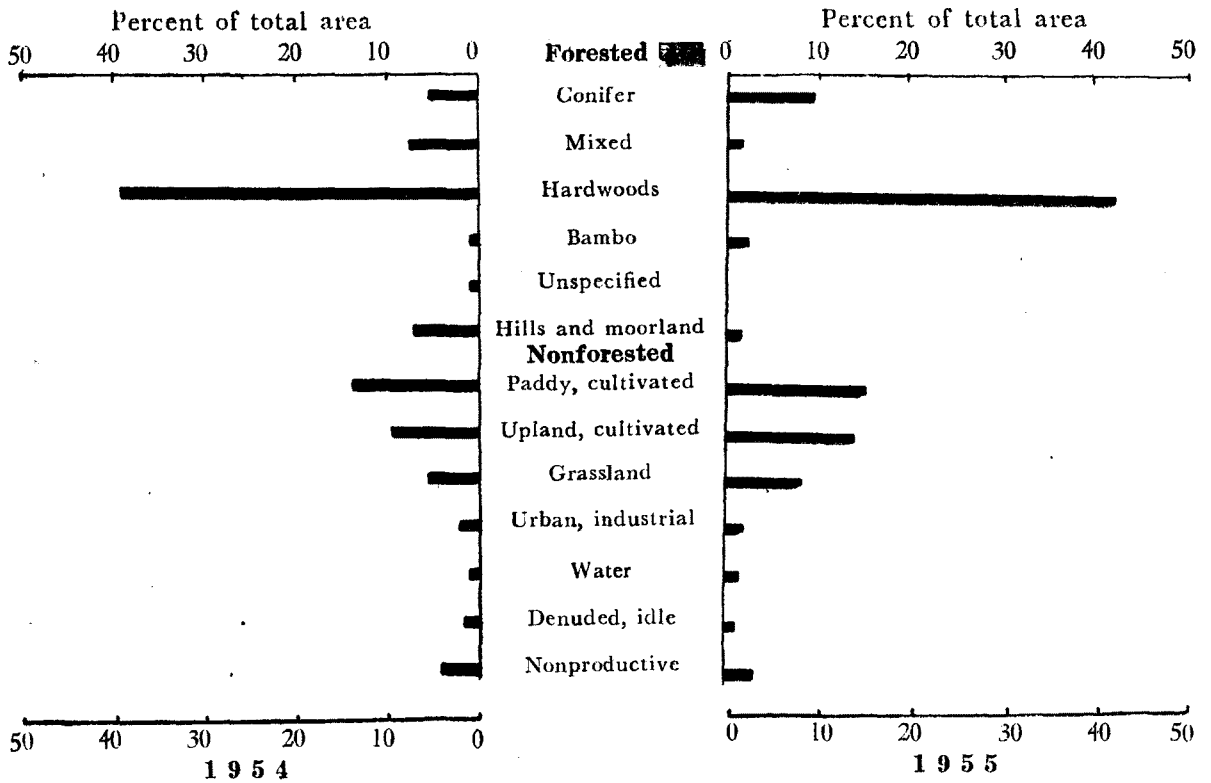


Fig. 10. Land use changes in Taiwan, 1945-1955

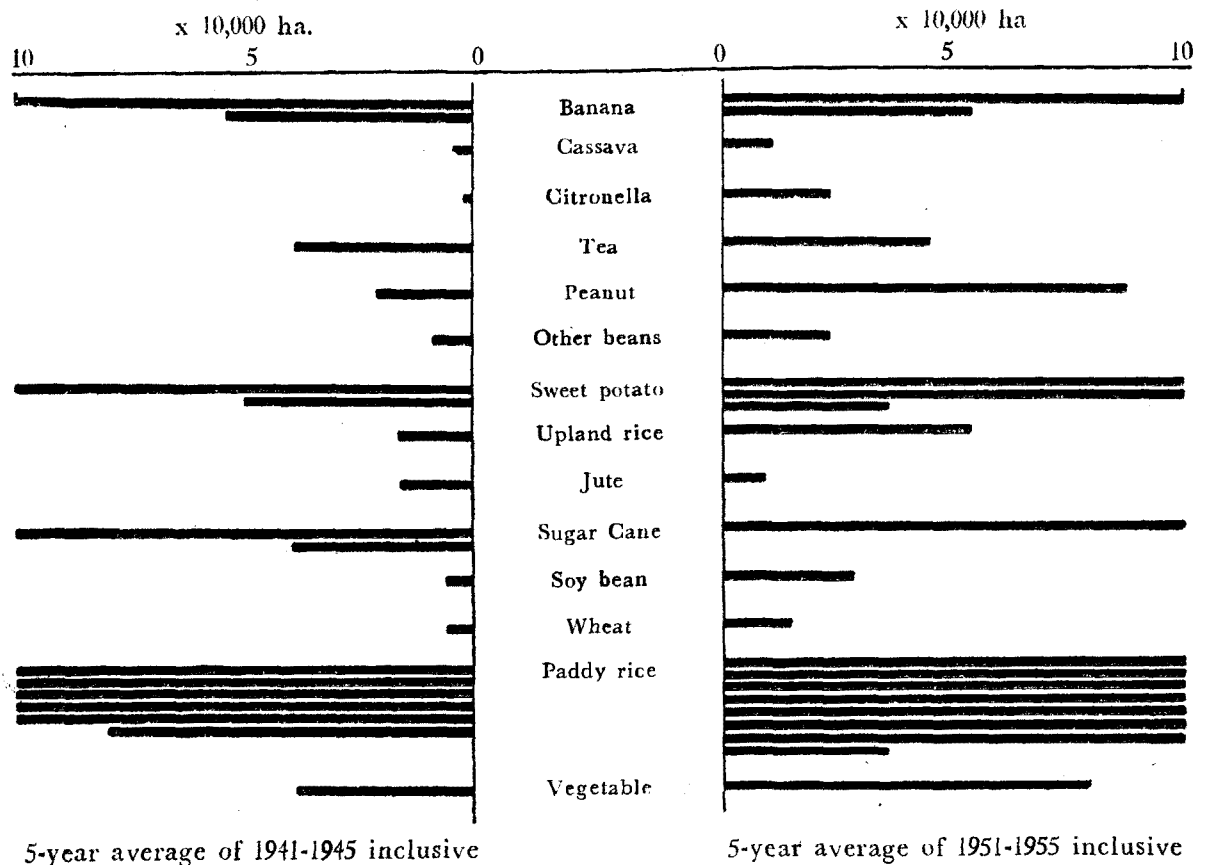


Fig. 11. Recent changes in crop areas

THE PROBLEM AREAS

Based upon the cumulative cost index of conservation practices as dictated by physical characteristics of land such as slope, degree of erosion, effective depth and texture of soil, and other secondary factors, the classification of nonforest land into 5 problem areas, I to V, with increasing soil conservation needs has been found practical and pertinent to local requirements.¹¹

Taking the value of New Taiwan Dollar at the price and wage level in May 1953 as unit, the range of cost index of soil conservation practices per hectare recommendable by problem area is as follows:

Problem area	Range of cost index
I	0 - 59
II	60 - 199
III	200 - 599
IV	600 - 1200
V	1200+

Under this classification, the non-forest land of Taiwan totals to slightly over 1.6 million hectares or 44.9 percent of the island's total land area. (Figs. 8 & 12). Lands with the highest agricultural potentialities, namely

those in problem areas I and II, constitute 21 percent. The transitional class between arable and non-arable, namely land in problem area III, amounts to 7.2 percent or a little over 250,000 hectares. Nonforest lands in problem areas IV & V both being definitely non-arable, form another 16.7 percent of island's land area. (Figs 12, 14 & 15).

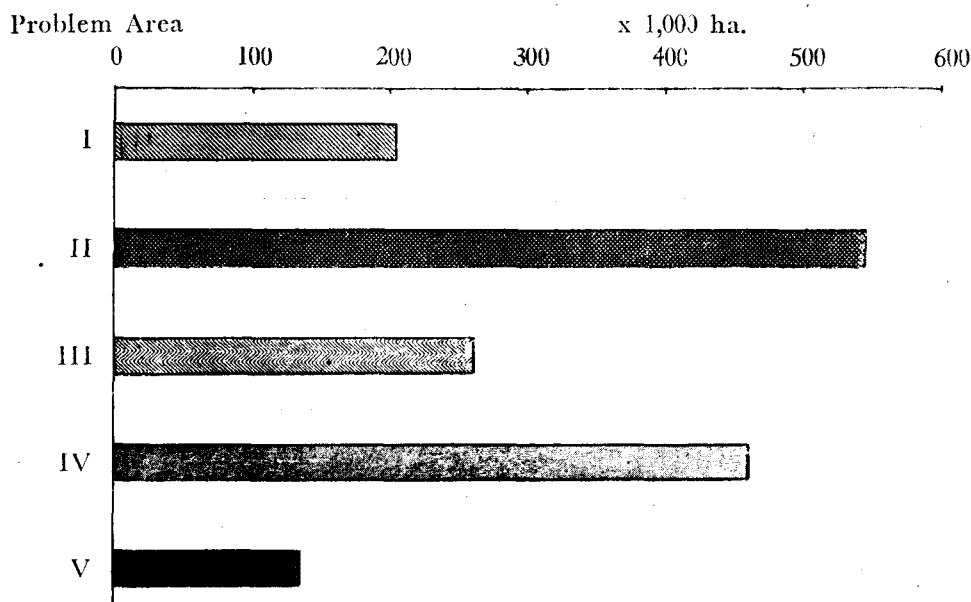


Fig. 12. Areal distribution of nonforest land by Problem Area

INTENSITY OF SOIL EROSION ON MAJOR WATERSHEDS

An analysis of statistical data of the present survey shows that 10 out of the 15 major watersheds of Taiwan (Fig. 13) have more hectares of land in severe or worse stages of soil erosion than in relatively stable condition. The accumulated area undergoing from severe to extremely severe soil erosion approximates to

11. cf. chart in appendix showing the relative position of land use capability classes as grouped into Problem Areas I to V.

400,000 ha. or over 39 percent of all the cultivated area of Taiwan. (Table 3)

The remaining watersheds show slightly larger areas of relative stable farming land than areas undergoing from severe to extremely severe soil erosion. But the arable lowlands of these respective watersheds recurrently suffer from silting and flood damages caused by the deteriorating conditions of the up stream areas. These include the following five watersheds: (Table 4)

The present survey did not find a single watershed that is free from destructive hazards of fire, flash floods, drouth, silting, and soil erosion by wind and/or water. The headwaters (1,200 m. and up) of all watersheds in Taiwan have areas of non-forested land in problem areas IV & V, totaling over 180,000 hectares. (Figs. 22, 23). These areas present a constant menace to the safety and continuity of productive uses of land and water in the lower reaches of the watersheds. The few small watersheds such as Tachiachi, the North-eastern Coastal and the S-tip area have relatively small nonforested land in Problem areas IV and V in their upper parts, but their lower plains are proportionally very limited in area and rather low in productive potentiality. (Figs. 20-23).

The vast expanse and wide distribution of these seriously eroding areas (totaling over 600,000 ha.) in all watersheds, not counting the forested areas, make the task of soil and water conservation a tremendously exacting one.

ELEVATION VS. PROBLEM AREA

79.1 percent of all nonforest land is distributed in elevations from sea level to less than 600 meters above sea level. (Fig. 16). The distribution of the remaining nonforest land is as follows:

Elevation Class, meters	%
600 - 1199	9.2
1200 - 1999	4.4
2000 - 2999	5.7
3000+	1.6

Lands in problem areas I and II have the highest agricultural potentiality and the fewest conservation needs. Forty six percent of the non-forested land or 743,800 ha of class I and II lands are situated at elevations of less than 600 meters above sea level. Thirty three percent of the non-forested class III, IV and V lands or 526,800 ha are also below 600 meters elevation. With few exceptions, the nonforest land found at altitudes higher than 600 meters fall mostly in problem areas III, IV and V (constituting 21 percent of the island's

Table 3.—Land undergoing from severe to extremely severe soil erosion in 10 major watersheds

Watershed	Area (hectares)
Chushuichi	94,000
Hualienchi	56,000
Hsiatanshuichi	54,000
Tanshuiho	52,000
Taitung	40,000
Taanchi	30,000
Hsiukuluanchi	21,000
S-tip	21,000
NE Coastal	15,000
Tachiachi	6,000
Total	389,000

Table 4.—Areas in watersheds suffering from serious soil erosion in upstream areas

Watershed	Area (hectares)
Tatuchi	72,000
Tsengwenchi	50,000
NW Coastal	35,000
Ilan Chushuichi	29,000
Pachangchi	25,000
Total	211,000

1. Chushuichi 濁水溪
2. Hsiukuluanchi 秀姑巒溪
3. Hualienchi 花蓮溪
4. Hsiatanshuichi 下淡水溪
5. Ilan Chushuichi 宜蘭濁水溪
6. NE Coastal 東北海濱
7. NW Coastal 西北海濱
8. S-tip 鵝鑾鼻楓港各河川
9. Panchangchi 八掌溪
10. Taanchi 大安溪
11. Tachiachi 大甲溪
12. Taitung 臺東
13. Tanshuiho 淡水河
14. Tatuchi 大肚溪
15. Tsenwenchi 曾文溪

