CHINESE-AMERICAN

JOINT COMMISSION ON RURAL RECONSTRUCTION

Plant Industry Series No. 13

NATURAL ENVIRONMENT AND CROP DISTRIBUTION IN TAIWAN

by

H. T. Chang

TAIPEI, TAIWAN, CHINA

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FOREWORD

This booklet is intended to provide the readers with the basic background information on the agriculture of Taiwan in a condensed form. In discussions on natural environmental factors, efforts have been made to give only the essential facts in relation to agricultural production. Technical terms are avoided as much as possible in favor of common descriptive terms. For more detailed information on any of the subject headings, readers are referred to the cited reference.

H. T. Chang

June, 1956

Conversion Factors

1 kilometer	=	0.621 mile
1 meter	=	39.4 inches
1 millimeter	=	0.039 inch
1 hectare	=	2.471 acres
1 sq. kilometer	=	0.386 sq. mile

Natural Environment and Crop Distribution in Taiwan

1. Area of Taiwan

The Province of Taiwan is composed of 78 Islands, with a total area of 35,961 square kilometers. It is about one third the area of Kiangsu Province of the Mainland China and one-fourth the size of the State of Illinois of the United States. The area of the main Island of Taiwan itself is 35,760 square kilometers. The length of the Island from north to south is 394 kilometers, and the width from west to east, 144 kilometers. The Tropic of Cancer crosses the Island slightly south of the middle of the Island.

Administratively, Taiwan Province is divided into 16 prefectures (locally called "Hsien"), 5 municipalities (Shih) and one administration. The Prefectures are divided into townships ("Chen" with a larger town or "Hsiang" with a smaller town), and the municipalities into districts (Chu). There are a total of 360 townships and districts which form the basic administrative units of Taiwan (Map 1 and Table 1).