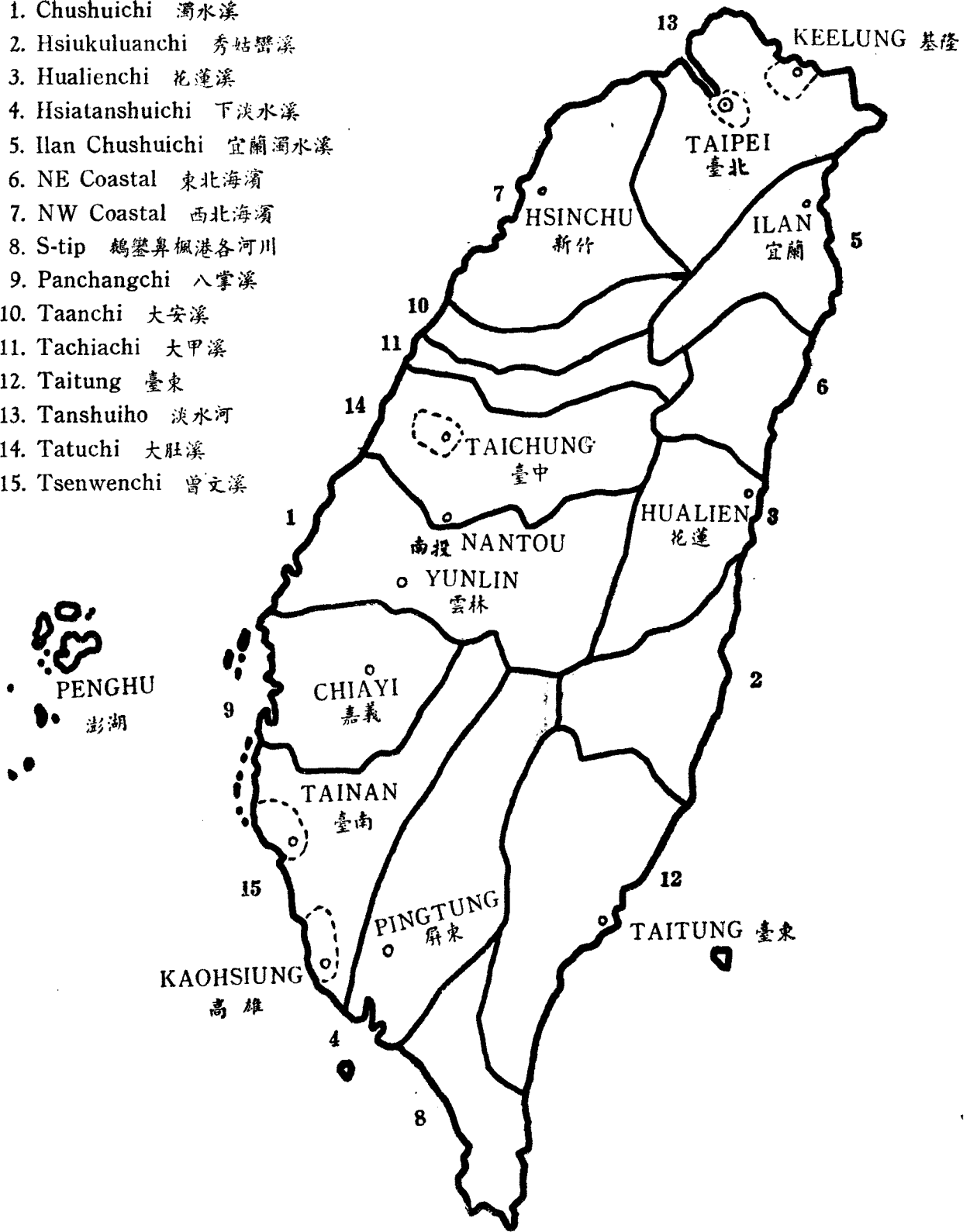


Fig 13. Watershed Map

total nonforested area). The important fact is that almost 90 percent of all non-forest land is situated at less than 1,200 meters above sea level.

GENERAL TRENDS OF LAND USE

The agricultural use of lands with the highest agricultural potentialities finds increasing competition with urban and industrial expansions around highly urbanized centers. To date about 60,000 hectares of the best arable land in problem areas I and II are under urban and industrial uses. Only 14,000 hectares out of problem areas prohibiting agricultural uses are utilized for building constructions and industrial developments. Water areas also cover over 10,000 hectares of land tracts in problem areas I and II. (Figs. 6 and 19).

Of the one million odd (1.04 million) hectares of nonforest land under cultivation, there are about 290,000 hectares or almost 8 percent of the total land area, being cultivated beyond and against the physical limitations of land. (Figs. 14 and 15). Almost all lands in problem area III have been brought under cultivation. Furthermore, cultivation has already taken place in some problem area IV and V lands. The present trends seem to show (1) that there is considerable increase in cultivated areas particularly to the upland crops in recent years, (2) that there is also definite increase in grassland areas, (3) that there is significant decrease in forested areas and (4) that the increase in paddy and other use type areas is insignificant in area but very important in the island's economy.

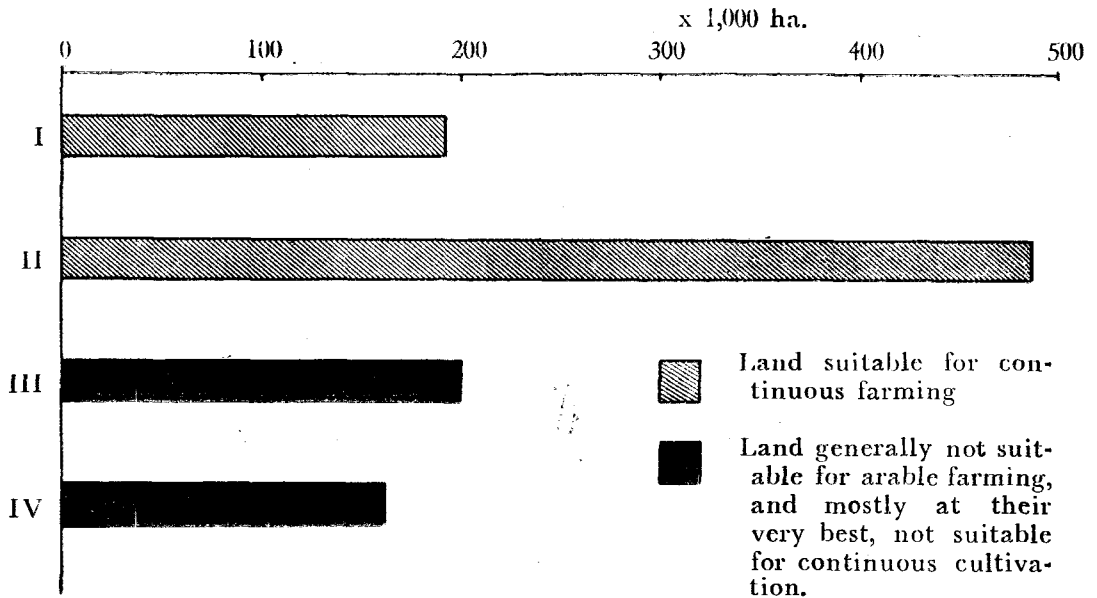


Fig. 14. Nonforest Land area under cultivation by problem area

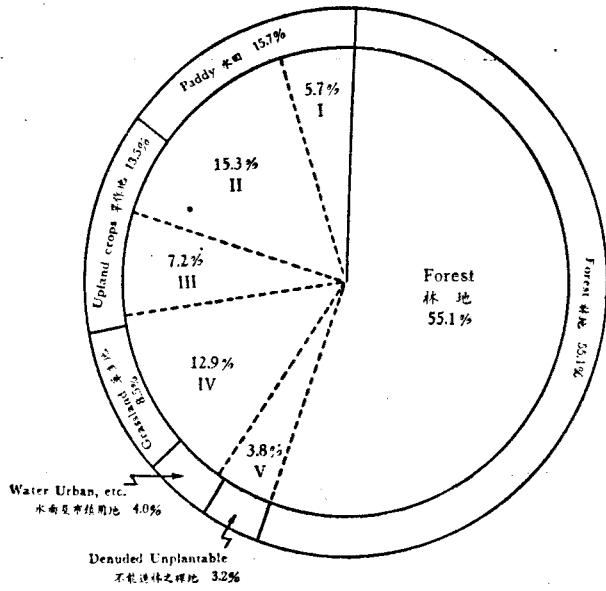


Fig. 15. Percentage distribution of present land use Vs. problem areas of nonforest land, Taiwan.

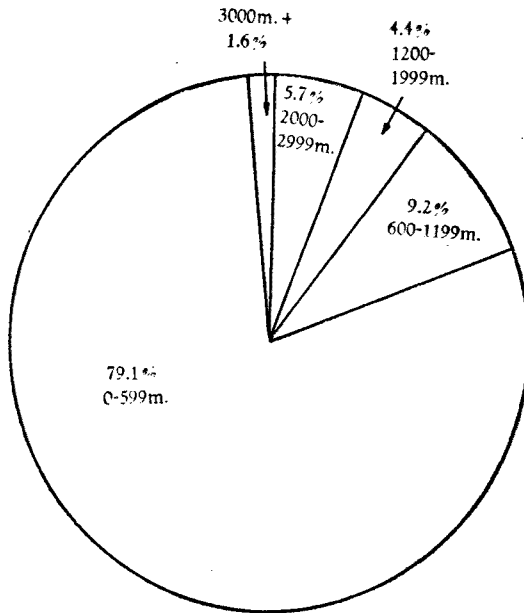


Fig. 16. Percentage distribution of nonforest land by elevation in meters above sea level

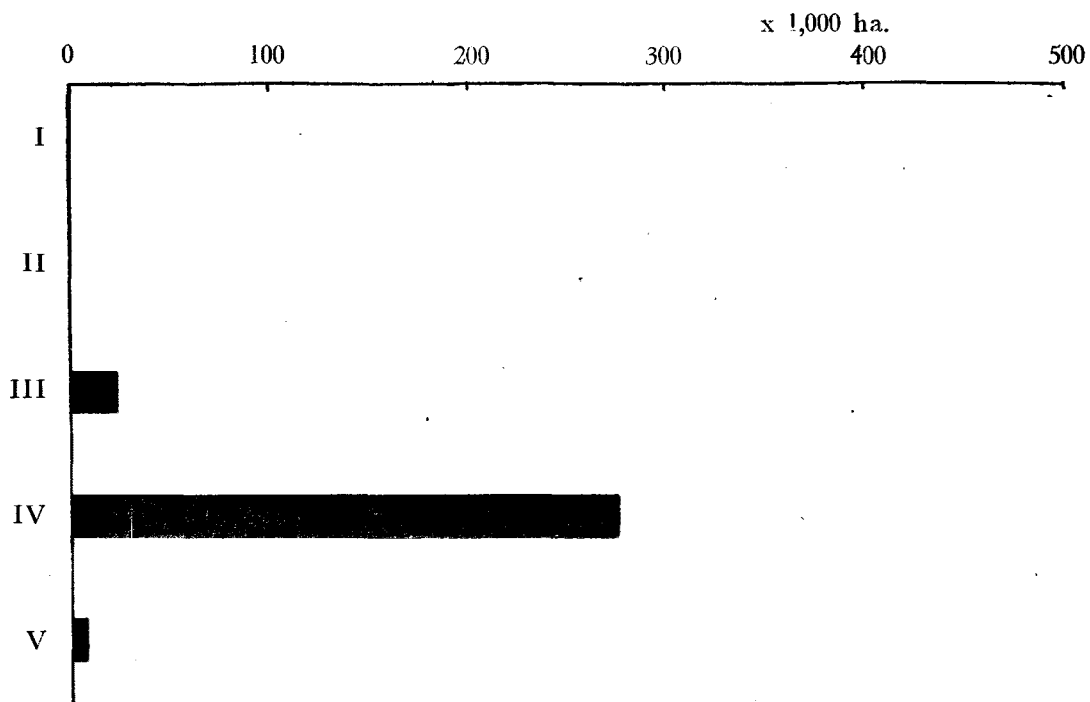


Fig. 17. Grassland by problem area

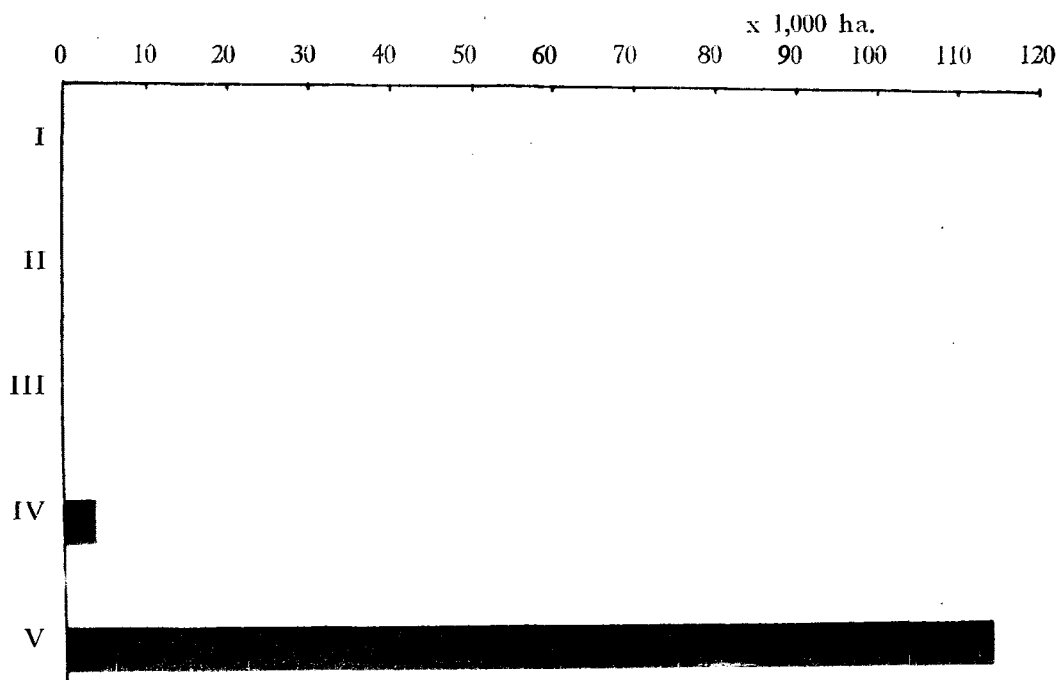


Fig. 18. Unplanted, denuded or nonproductive nonforest land areas by problem area.

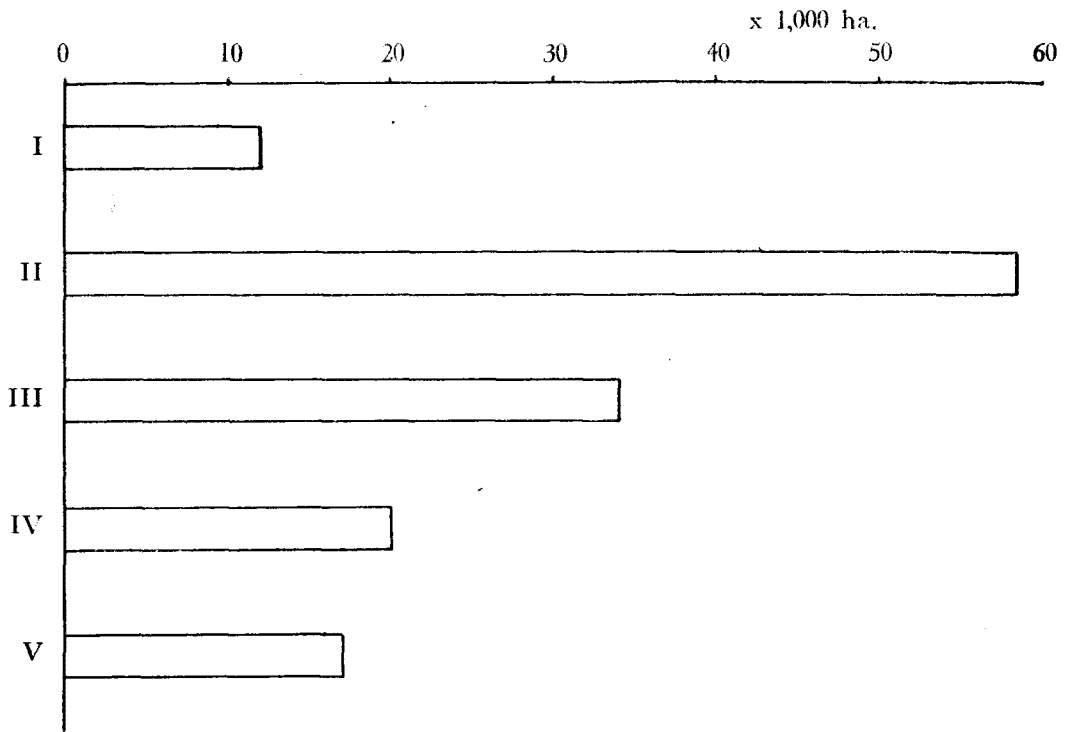


Fig. 19. Water, denuded plantable nonforest, urban-industrial land areas by problem area

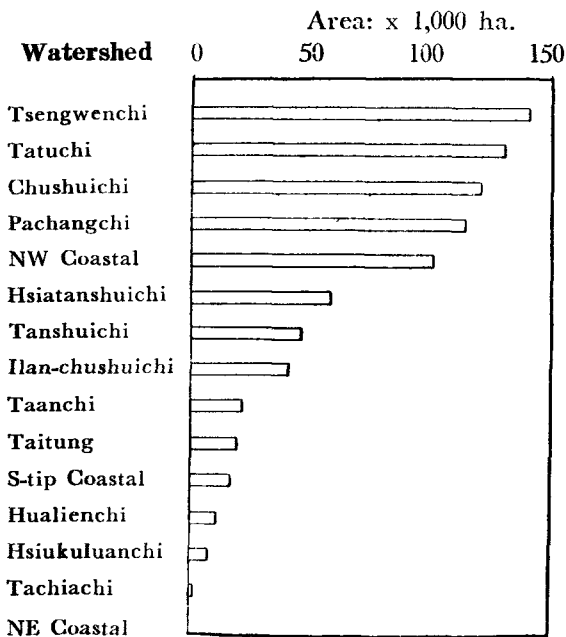


Fig. 20. Distribution of problem area I and II nonforest land by watershed.

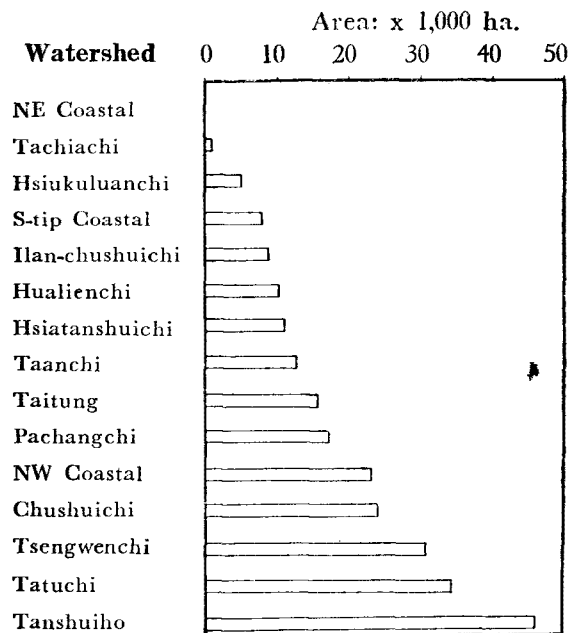


Fig. 21. Distribution of problem area III nonforest land by watershed

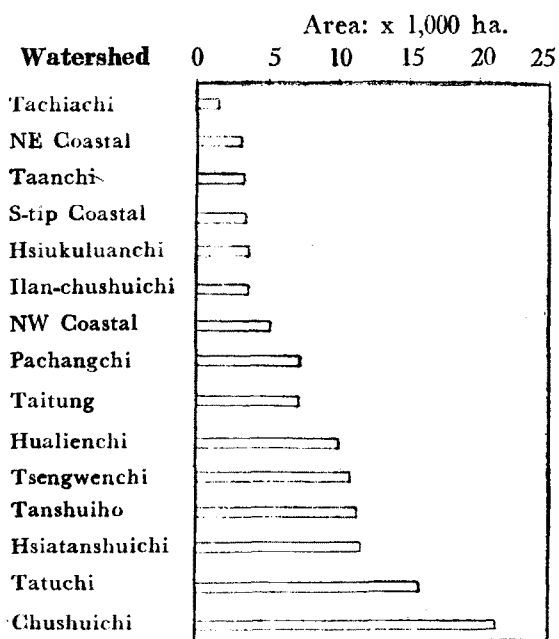


Fig. 22. Distribution of Problem Area IV nonforest land by watershed

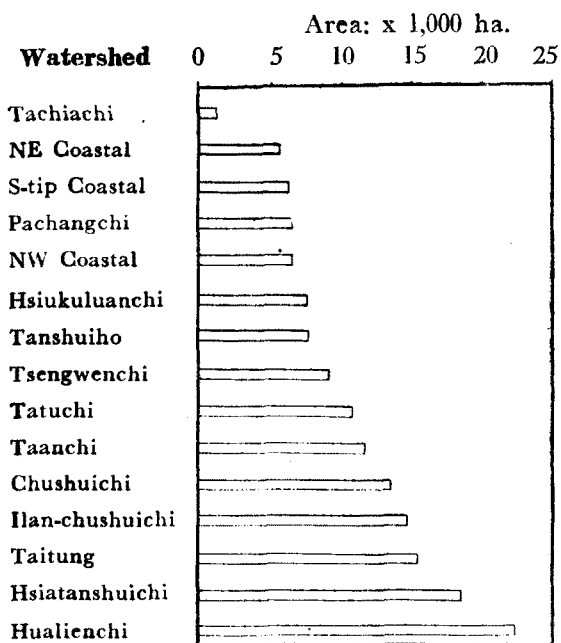


Fig. 23. Distribution of problem area V nonforest land by watershed

AGRICULTURAL INDUSTRIES IN RELATION TO LAND USE AND CROP REQUIREMENT

THE ECONOMIC ROLE OF AGRICULTURAL AND OTHER USES OF LAND

The gross value of products from the various forms of direct and indirect uses of land accounts for 70 percent of the entire national income of Taiwan calculated at current prices of either 1953 or 1954. Direct products from agriculture, forestry, fishery and animal husbandry contribute about 29.5 percent of this national earning. Indirectly from mining, manufacturing (mainly processing of products from land) and other non-agricultural uses of land and its products the nation as a whole derived another 23.5 percent of its income. The remaining 17 percent is earned from the services of transportation and distribution of goods chiefly agricultural and products from land¹².

The significant role of land and good land use in the island's economy may be further comprehended from the fact that about 70 percent of the island's population are making a living from the direct and indirect utilization of land (Fig. 24). In table 5 is given the estimated number of persons deriving their livelihood from agriculture and major agricultural industries or professions relating to non-arable uses of land in 1954. Not included in this table are part time fishermen, government employees in the administrative, educational and research agencies of agriculture, forestry, animal husbandry, water and land and their dependents. Nor is the number of persons engaged in logging, lumbering and other industries dealing in timber included here. These data will be presented in a separate report by LUFFS: "Forest Resource of Taiwan". The average size of family in rural Taiwan is 6.23. It follows therefore that the wellbeing of seven persons out of every 10 on the island now is directly affected by the manner and proficiency in which land is utilized and taken care of.

Table 5.—Number of persons¹³ making a living from utilizing land
or manufacturing of its products

Industry	Employees	Dependents (Estimated)	Employees & dependents
Farming	784,165	3,920,825	4,704,990 ¹⁴
Pisciculture & fishing	109,132	545,660	654,792 ¹⁵
Food processing	57,067	285,335	342,402
Fertilizer manufacturing	3,922	19,610	23,532
Beverages manufacturing	11,480	57,400	68,880
Salt refinery	6,132	30,660	36,792
Tobacco manufacturing	6,450	32,250	38,700
Textile manufacturing	53,087	265,435	318,522
Headwear, footwear & apparel	5,498	27,490	32,988
Leather tanneries	928	4,640	5,568

12. Directorate-General of Budget, Accounts and Statistics, Executive Yuan: National Production and National Income in Taiwan, 1955.

13. CIPEM Report, 1954. not including lumbering and associated industries.

14. MOEA: Economical Statistical Yearbook, published Sept., 1955

15. *ibid.* not including 127,177 part time fishermen and their dependents.