MAP 1 ADMINISTRATIVE DISTRICTS OF TAIWAN, CHINA

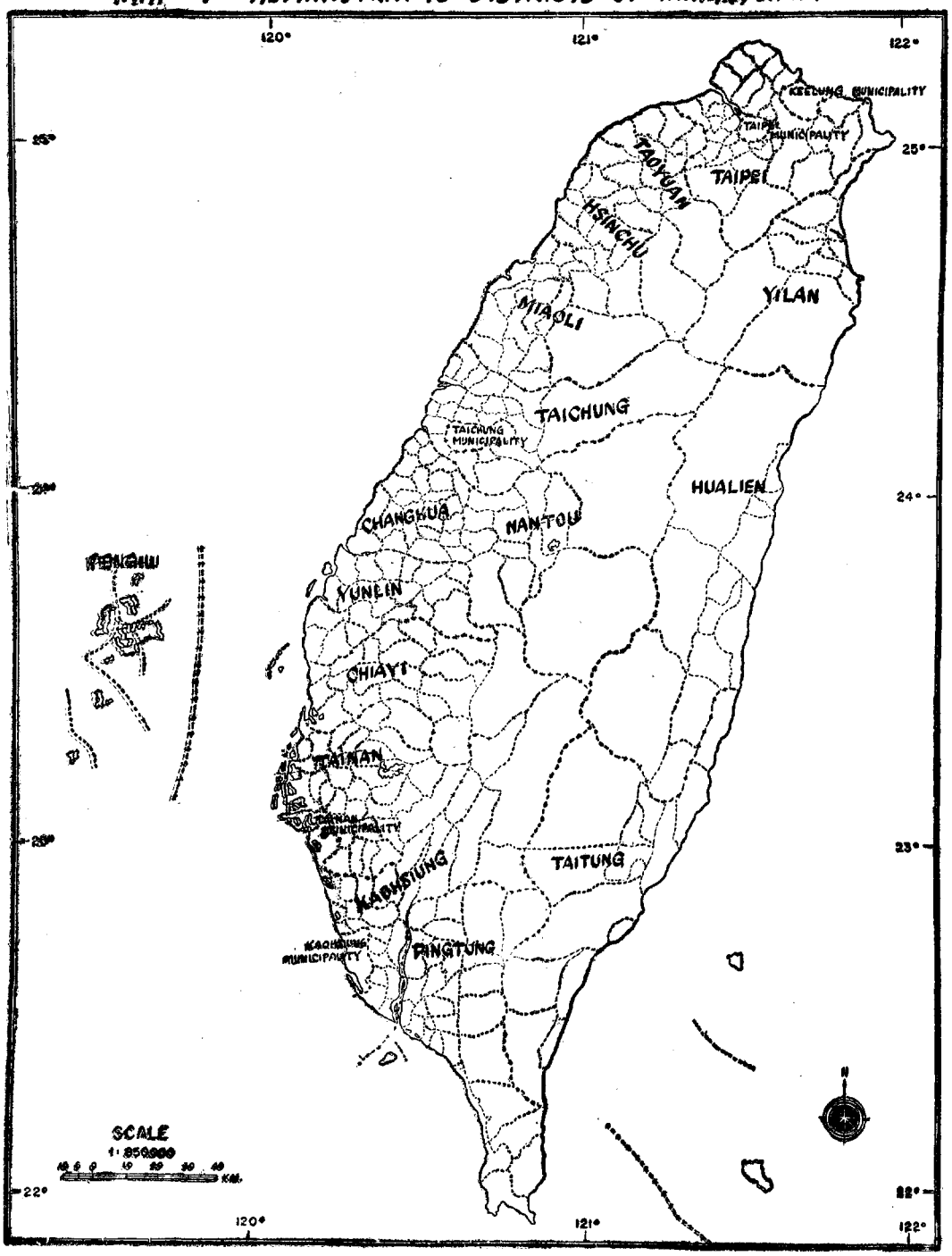


Table 1. Administrative Districts of Taiwan

Prefecture or Municipality	Area	Number of townships or districts
	sq. km.	
West Coast		
Taipei Prefecture	2,138.5	32 townships
Taoyuan Prefecture	1,220.9	13 townships
Hsincnu Prefecture	1,528.8	15 townships
Miaoli Prefecture	1,820.3	18 townships
Taichung Prefecture	2,051.4	21 townships
Nantou Prefecture	4,106.4	13 townships
Changhwa Prefecture	1,061.7	26 townships
Yunlin Prefecture	1,290.8	20 townships
Chiayi Prefecture	1,951.4	19 townships
Tainan Prefecture	2,003.6	31 townships
Kaohsiung Prefecture	2,832.5	28 townships
Pingtung Prefecture	2,775.6	33 townships
Penghu Prefecture (Pescadores)	126.9	6 townships
Keelung Municipality	132.3	7 districts
Taipei Municipality	67.0	10 districts
Yangmingshan Administration	119.0	2 townships
Taichung Municipality	163.4	8 districts
Tainan Municipality	175.6	7 districts
Kaohsiung Municipality	113.7	10 districts
East Coast		
Ilan Prefecture	2,137.5	12 townships
Hwalien Prefecture	4,628.6	13 townships
Taitung Prefecture	3,515.3	16 townships
Total:	35,961.2	360 townships & districts

Source of Data: Reference (1)

2. Elevation of Taiwan

Virtually all plains and basins, on which most of Taiwan's rice, sugarcane, sweet potato, peanuts, soybean, jute, wheat, tobacco, etc. are grown, are below the 100-meter contour line. Land lies between the 100 and 1,000-meter lines may be considered as the crop/forest marginal land, on which such crops as tea, citrus, banana, pineapple, citronella grass, cassava, sugarcane for brown sugar are grown, intermingling with hardwood and bamboo forests or newly reforested conifers. Above the 1,000-meter lines, the land is mainly in forest or grass (Map 2).

A major central mountain chain runs NNE-SSW along the axis of the Island and roughly divides the Island into two parts, two-thirds on the west with gentler slopes and one third on the east with very steep slope. The highest summit of the range is 3,950 kilometers above the sea level. The location and the course of this mountain chain not only basically decide the distribution of agricultural land, but also profoundly affect the climatic condition of different parts of Taiwan.