Furniture, wood & bamboo craft mfg.	11,095	55,475	66,570
Paper manufacturing	5,814	29,070	34,884
Non-metallic mining & mfg.	27,894	139,470	167,364
Hydro-electrical power	3,111	15,555	18,666
Transportation, services, etc.	59,640	298,200	357,840
Total	1,145,415	5,727,075	6,872,490

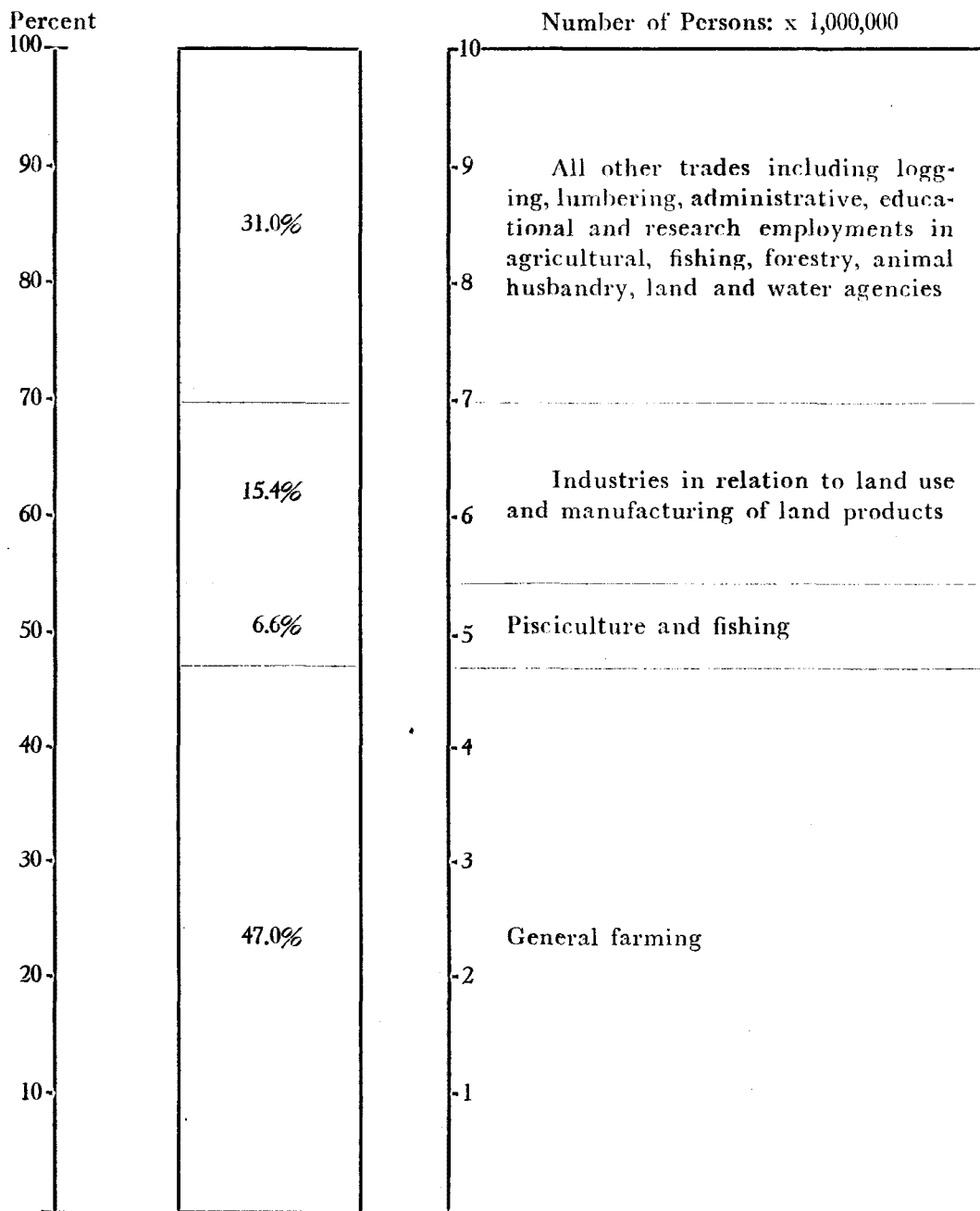


Fig. 24. Percentage of present population depending upon farming and industries in relation to land for livelihood in Taiwan.

THE ROLE OF AGRICULTURAL EXPORTS

In the potentiality of earning foreign exchange, agricultural products exported from Taiwan in the past 4 years (1952-1955 inclusive) averaged 93.6 percent in gross value of all exports annually (Figs. 25 & 26). Out of US\$124,042,000 realized from agricultural exports in 1955, 54.7 percent is from cane sugar and 26.3 percent from rice. Tea, banana, pineapple citronella oil, bamboo shoots and other fruits together earned about 16 percent. The remaining 3 percent derived from other farm and forest products of which timber and feathers are the main contributions amounting to 0.7 percent and 0.6 percent respectively. Some of the exportable items fluctuate somewhat in their percentage contribution to the nation's foreign exchange earnings partly on account of price changes in the export market. (Figs. 27, 28 and 29)

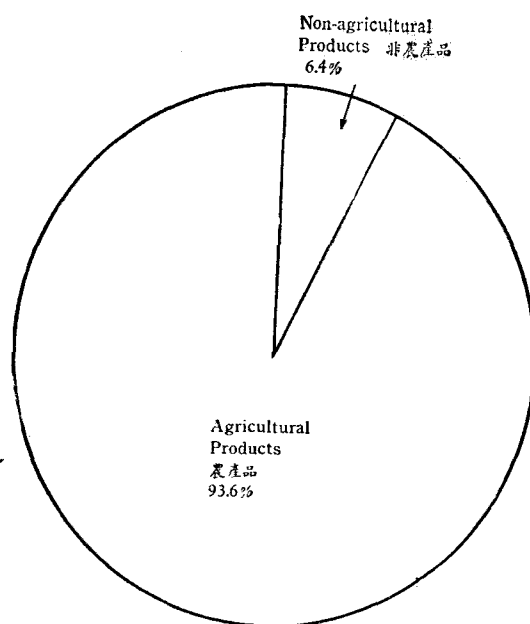


Fig. 25. Value of agricultural products in percent of gross value of all goods annually exported from Taiwan. (4 year average of 1952-1955 inclusive) Total export value in the 4 year period 1952-1955 US\$ 480,470,000

EFFECTS OF INTERNATIONAL TRADE ON LAND USE

The significance of exporting surplus farm and forest products is not merely in gaining financial credit in Free China's international trade but particularly in making possible the timely import of productive equipment and materials needed by the island's industrial, mining and agricultural enterprises. This unavoidable drain of foreign exchange is better than counterbalanced in 1955 by the export earnings from agricultural products. (Figs. 29,30)

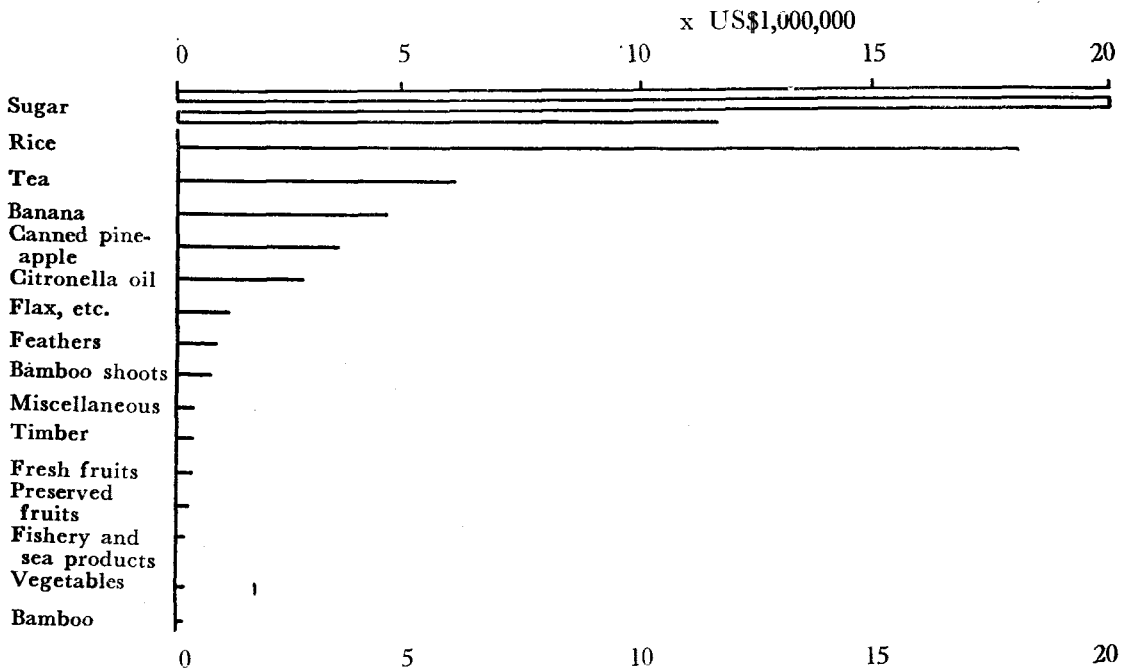


Fig. 26. Averaged value of agricultural products annually exported from Taiwan (1952-1955)

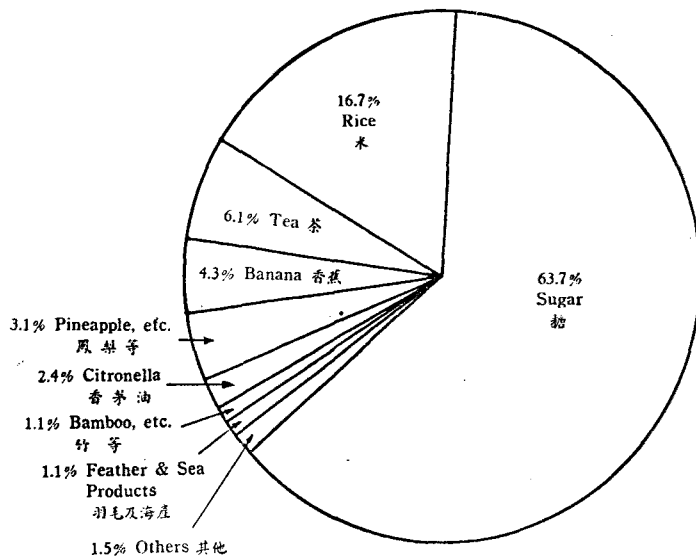


Fig. 27. Percentage of value of agricultural products exported annually from Taiwan.
 (4 year average of 1952-55 inclusive)
 Averaged value of annual export of agricultural products-US\$119,541,000

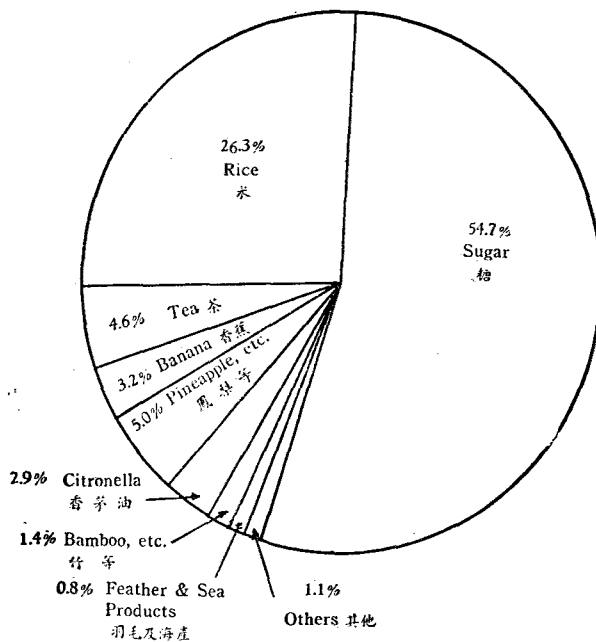


Fig. 28. Percentage of value of agricultural products exported from Taiwan in 1955. Total agricultural export, 1955-US\$124,042,000.

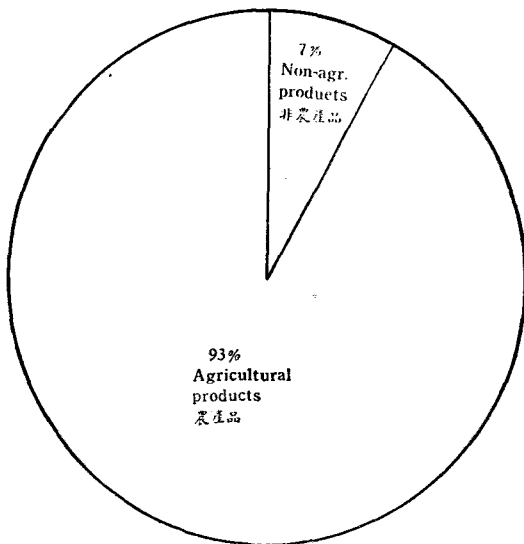


Fig. 29.

Agricultural products in percentage of gross value of all goods exported from Taiwan, 1955.

Total value of exports: US\$133,378,000

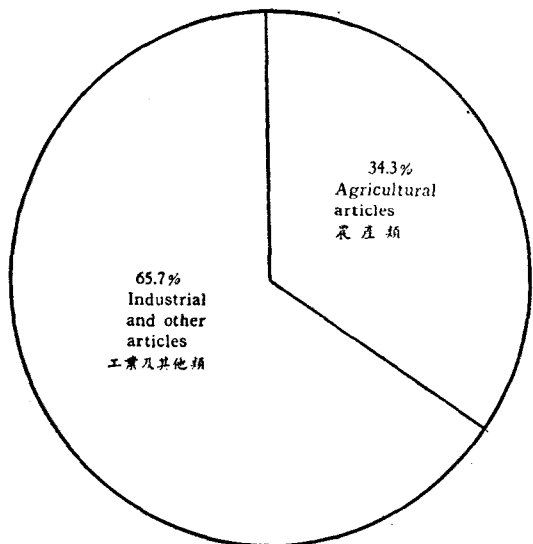


Fig. 30.

Agricultural articles, in percentage of gross value of all goods imported to Taiwan, 1955.

Total value of imports: US\$180,653,000.

Through the export of cane sugar, Taiwan disposes of only some carbohydrates thus leaving practically all essential plant nutrient elements theoretically still within the shores of the island. But the export of other farm products means certain amount of drain on the nutrient materials and therefore some lowering of the island's soil productivity level. In the production operations of growing tea, banana, citronella and most other exportable crops land is invariably exposed and soils excessively depleted as already pointed out in previous discussions. Such cover or use types as timber forest, pastures, grass meadows, or even leveed paddies may serve the multi-purposes of helping conserve soil and water on the one hand and on the other producing articles fit for export as well as home consumption. In the past, unfortunately, these use types have neither offered as high yields as other use types here nor as favorable economic returns as for the same use types elsewhere in the world or locally. The gross economic returns in both their export earnings and domestic contributions are far from being proportionate to the land areas suited or allocated for their production. (Fig. 31).