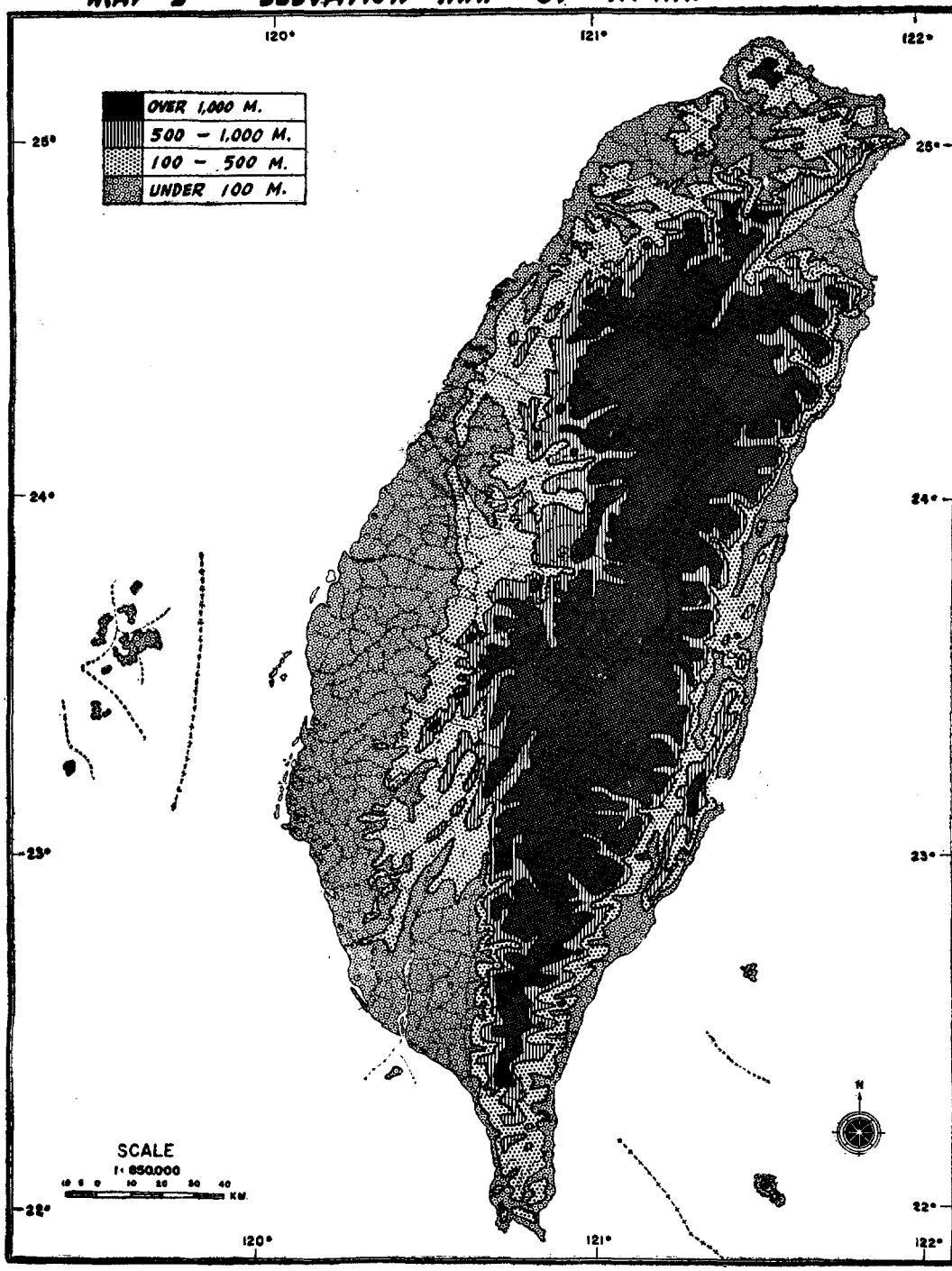
Even though the western slope of Taiwan is gentler than the east slope, it is still quite steep. The land rises from 100-meter hill foot to the mountain range of 3,000 meters within a horizontal distance of 50 to 60 kilometers. The land of Taiwan may be classified by altitude as shown in Table 2.

Table 2. Elevation of Taiwan

Elevation	Area	% of total
(m.)	(sq. km.)	
0 — 100	11,244	31.3
100 — 500	8,467	23.5
500 — 1,000	4,925	13.7
1,000 — 2,000	7,095	19.7
2,000 — 3,000	3,778	10.5
Above 3,000	452	1.3
Total:	35,961	100.0

Source of data: Reference (2)

MAP 2 ELEVATION MAP OF TAIWAN



Simplified from a map in Reference (2)

3. Rainfall of Taiwan

The effect of topography on rainfall in Taiwan is pronounced:

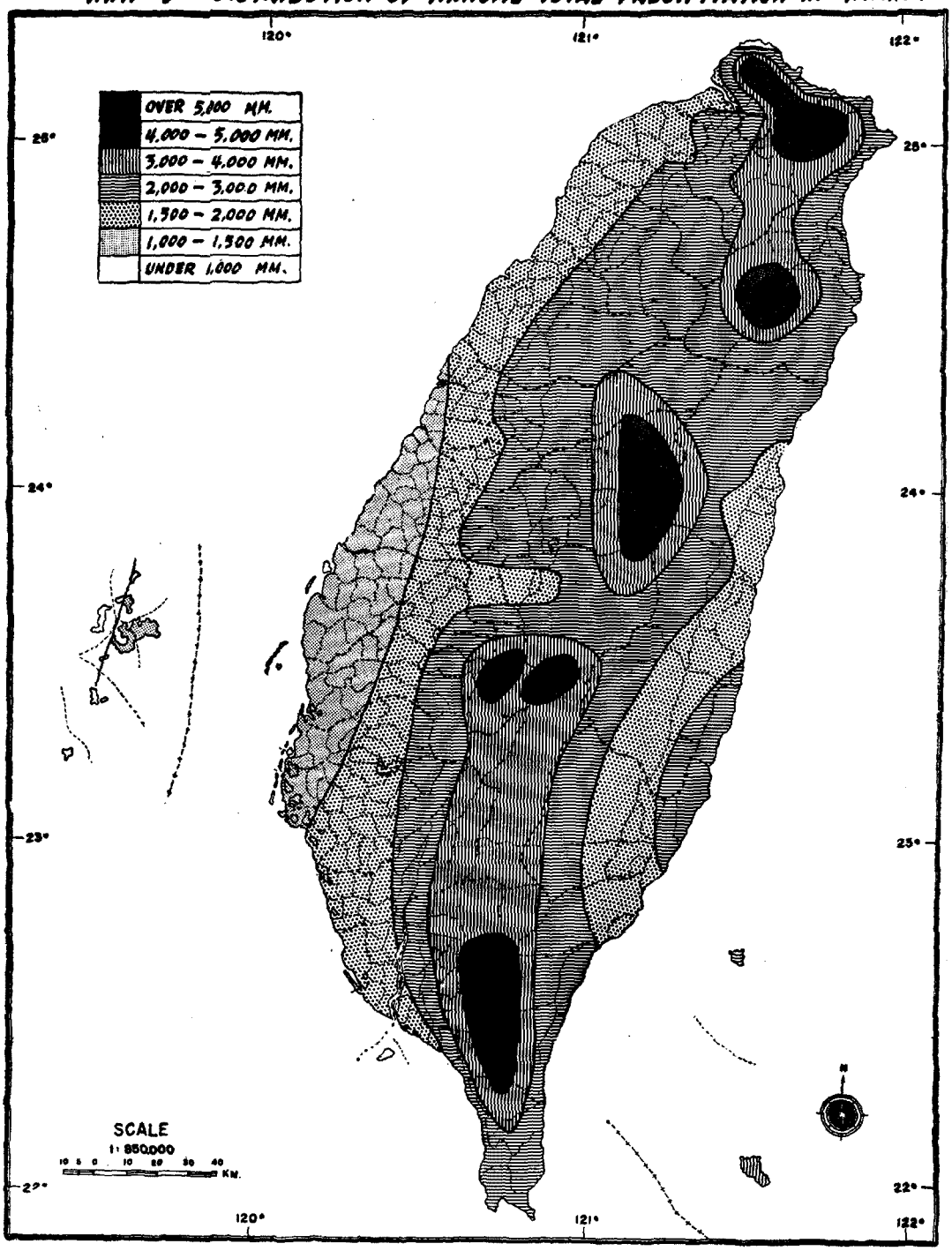
A. Annual rainfall and altitude—Generally speaking, rainfall increases from the sea coast toward the higher altitude of the central mountain range. A strip along the west coast from the coast of Taichung Prefecture to Tainan Municipality has the lowest annual rainfall, below 1,500 mm. In this area, sugarcane, sweet potato and peanut are important crops besides rice. All the rest of the low land area for the farm crops on the west coast and along the rift valley of the east coast has annual rainfall of from 1,500 to 2,000 mm. The plain of Ilan and the basin of Taipei have over 2,000 mm. a year. Tea, citrus, banana and pineapple are grown mostly within areas with over 2,000 mm. of annual rainfall. Areas with highest annual rainfall are the northeastern corner of the Island and along the central mountain range, running from 3,000 mm. to even 5,000 mm. a year (Map 3).

B. Central mountain range and seasonal distribution of rainfall in Taiwan—In winter, the moisture laiden NE monsoon, when uplifted by the mountain range, precipitates prolonged rains to the eastern and northern shores of Taiwan. The central and southern parts of the west coast, being in the rain-shadow, have sunny and dry winter. The contrast gradually evens off in April and May, when the NE monsoon weakens in strength. From May to September, rainfall is plentiful all over the Island, but is especially heavy in the southern part of the Island. The moisture carried by the SW monsoon and local terrestrial winds falls largely in the form of summer showers. Starting October, rainfall again recedes in southern Taiwan and increases in the northeastern corner. The seasonal distribution of rainfall in different parts of Taiwan may be described as follows (Table 3a and 3b):

1. *Northeast Corner of the Island* has relatively even distribution of rainfall throughout the year. Relatively speaking, rainfall is highest in December and January and lowest in July and August. But even in July and August, the normal monthly rainfall of Keelung are 137.3 mm. and 167.1 mm. and those of Ilan are 157.3 mm. and 187.9 mm. respectively. Total rainfall from October to March makes up over 50 percent of the annual rainfall.

2. *North Taiwan,* including Taipei, Hsinchu and Miaoli area on the west coast and Hwalien area on the east coast, has a mild summer concentration, but the rainfall from October to March still claims over 25 percent up to over 35 percent of the annual total.

MAP 3 DISTRIBUTION OF ANNUAL TOTAL PRECIPITATION IN TAIWAN



Reference (2)

Table 3 a. Normal Precipitation of Taiwan (mm.)

Location	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Keelung	305.8	293.2	297.8	217.3	261.0	287.4	137.3	167.1	250.4	247.1	268.6	309.3	3,042.3
Taipei	90.0	135.8	173.5	163.4	218.5	315.7	233.6	285.0	220.6	122.1	63.7	73.6	2,095.5
Hsinchu	71.4	133.8	158.3	204.7	245.5	396.9	145.5	179.5	104.2	33.6	35.7	54.3	1,763.4
Ilan	152.2	148.6	128.9	124.9	213.7	244.9	157.3	187.9	385.7	398.9	357.5	244.8	2,745.3
Hwalien	59.2	83.4	106.6	114.4	202.1	195.3	267.3	233.6	300.8	262.4	135.5	71.8	2,032.4
Taichung	33.9	66.8	106.5	128.4	236.1	393.7	292.0	325.2	134.2	22.3	16.6	28.6	1,784.3
Tainan	18.5	33.0	47.3	70.1	185.1	389.6	437.5	422.3	164.0	35.4	17.3	18.9	1,839.0
Taitung	35.8	43.0	60.3	75.2	164.7	233.3	339.2	293.4	299.8	177.2	80.5	41.2	1,843.6
Kaohsiung	8.5	19.5	36.0	53.3	162.9	475.0	569.4	386.0	134.5	39.4	19.9	19.0	1,923.4
Hengchun	21.0	28.3	22.9	45.2	173.2	417.4	538.9	539.1	291.7	142.2	54.0	19.0	2,292.9

Source of data: Taiwan Weather Burean

3. *Central Taiwan,* including Taichung and Changhwa Prefectures, has a greater degree of summer rainfall concentration. The rainfall of Taichung from October to March forms 15.39 percent of the annual total. It is the area with largest acreage of winter crop (Map 13).

4. *South Taiwan,* from the Cho-Shui river on southward, the summer rainfall concentration becomes very prominent. The rainfall from October to March of Tainan is only 9.27 percent and that of Kaohsiung is only 7.40 percent of the annual total. The summer rainy season and the winter and spring dry season are in very sharp contrast. The onset of the winter dry season in this area has profound effect on the planting and the winter growth of sugarcane and pineapple. The prolonged dry winter and spring have also so far precluded tea and citrus as important commercial crops in this area.