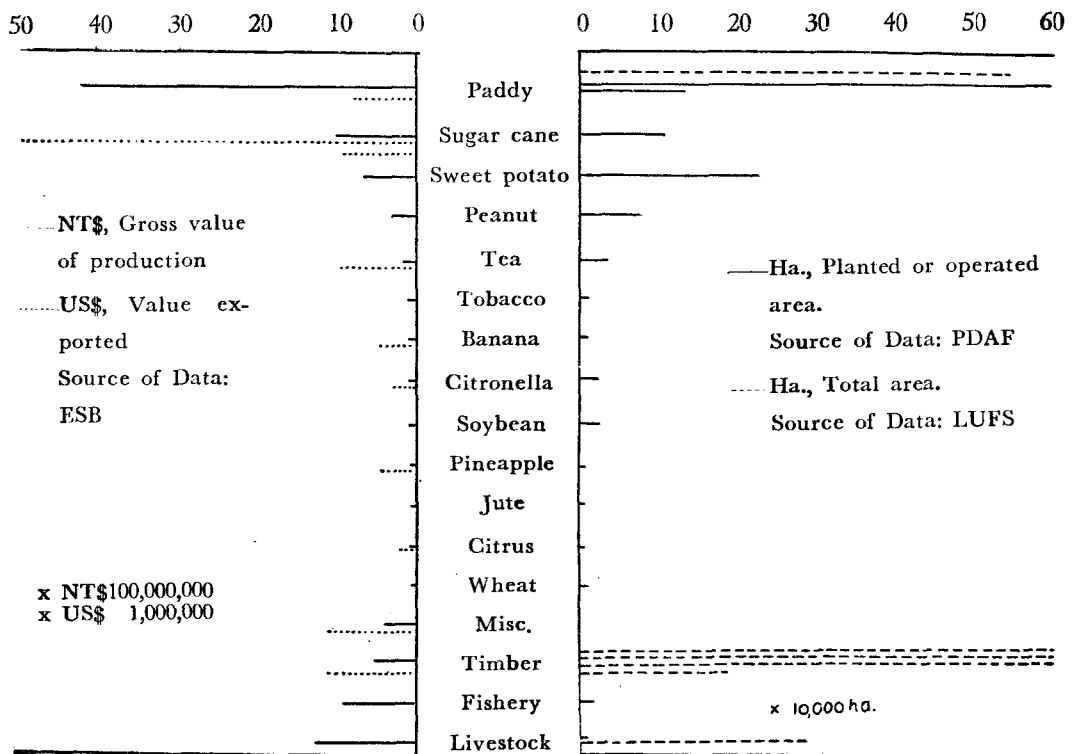


Fig. 31. Areas under and cash returns from various crops, fishery and livestock in 1954

An analysis of the agricultural imports in 1953 and 1954 shows that Taiwan is almost self-sufficient in most agricultural raw materials except the few items as shown in Table 6.

Table 6.—Estimated quantities of agricultural raw materials deficient annually in Taiwan¹⁵

Article	Estimated quantity deficient annually
Soy beans	250,000 M/T
Wheat	150,000
Raw cotton, etc.	30,000
Beef tallow	17,000
Fishery & sea products	6,100
Animal products	6,900
Vegetable oils	4,200
Flax, ramie, etc.	2,000
Fruits, vegetables	2,000
Cereals	1,500
Wool & products	1,200
Total	470,900

From Figures 26, 27, 28 and 31, it is clear that next to cane sugar, rice has the greatest potentiality of boosting foreign exchange earnings besides satisfying domestic demand for a staple food. But even in the maintenance of productivity of land under this crop, there is still room for economical readjustment as well as scientific improvement.

REQUIREMENTS OF PADDY

For the irrigation water alone, the paddy farmer pays from a few NT dollars to NT\$600 per ha. of paddy field operated annually. The 1954 average for all of Taiwan is about 110 kilograms of paddy rice or NT\$181 per ha. Aside from this, there is approximately an equal amount of expenses under the general term of special fee for flood hazard prevention (Reportedly for defraying expenditures incurred in the conservation of water and irrigation/drainage facilities and organizations). The sources of these latter funds are mainly from the financial aids and loans granted by the government and other organizations. It is therefore rather conservative to estimate that the island's annual expenditure exceeds NT\$300,000,000 for maintaining status quo of productive use of water in agriculture alone. Much work in water development and its conservation will have to be done in the source areas before any program of increasing the production of rice, sugar, citrus and other crops or meeting the growing demand for water in urban and industrial communities can be economically reasonable and hydrologically sound.

In view of the huge sums of money contributed every year by farmers and the government for water and irrigation facilities (Old Taiwan \$9,243,158,000 and New Taiwan \$1,791,390,000 from 1945-1955), it is fit and proper to investigate the conditions of the major watersheds which supply this vital liquid raw material essential for all crop production, especially the production of paddy rice. Table 7 shows the extent in hectares and percentages to which the major watersheds on the island provide this agriculturally productive use of water.

¹⁵ Chinese maritime customs: The trade of China (Taiwan), 1953, 1954. and CIPEM: 1954 report.

Table 7.—Watersheds providing irrigation water in the order of decreasing sizes of irrigated area

Watershed	Irrigated area (ha.)	Percent of total irrigated area on island
Chushuichi	110,457	22.12%
Tsengwenchi	103,899	20.38
Hsiatanshuichi	64,461	12.50
Tanshuiho	54,211	10.63
Tatuchi	40,082	7.86
Pachangchi	30,334	5.95
N-W Coastal	28,036	5.48
Tachiachi	24,888	4.88
Ilan-chushuichi	19,959	3.92
Taanchi	12,144	2.38
Taitung	7,940	1.56
Hsiukuluanchi	7,607	1.49
Hualienchi	3,079	0.60
Others	1,474	0.25
Total	508,571	100.00%

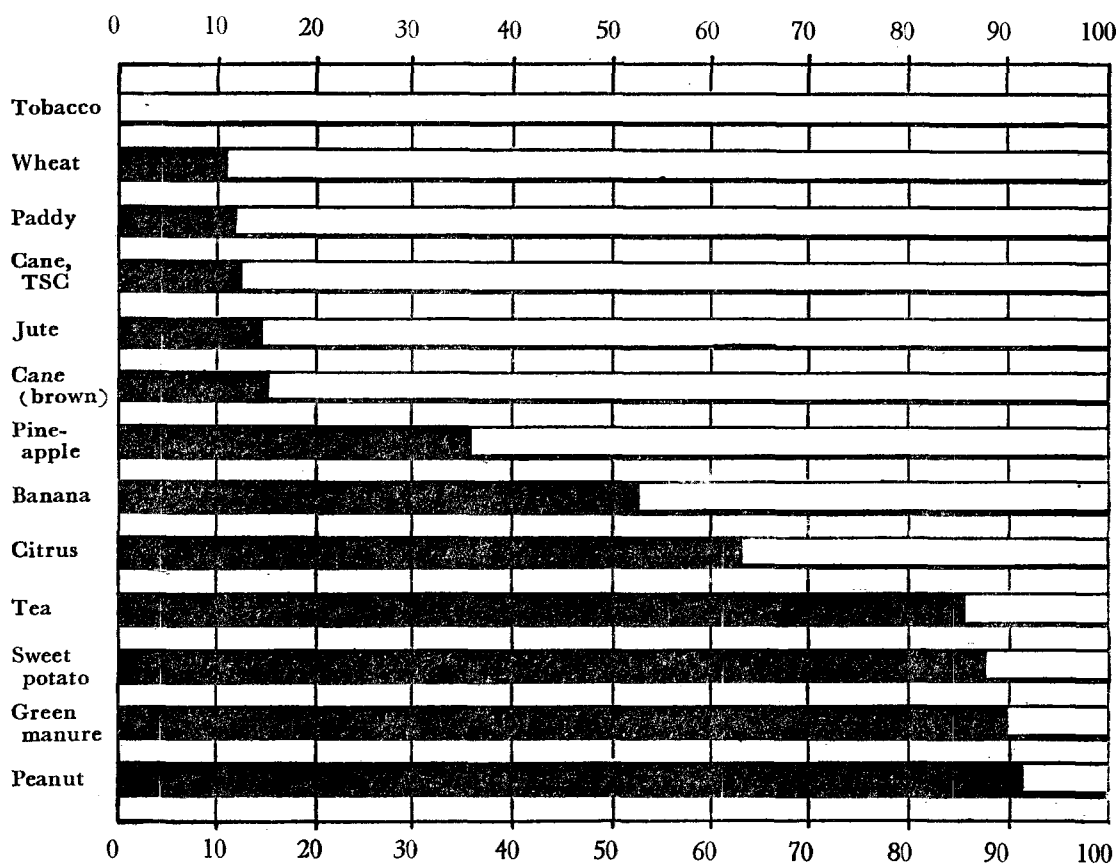


Fig. 32. Percentage of crop areas not receiving fertilizer allocations in 1954

Aside from its water requirements, the paddy rice takes away from the soil considerable amounts of principal plant nutrients. It was estimated that the grain of paddy rice alone removed in the 48 year period prior to 1948 amounts of N, P₂O₅ and K₂O from the paddy fields of Taiwan enough to make 2.6 millions M/T of 20 percent ammonium sulphate, 0.9 million M/T of 20 percent superphosphate and 151,300 M/T of 50 percent muriate of potash respectively. Only a fraction of the crop residue goes back to the paddy fields as manure. Practically all the nitrogen removed by the crop, in seed, stem and leaves is lost in burning as fuel or in uses such as rope and bag making, building and constructions and others except as manure. Prompt and adequate replenishment of the nutrient elements removed by the crop as a whole is necessary for every crop season if normal yield is to be sustained on the same soil. This, however, has not always been so. The unfulfilled fertilizer requirements of the island's major crops can be readily comprehended by comparing the crop areas receiving and not receiving fertilizer allocations in 1954 in Fig. 32 and also the departure of actual fertilizer applications from the tested optimum amounts required as given in Fig. 33.

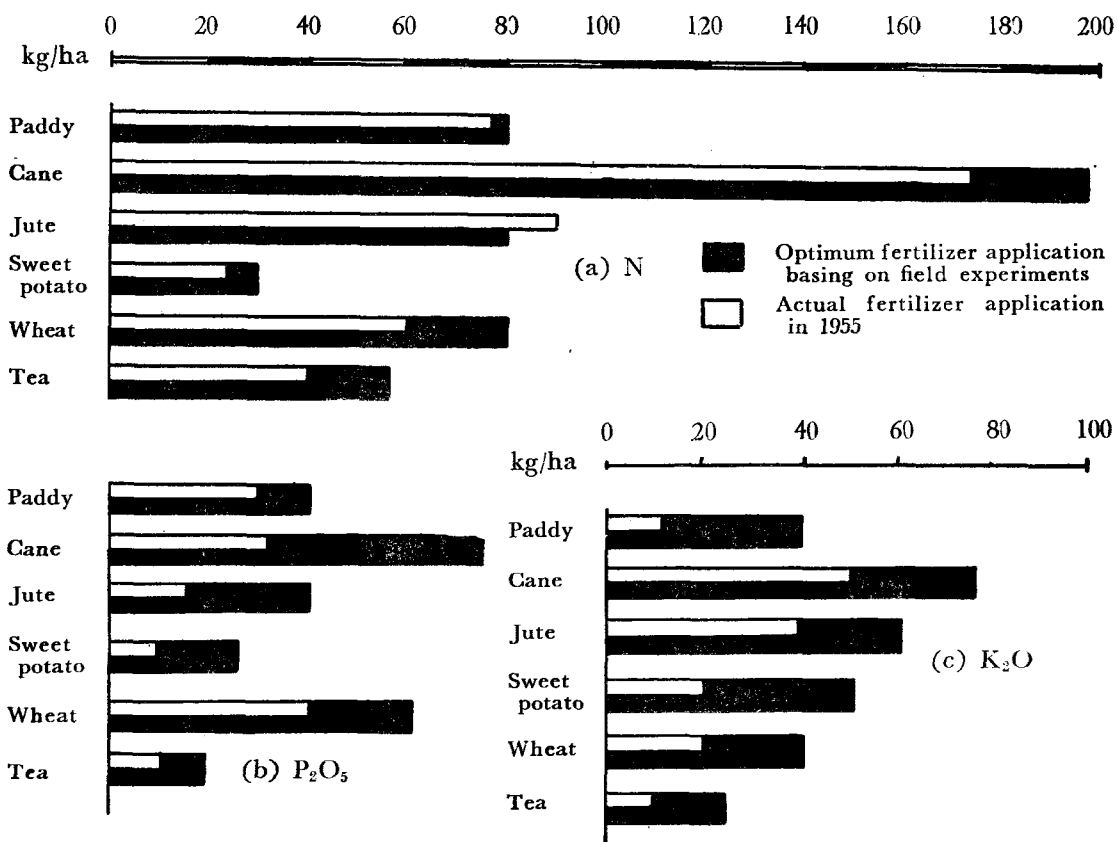


Fig. 33. Actual and optimum application of fertilizers on major crops of Taiwan, 1955

With the exception of upland varieties, rice culture in paddy field is considered to be the field crop that best minimizes soil erosion hazards under normal conditions. The miniature earthen dykes or levees averaged 40 cm. in height enclosing each partitioned unit of level paddy field, regardless whether it is

terraced or not, can conserve almost all the rain water even during the highest rainfall intensity for the majority of cases. The first stage of soil disintegration by water can be thus minimized. The surface drainage of surplus water after sufficiently long period of settling within each of the miniature reservoirs formed by artificial levees is done generally under regulated conduits or paved ditches. Only very small amount of dislocated soil particles may thus be lost in transport.

REQUIREMENTS OF UPLAND CROPS

Soil conservation requirements are most urgent on land cultivated to upland crops. Out of the island's total cultivated land, dryland crops occupied about 480,000 ha. or 46% in 1955. By the definition of the LUFs, they include all land under the following field and special crops, vegetables and fruits:

A. Crops:

Sugar cane	Sweet potato	Upland rice
Peanut	Barley	Wheat
Millet	Corn	Buckwheat
Soy bean	Other beans	Sesame
Rapeseed	Cassava	Tobacco
Cotton	Ramie	Arrow root
Flax	Tea	Coffee
Citronella grass	Sisal	Derris root

B. Vegetables:

Radish	Parsley and other leaf and flower vegetables
Ginger	Cucumber
Taro	Water melon
Irish potato	Guard melon
Onion	Squash
Scallion	Egg-plant
Garlic and other stem vegetables	Asparagus bean
Cabbage	Peas
Leaf mustard	Tomatoes and other fruit vegetables
Water convolvulus	

C. Fruits:

Banana	Lungyen
Pineapple	Mango
Ponkan	Betel-nut
Tonkan	Pomegranate
Sweet orange	Prune
Wentan Pomelo	Peach
White Pomelo	Persimmon
Wenchos orange	Papaya
Velencia orange	Wax apple
Lemon	Grape
Grapefruit, etc.	Loquat

With the exception of a very few, most of these upland crop varieties are exotic in origin. Practically all upland crops require clean cultivation and frequent soil disturbance.

Until now very limited attention has yet been paid to their cultural requirements, not to mention the conservation needs for their cultivation. If there is a favorable price offered for any of these crops, the farmer usually goes ahead planting them on any kind of land currently available and managing them in any manner apparently convenient to him. As a result, surface runoff on most upland farms is unchecked. Removal of top soil cultivated to upland crops is severe and widespread. This is so because of the general slack of conservation management practices such as indicated below:

- (1) Underfertilized.
- (2) Not included in the consistent practices of crop rotation.
- (3) Not terraced at all or not intensively leveled into miniature reservoirs as paddy terraces.
- (4) Lacking well regulated or protected surface drainage facilities.
- (5) Lacking conservation irrigation, that is irrigation water made available by saving rain water with various conservation practices.
- (6) Suffering heavy soil losses from frequent, unchecked and excessive surface runoff.
- (7) Indefinite in their claims over land on the part of the cultivators. This uncertainty in land tenure plus price fluctuations account for crude production and management operations on most upland farms.

OWNERSHIP OF LAND AND LAND USE READJUSTMENT

GOVERNMENT

Government owns over 57% of the land area of Taiwan. This land is in economic and protection forests, aborigine reservations, experiment stations, and other uses. The operation of these national lands is left to various agencies on national,¹⁷ provincial,¹⁸ and hsien¹⁹ levels. In addition, certain enterprising organizations of private or quasi-governmental nature also acquired under various circumstances certain forms of claim over these national lands.²⁰ (Fig. 34)

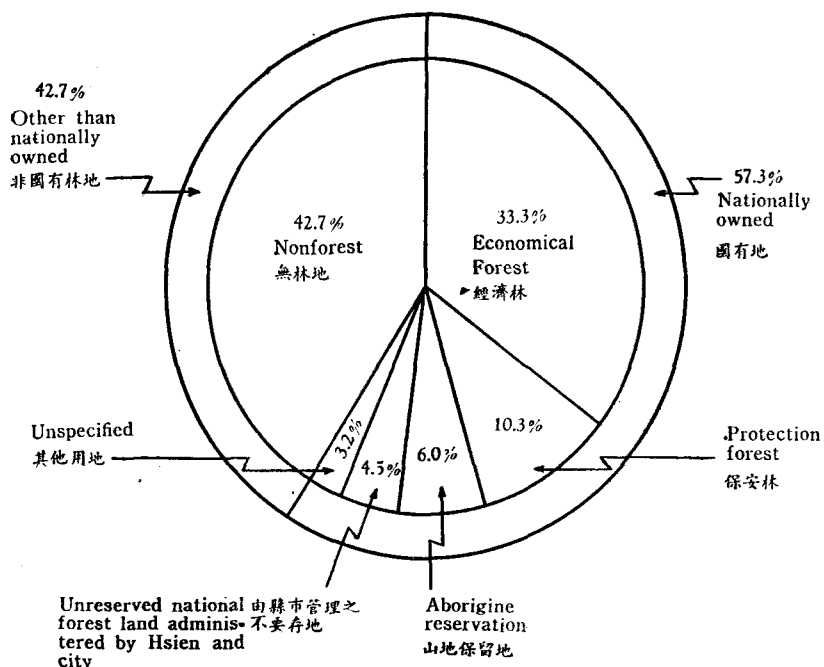


Fig. 34. Land ownership on Taiwan, in percent

Dispute and conflict over proper land use are frequently reported in the national forest land formerly classified by Japanese as unreserved forest and in the "aborigine reservation" land areas. The administration of large parts of these lands is under the Hsien Land Offices, Hsien Bureaus of Reconstruction, Provincial Forestry Administration, PDAF and Provincial Department of Civil Affairs. As a rule there are no permanent land marks on the ground nor conforming boundary lines on most of the separately prepared maps.

It is conventionally accepted that land under national government ownership is principally managed for forest production and/or protection purposes. The obvious need for land use readjustment on these national lands can be readily

17. Experimental Forest, National Taiwan University, Salt Administration and others.
18. TFA, TFRI, Provincial College of Agriculture, Provincial Department of Civil Affairs.
19. Land Office, Agricultural and Forestry Section, Bureau of Reconstruction, Bureau of Civil Affairs.
20. Taiwan Agriculture and Forestry Development Corp., Taiwan Paper and Pulp Corp., Taiwan Sugar Corporation and others.

seen from the fact that there are about 230,000 ha. of nonforest land in nationally owned economic forest areas plus almost 76,000 ha. of nonforest land in areas classified as protection forest.

87% of the nonforest land in the nationally owned territories fall into Problem Areas IV & V (72% and 15% respectively). There are, however, 6.3% of such nonforest land pertaining to the relatively good arable class (Problem Area II) and another nearly equivalent area, to Problem Area III. It is therefore a reasonable estimate that about one tenth of the nonforest areas within the nationally owned land has agricultural possibilities. (Fig. 35).

NON-GOVERNMENT

The management of the remaining 43% of land is mainly by private operators, township level communities and other semi-governmental organizations. These are mainly nonforest lands.

Size of private holdings is relatively very small in nonforest areas. Prior to 1952, almost half of the farm families operated less than $\frac{1}{2}$ ha. About $\frac{1}{4}$ of them operated farms ranging from $\frac{1}{2}$ to 1 ha. In other words, over 70% of the island's farming families used to operate on holdings less than 1 ha. up to 1952. The remaining farming families, with the exception of about 7% cultivating more than 3 ha., operated on farms between 1 and 3 ha. (Fig. 36). After the land to the tiller program, completed over two years ago, the percent distribution of farm sizes underwent noticeable changes particularly among the land purchasing farmers. By 1953, those operating less than 1 ha., 1-3 ha. and over 3 ha. constituted respectively 28%, 56%, and 16% instead of 70%, 23% and 7% as reported previously for all farmers. (Fig. 37) Large holdings now exist only in some government agencies and the one time government operated corporations engaged in the production and processing of cane sugar, tea, pineapple, coffee, paper and pulp products.

In areas other than nationally owned, there are 55.8% of nonforest land belong to the classes with high use capabilities, namely Problem Areas I & II (15.7% and 40.3% respectively). Nonforest lands of Problem Area III and IV occupy about equal areas (18.3% & 18.8% respectively). Problem Area V land amounts to almost 7% in the nonforest category other than nationally owned. (Fig. 38) This last Problem Area includes the alluvial wastes, tidal flats, coastal and other unplatable denuded areas. Regardless of ownership, therefore, there are almost 140,000 ha. of such nonproductive land which present a constant problem of watershed protection and soil conservation in the other productive areas.

After the land reform program was put into practice on Taiwan following 1947, considerable changes in ownership of arable nonforest land took place. The program consisted of three successive steps: (1) farm rent reduction, i. e., limitation of land rent to 37.5% of normal harvest, notably in 1949; (2) sale of public lands, 1951 and (3) land to the tiller, 1953.

Because of the fact that ownership over most arable public land has been distributed among the various agencies on different strata of the government and other organizations, it was necessary to begin the implementation of its first phase by training a total of 4,227 persons recruited from provincial (85), hsien & city (227), district (945) and villages and townships (3,000).

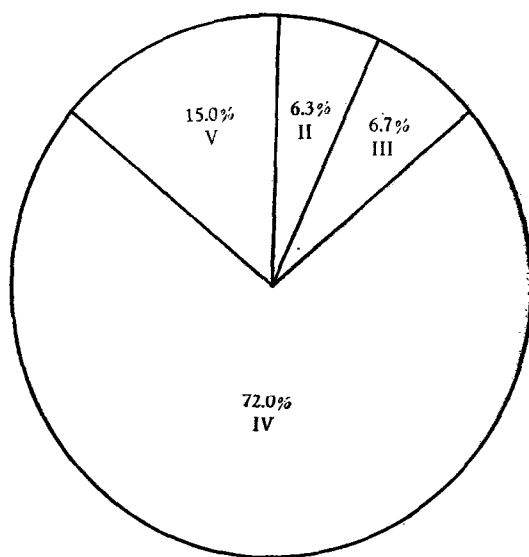


Fig. 35. Nonforest land nationally owned by Problem Area (II-V)

Pre Land-to-the-Tiller Status

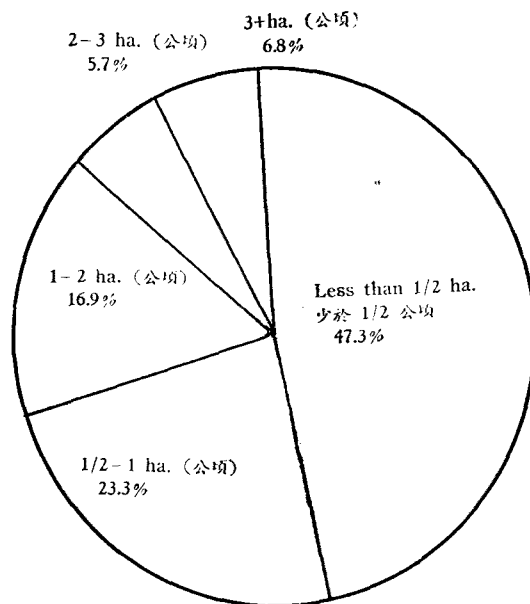


Fig. 36. Percent distribution of sizes of farm holding in Taiwan, 1952.

Original size figures were given in "Chia". 1 chia equals 0.969917 ha. or 2.3968 acres. Same conversion holds for Figs. 37, 40, 41, and 42.

Post Land-to-the-Tiller Status

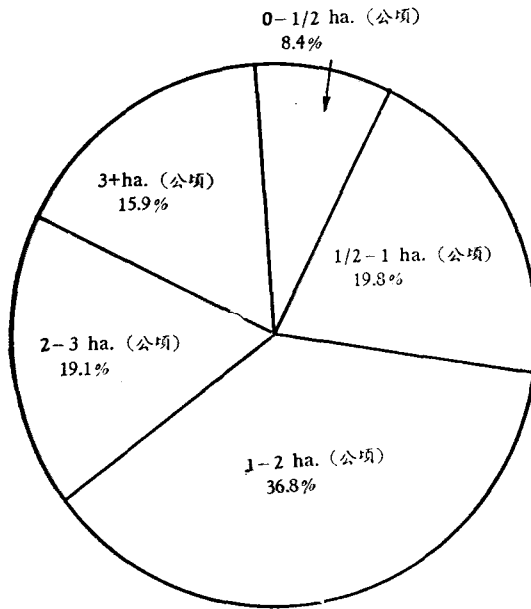


Fig. 37. Percent distribution of farm sizes cultivated by land-purchasing farmers, 1953.