Table 3 b. Seasonal Distribution of Rainfall

Location	Annual precipitation	Seasonal Distribution			
		April to Sept.	%	Oct. to March	%
	mm.	mm.		mm.	
Keelung	3,042.3	1,320.5	43.40	1,721.8	56.60
Ilan	2.745.3	1,314.4	47.88	1,430.9	52.12
Taipei	2,095.5	1,436.8	68.57	658.7	31.43
Hsinchu	1,763.4	1,276.3	72.37	487.1	27.63
Hwalien	2,032.4	1,313.5	64.63	718.9	35.37
Taitung	1,843.6	1,405.6	76.24	438.0	23.76
Taichung	1,784 3	1,509.6	84.61	274.7	15.39
Tainan	1,839.0	1,668.6	90.73	170.4	9.27
Kaohsiung	1,923.4	1,781.1	92.60	142.3	7.40
Hengchun	2,292.9	2,005.5	87.47	287.4	12.53

Source of data: Calculated from Table 3a.

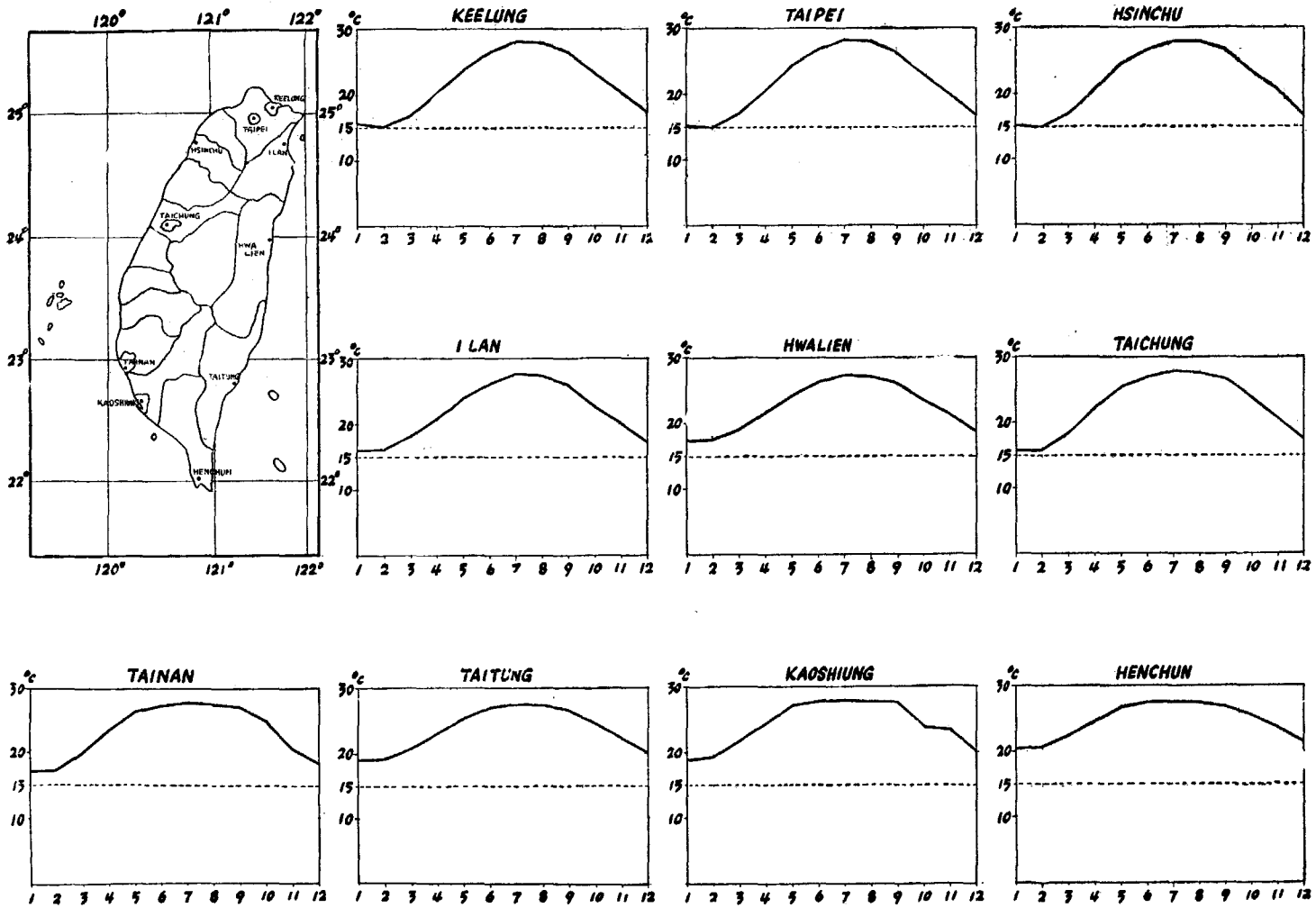
4. Temperature of Taiwan

Temperature is much less variable than rainfall over the agricultural land of Taiwan. In summer months, temperature in south and north Taiwan along the coastal plains is almost identical. In January and February, the mean monthly temperature of Kaohsiung is about 5°C warmer than that of Keelung. But even in the northern cities, the lowest mean monthly temperature seldom goes below 15°C (Map 4 and Table 4).

Taiwan's agriculture is greatly benefited by the subtropical and tropical climate: (1) It permits the production of two or more crops per year on the same piece of agricultural land. In the Taichung and Changhwa area of central Taiwan, which has an ideal combination of temperature and rainfall distribution, an extremely intensive system of growing four crops a year (spring rice, summer pickling melon, fall rice, and a winter crop such as wheat, tobacco, flax or vegetables) is being practised. (2) The year-round warm climate also makes it possible for Taiwan to grow a great variety of crops, which could be fitted into various lengths of growing period during different months of the year, resulting in an immensely complicated cropping system with highly developed intercropping cultural practices. (3) Under such cropping system, earlinese of crop varieties is of great importance. For instance, winter crops in many places can be gronwn after the Japonica type of rice varieties, but not after the Indica type of rice varieties, for the former is two to three weeks earlier. Breeding