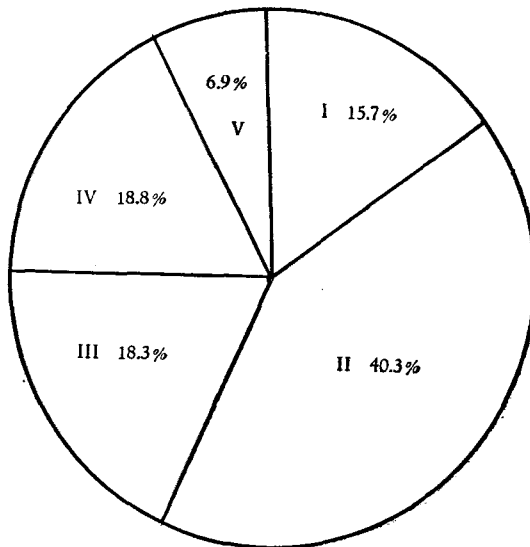


Fig. 38. Nonforest land not nationally owned by Problem Area (I-V)

The second phase of the land reform program was mainly aimed at liquidating some of the 176,045 ha.* public land formerly owned and operated by the government's civil and military agencies, and other organizations. The enterprising corporations of quasi-governmental nature owned nearly 67% of these public lands or over 8% of total cultivated area of Taiwan (Fig. 39).

The transfer by official lease of some of these public lands to tenant farmers was first made in 1947 with the result that the government departments, schools and public enterprises retained only 41.1% of the former public lands. This amounts to about 72,295 ha.** of which the sugar corporation retained 59,606 chia or 57,818 ha.

The successive sales from 1948 to 1953 of public farm lands to farmers changed the percentage of area leased to farm families from 58.9% to 24.2% with the remaining 34.7% of public farm land sold to farmer purchasers. The entire picture of ownership changes is summarized as follows:

Public Farm Land	Area	Percent
(1) Retained by government agencies, public enterprises etc.	72,295 ha.	41.1%
(2) Leased to private cultivators	42,640 ha.	24.2%
(3) Sold to farmer purchasers	61,110 ha.	34.7%
	176,045 ha.	100%

It is not unlikely that during the campaign of liquidating public land from 1948 to 1953, high percentage of the 107,000 ha. dry farming upland originally owned by the public offices on various levels was not very suitable for farming.

Those farmers who purchased public lands are mostly in the low economic

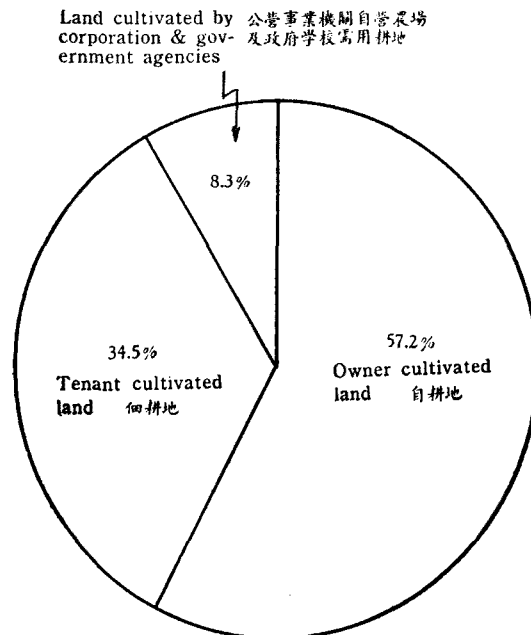


Fig. 39. Percent area of cultivated land by ownership as of 1952

*181,490 chia.

**74,531 chia.

brackets (Figs. 40, 41, & 42). It is natural that in majority of cases, the needs for some use readjustment, for intensified soil conservation and management practices were left unheeded.

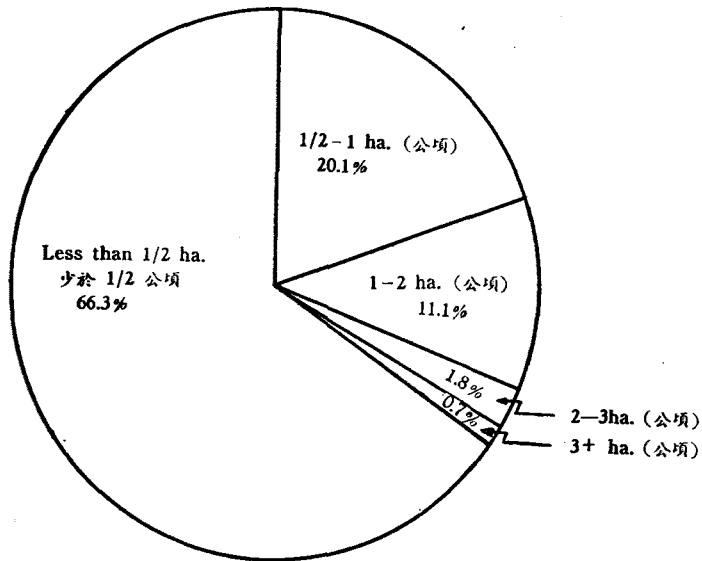


Fig. 40. Percent distribution of farming families purchasing public land 1948, 1951 & 1952.

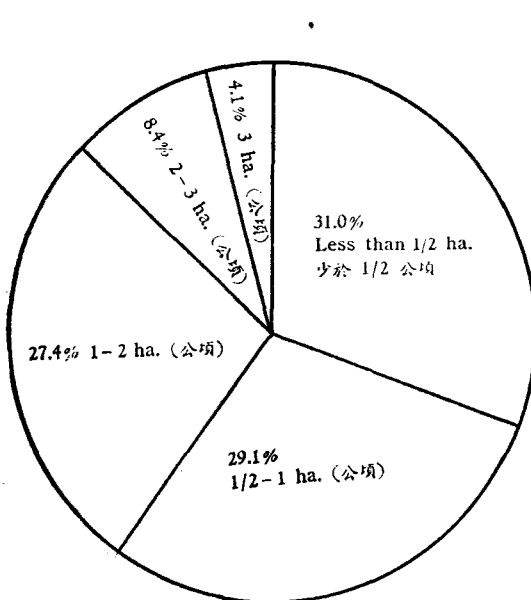


Fig. 41. Percent distribution of farming families buying land under LTTT Program, 1953 by size of farm cultivated.

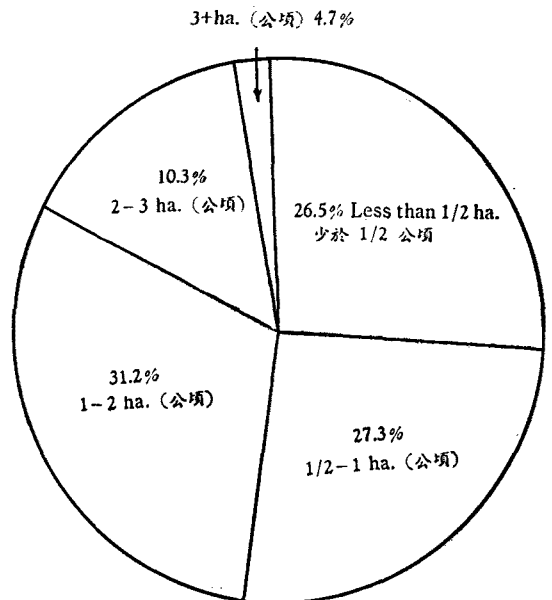


Fig. 42. Arer cultivated by 96,906 farming families purchasing public land in 1948, 1951 & 1952.

CONCLUSION AND RECOMMENDATION

1. Nature has bestowed upon Taiwan a well diversified climatic environment for agricultural and forestry development. The wisest use of land resources and appropriate allocation of economic means must now be made in order that land productivity can be safeguarded for the ever-increasing population.

2. The interest of the general public has been focussed so far on the plains areas which constitute less than $\frac{1}{4}$ of the Island's land surface. More attention should be directed to the proper development and conservation of the foothills, tablelands and mountains. Combined, these constitute nearly 70 percent of total land area of Taiwan

3. Generally very susceptible to wind and water erosion, most of the Island's soils need prudent care to prevent further deterioration in their present level of productivity

4. The greatly expanded cultivation of steep hillsides to upland crops greatly aggravates the denuded condition of land and exposes the soils to destructive forces of erosion. More intensive conservation practices should be employed to counterbalance the lack of wise land use.

5. For every hectare of good paddy field in the plain areas recently converted into urban, industrial and other uses, it often takes at least 7 hectares of hilly upland to make up the productive capacity of the reduced crop area. Much therefore is desired in the conservation and management of these marginal uplands. More detailed land capability surveys in these areas are being conducted and capability classes delineated on 1:20,000, scale maps by the Taiwan Agricultural Research Institute (TARI). These surveys should be used as a basis for promoting proper land use and soil conservation programs.

6. For annual repair and construction of dikes and embankments, levees and other works to bring about temporary relief from silting, inundation, flash floods and other run-off hazards in the productive plains, the huge expenditure incurred every year drains heavily from the government's as well as farmer's financial budgets. Long range protection and conservation measures should be further strengthened at the source areas of silting materials and flood waters, namely along the headwaters in the highlands.

7. To increase the yield of paddy rice on the present acreage it is necessary that steady and dependable sources of irrigation water be developed and protected, and improved farming practices be instituted. This means the prompt strengthening of protection management measures in the headwater areas in the mountainous highlands.

8. For timely and adequate replenishment of the plant nutrients removed by crops or lost in eroded soils it is necessary also to intensify and expedite the adoption of good soil management and conservation practices, particularly in the communities depending on lands in problem area III or IV.

9. A portion of the 305,000 hectares of grasslands may possibly be developed for livestock production. But due to their high inaccessibility, scattered distribution, steepness in slopes, lack of stock water supplies, severity of soil erosion etc., it will be difficult to readily develop many of these areas for grazing purposes. A large proportion of mountain grasslands should be planted to locally adaptable species of trees. These areas need better protection rather than development for

economic production alone. Frequent ground fires in high mountainous areas are reported to have started from grasslands. This is due to the fact that this type of vegetation dries fast and reaches the dangerous kindling point before most other types. They represent, therefore, areas deserving the nation's foremost attention in protection measures.

10. Increased employment can be provided by releasing, in any legitimate manner, some portions of the nationally owned nonforested and poorly stocked lands which urgently need improvement in use and management. Large number of trained rangers, foresters, fruit or vegetable growers, handicraft technicians and others will be needed in implementing an overall conservation development program based on the wisest and safest utilization of these "semi-idle lands".

11. It is recommended that a committee consisting of specialists and key personnel of agencies concerned in the use, management and administration of land be set up at the highest level of the government to work out practical steps to expedite the early release of government owned nonforest lands (and some poorly forested lands) to enterprising individuals or organizations for proper development. In return the government should be guaranteed increasing amounts of rental, share crop, or advance payment from year to year either as collateral or as a down payment for land purchased on instalment plan for approved land use. The nation's present financial strain can certainly stand some of this reliable revenue which is conservatively estimated at NT\$20,000,000 annually @NT\$400/ha. for 50,000 ha, in the first five years. In later years the established plantations, handicraft industries etc. may bring many times this figure in annual revenues to the government treasury as well as the enterprising operators' pocket book.

12. It is further recommended that strict penalty should be enforced on the illegal transfer of, or conscious departure from the approved use or development plan. This is to insure the safe use of land resources without damaging any.

13. From the standpoint of land capability for implementing soil and water conservation, there are in both the nonforested and forested areas more lands suitable for building up the island's forest resources than lands suitable for arable agriculture. It is therefore rather risky should more incentive be given to resettlement projects involving farming activities by untrained hands on lands of conservation problem areas lower than III.

14. The time of spurring people by government decrees or police force to adopt a new way of doing things is past. Soil and water conservation, in particular, can not be achieved on a national scale by such compulsory measures. Since the myriads of individual farmers are separately managing their land and water resources, each on his own piece of property and with his own incentive and implements, an overwhelming majority of them must be convinced of benefits of conservation practices by demonstration and financial and technical assistance in putting such measures into practice on their individual farms. This involves a great deal of extension education and technical training. It is recommended that the present small unit in the Provincial Government on soil and water conservation be strengthened both in trained personnel and action program and that practical field training for personnel on different levels be continued and enlarged for at least 3 more years to reach a goal of one field conservationist in 3 to 5 hsiang or townships. These technicians might be paid by the Provincial Government, but work with the local extension agents, and periodically be briefed or trained for more practical experience and technology in soil and water conservation practices.

15. This report is but the first overall analysis of land use condition on the island of Taiwan. More specific studies should be separately made in mapping conservation and management plans for special regional areas. Some of the generalized recommendations, it is hoped, may be implemented before much more land is ruined by the incessantly active erosion forces. Much can be gained from the old Chinese proverbs, "Better go to the business before the rain comes" and "It is often later than you think".

APPENDICES

SURVEY PROCEDURE

These estimates of land use areas are based upon data obtained from a double-sampling survey, combining the use of aerial photography with ground sampling procedure.

Aerial photography.—Twenty-four sample strips of aerial photography were flown in an east-west direction (at a right angle to the general topography). A random-systematic system of spacing placed the flight lines 10 miles apart. The photography was done with a 24-inch focal length, minus blue filter and infra-red film at an elevation of 20,000 feet with 1,500-3,000 feet between photo centers.

The basic statistical data of this survey were derived from the sample strip photography.

In addition to the sample strip photography, almost complete coverage of the island in 1/40,000 panchromatic, mapping photography taken from 1948 to 1952 was available. The mapping photography was interpreted and delineated into land use and forest cover types, problem areas, and stand-size classes. The delineated data were transferred to 1/50,000 topographic maps which are available to technicians for various types of land use and forest management planning. The delineated data on the 1/50,000 maps were condensed and placed in color on 1/250,000 topographic maps. These maps are small enough to be displayed on walls, and are of value for policy planning. The 1/250,000 maps were further condensed for inclusion in the analytical reports as well as for illustrative purpose in other publications.

Photo-interpretation.—A large number of plots (37,495) were distributed over the photographs. Nonforested areas were classified by present use classes. In addition, all plots were classified by problem area classes (based upon depth, texture and erodible qualities of the soil as well as slope and aspect).

Ground plot examination.—A total of 545 of the plots established on the aerial photographs were chosen by random selection for examination on the ground. Non-forest ground plots were examined to check the accuracy of the photo-interpretation and to estimate conservation measures needed and their costs.

Compilation of data.—Photo interpretation and field plot data were entered on punch cards by the Bank of Taiwan's statistical department. Tabulations were made from these punch cards to obtain the data set forth in this report.

ACCURACY OF DATA

Accuracy of the estimates is affected by two types of errors. One type of error involves human mistakes in measurement and judgement and from limitations of method and equipment. Effects of this type of error—often referred to as reporting and estimating error—cannot be appraised mathematically, but constant attention was given to hold this type of error to a minimum by proper training and good supervision and by emphasis on careful work.

The second type of error is called sampling error and it is subject to a mathematical evaluation of the probability of error. The sampling error comes from the use of a sample to estimate the total and its size is determined by the varia-

bility of the items sampled and the number of samples measured.

Acreage estimates of small numerical size can be expected to have larger sampling errors than estimates of large numerical size. Sampling errors for the principal items for Taiwan as a whole are given below as percentages of their respective totals:

Nonforested land area $\pm 1.9\%$

Area statistics by use or cover type, problem area class, etc., reported in the tables herewith are subject to increasing sampling error as the class becomes finer and the area in a class smaller. In general the ranges in area sampling error shown below can be expected.

Class area in hectares	Approximate area sampling error in percent
Less than 50,000	Variable, usually over 40
50,000 to 100,000	Ordinarily between 20-40
100,000 to 300,000	Usually between 10-20
More than 300,000	Commonly less than 10

DEFINITION OF TERMS

LAND

Forested land.—Land that is at least 0.5 hectare in size and 36 meters wide with at least 10 percent of the area covered with tree crowns or commercial bamboo, or land that has at least 250 uniformly distributed trees of reproduction size per hectare. Open lands less than 0.5 hectare in size or less than 36 meters wide (except main roads and railroads) which are surrounded by forest are considered as forested land. Orchards, shade trees in cities or agricultural areas, and tree nurseries are not considered forested land.

Nonforest or Nonforested land.—Land that is at least 0.5 hectare in size and 36 meters wide with less than 10 percent of the area covered with tree crowns or commercial bamboo, or that has less than 250 evenly distributed trees of reproduction size per hectare. Forests less than 0.5 hectare in size or less than 36 meters wide which are surrounded by nonforest are considered as nonforest land.

Protection land.—Land on which utilization of timber is prohibited through existing statute, ordinance or administrative order for protection of soil and conservation of water.

Unreserved forested land.—Forested land on which utilization of timber is not prohibited.

National forest land.—Nationally owned land now under the jurisdiction of the Taiwan Forest Administration. Includes the National Taiwan University Experimental Forests, Taiwan Forest Research Institute Experimental Forest, Provincial College of Agriculture Experimental Forest, Taiwan Tea Corporation land now under the jurisdiction of Taiwan Forest Administration, and land formerly owned by Private Japanese Corporations.

Other land.—Includes all lands not under the jurisdiction of the Taiwan Forest Administration. Included is private land and lands under the jurisdiction of county governments or Provincial agencies other than the Taiwan Forest Administration.

NONFORESTED LANDS

LAND USE

The present use or cover types of nonforested land is classified as follows:

Use/cover	Description
Grassland	Tall or short grass excluding commercial bamboo groves.
Cultivated (Paddy)	Continuously cultivated land primarily managed for, or already having facilities capable of, paddy rice production.
Cultivated (Dry-farming)	All cultivated land other than Cp as described above, including all dry farming land under continuous, intermittent or shifting cultivation.
Farm woodland	Hedgerows, windbreaks and other wooded areas less than 0.5 hectares in size or less than 36 meters wide.
Urban or industrial	Urban or industrial areas including salt flats, villages, cemeteries, etc..
Water area	Water area including tidal flats lakes, reservoirs, streams and rivers.
Denuded, plantable	Bare lands such as sand dunes, denuded land and badly eroded land that is suitable for planting to trees.
Denuded, unplantable	Bare lands such as land slides, unstabilized alluvium and bare rocks that are not suitable for planting to trees.

PROBLEM AREA CLASSES

Problem area classes were determined by the intensity of conservation problems confronting the use of nonforested land. They are based on such physical land conditions as slope, soil depth and texture, susceptibility to erosion and related data for these areas.

Problem area class I.—Land with no appreciable conservation problem which can be continuously cultivated without any particular hazard to sustained productivity.

Problem area class II.—Lands with minor to moderate conservation problems which require moderate soil conservation practices to maintain the structure and productivity of the soil.

Problem area class III.—Nonforest lands that are marginal. Continuous farming on these lands will cause serious soil losses unless intensive treatment and conservation practices are followed. Proper future use and treatment must be based on physical and other related data for each individual case.

Problem area class IV.—Lands in this class are not suitable for farming but should be kept under permanent vegetative cover for protection and production purposes. It includes lands with sufficient soil material for reforestation.

Problem area class V.—Denuded lands which lack sufficient soil to support forest cover. Only by very expensive uneconomical measures can such lands be made productive.

TABLE 1.—LAND AREA BY PRINCIPAL USE AND
MAJOR FOREST TYPES

Land class	Area
	Thousand Hectares
Forested land	
Conifers	373.0
Conifer-hardwood	55.3
Hardwoods	1,427.3
Bamboo	113.9
Total	1,969.5
Agricultural	
Paddy	559.6
Dry-farming	445.0
Farm woodland	38.2
Total	1,042.8
Other land	
Grassland	305.1
Denuded, plantable	20.1
Denuded, unplantable	117.4
Urban and industrial	74.1
Water area	47.0
Total	563.7
All lands	3,576.0

TABLE 2.—FORESTED AND NONFORESTED LAND
BY MAJOR OWNERSHIP

Ownership	Forested land	Nonforested	Total
	Thousand Hectares		
National forest			
Unreserved	1,114.7	229.2	1,343.9
Protection	295.2	72.6	367.8
Total	1,409.9	301.8	1,711.7
Other lands			
Unreserved*	551.9	1,300.9	1,852.8
Protection	7.7	3.8	11.5
Total	559.6	1,304.7	1,864.3
All ownership	1,969.5	1,606.5	3,576.0

* Includes aborigine reservation.

TABLE 3.—FORESTED LAND BY MAJOR FOREST TYPES

Forest type	Area
	Thousand Hectares
Conifers	
Spruce-fir	61.3
Hemlock	133.0
Cypress	43.0
Pine	70.2
Other conifers	65.5
Total	373.0
Conifer-hardwoods	55.3
Hardwoods	
Tropical hardwoods	612.8
Subtropical hardwoods	565.8
Temperate hardwoods	248.7
Total	1,427.3
Bamboo	113.9
All types	1,969.5

TABLE 4.—FORESTED LAND BY COUNTY AND MAJOR FOREST TYPES

County	Forest types			Total
	Conifers	Conifer-hardwoods	Hardwoods & bamboo	
Thousand Hectares				
Changhua	—	—	5.2	5.2
Chiayi	16.5	2.0	60.7	79.2
Hsinchu	10.6	3.1	80.1	93.8
Hualien	99.6	10.6	247.2	357.4
Ilan	19.1	2.5	118.1	139.7
Kaohsiung ¹	13.7	5.6	106.8	126.1
Miaoli	20.4	9.8	69.5	99.7
Nantou	120.3	9.1	139.7	269.1
Pingtung	1.7	4.3	153.7	159.7
Taichung ²	33.6	0.3	71.5	105.4
Tainan ³	2.7	0.3	71.6	74.6
Taipei ⁴	10.6	0.9	133.2	144.7
Taitung	23.2	6.1	236.8	265.9
Taoyuan	1.0	0.7	33.4	35.3
Yunlin	—	—	13.7	13.7
Total	373.0	55.3	1,541.2	1,969.5

1. Includes Kaohsiung city.

2. Includes Taichung city.

3. Includes Tainan city.

4. Includes Taipei and Keelung city and Yangmingshan Administration.

TABLE 6.—ACCESSIBILITY OF FORESTED LAND
BY VOLUME CLASS

Volume class M ³ per ha.	Operable			Nonoperable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Hectares				
00-49	814.0	173.4	987.4	31.4	1,018.8*
55-99	222.0	145.2	367.2	15.1	382.3
100-149	93.3	69.3	162.6	7.1	169.7
150-199	59.9	49.2	109.1	6.5	115.6
200-299	68.3	63.0	131.3	8.4	139.7
300-399	28.6	39.3	67.9	4.2	72.1
400-499	6.8	11.1	17.9	1.7	19.6
500-749	12.9	20.0	32.9	1.6	34.5
750+	5.8	10.9	16.7	.5	17.2
Total	1,311.6	581.4	1,893.0	76.5	1,969.5

* Bamboo included.

TABLE 6.—NONFORESTED LAND BY MAJOR OWNERSHIP AND USE

Ownership	Land use class						Total
	Cultivated*	Grassland	Urban and industrial	Denuded, plantable	Denuded, unplantable	Water area	
	Thousand Hectares						
National forest							
Unreserved	36.4	151.0	1.0	3.4	36.4	1.0	229.2
Protection	16.4	41.8	0.3	1.2	8.0	4.9	72.6
Total	52.8	192.8	1.3	4.6	44.4	5.9	301.8
Other lands							
Unreserved	989.0	110.6	72.4	15.5	72.3	41.1	1,300.9
Protection	1.0	1.7	0.4	—	0.7	—	3.8
Total	990.0	112.3	72.8	15.5	73.0	41.1	1,304.7
All ownership	1,042.8	305.1	74.1	20.1	117.4	47.0	1,606.5

* Includes farm woodlands.

TABLE 7.—NONFORESTED LAND BY MAJOR OWNERSHIP
AND PROBLEM AREA CLASS

Ownership	Problem area class					Total
	I	II	III	IV	V	
Thousand Hectares						
National forest						
Unreserved	—	18.7	15.4	160.0	35.1	229.2
Protection	—	—	5.0	57.4	10.2	72.6
Total	—	18.7	20.4	217.4	45.3	301.8
Other lands						
Unreserved	204.6	525.8	238.6	243.7	88.2	1,300.9
Protection	—	1.0	—	0.9	1.9	3.8
Total	204.6	526.8	238.6	244.6	90.1	1,304.7
All ownership	204.6	545.5	259.0	462.0	135.4	1,606.5

TABLE 8.—NONFORESTED LAND BY EROSION CLASS AND
PROBLEM AREA CLASS

Erosion class	Problem area class					Total
	I	II	III	IV	V	
Thousand Hectares						
1	204.6	125.6	5.6	—	—	335.2
2	—	387.8	141.2	51.0	—	580.0
3	—	32.1	112.8	250.7	—	395.6
4	—	—	—	150.2	5.0	155.2
5	—	—	—	10.1	130.4	140.5
Total	204.6	545.5	259.0	462.0	135.4	1,606.5

TABLE 9.—NONFORESTED LAND BY PROBLEM AREA CLASS
AND MAJOR USES

Major uses	Problem area class					Total
	I	II	III	IV	V	
Thousand Hectarea						
Cultivated						
Paddy	192.6	302.7	59.3	5.0	—	559.6
Dry-farming	—	184.2	132.1	128.7	—	445.0
Farm woodland	—	—	10.2	28.0	—	38.2
Total	192.6	486.9	201.6	161.7	—	1,042.8
Grassland	—	—	23.8	276.2	5.1	305.1
Urban and industrial	—	—	—	—	—	74.1
Water area	—	—	—	—	—	47.0
Denuded, plantable	—	—	—	—	—	20.1
Denuded, unplantable	—	—	—	—	—	117.4
Total	—	—	—	—	—	563.7
Grand total	—	—	—	—	—	1,606.5

TABLE 10.—NONFORESTED LAND BY PROBLEM AREA
CLASS AND ELEVATION

Elevation in meters	Problem area class					Total
	I	II	III	IV	V	
Thousand Hectares						
0-599	204.5	539.3	228.3	202.6	95.9	1,270.6
600-1199	0.1	5.3	26.4	105.3	10.8	147.9
1200-1999	—	—	2.7	56.0	12.2	70.9
2000-2999	—	0.9	0.8	77.6	11.8	91.1
3000-	—	—	0.8	20.5	4.7	26.0
Total	204.6	545.5	259.0	462.0	135.4	1,606.5

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