for sugarcane varieties with a shorter growing season is one of the primary aims of sugarcane improvement in Taiwan. Otherwise adjustment of growing season of the crops is also an usual aim of agricultural improvement. Postwar experiment on delaying the planting season of cotton from April to late May or June has succeeded in placing the blooming period of cotton after the peak season of summer rainstorm and typhoons and significantly stabilized the cotton yield. To be able or not to fit into the tight schedule of the crop rotation system so that higher financial return may be obtained by the farmers usually mean the success or failure of a crop variety. (4) The above conditions make Taiwan a fertile ground for introduction and testing of foreign crop varieties. In the past few years, many foreign crop varieties have been introduced and successfully grown in Taiwan, including sugarcane, tobacco, soybean, grain sorghum, onion, citrus, vegetables, etc.

On the other hand, in Taiwan, like in all places where the weather is warm and humid, the insect and disease control, and a liberal application of both organic manure and chemical fertilizers are costly necessities for successful production of

MAP 4 MONTHLY TEMPERATURE MARCH OF TAIWAN (°C)



Prepared according to data of Table (4)

Table 4. Normal Air Temperature of Taiwan (°C)

Location	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Keelung	15.6	15.2	16.8	20.2	23.6	26.3	28.0	27.9	26.4	23.4	20.3	17.3	21.7
Taipei	15.2	15.0	17.1	20.7	24.2	26.6	28.2	28.0	26.4	23.1	20.0	16.9	21.8
Hsinchu	15.1	14.9	17.1	20.6	24.5	26.6	28.0	28.0	26.7	23.5	20.6	16.9	21.9
Ilan	16.0	16.2	18.1	20.8	23.8	26.0	27.6	27.3	26.0	22.7	20.1	17.3	21.8
Hwalien	17.3	17.5	19.1	21.7	24.2	26.2	27.3	27.1	26.1	23.6	21.3	18.8	22.5
Taichung	15.8	15.8	18.4	22.1	25.3	26.9	27.8	27.5	26.7	23.9	20.7	17.4	22.4
Tainan	17.1	17.2	19.9	23.4	26.4	27.4	27.9	27.6	27.2	24.9	21.8	18.5	23.3
Taitung	19.0	19.1	20.8	23.2	25.4	27.0	27.5	27.3	26.6	24.5	22.3	20.0	23.6
Kaohsiung	18.9	19.3	21.8	24.6	27.2	27.7	27.9	27.7	27.6	23.8	23.4	20.2	24.3
Hengchun	20.4	20.6	22.4	24.6	26.6	27.4	27.5	27.3	26.8	25.4	23.5	21.4	24.5

Source of data: Taiwan Weather Bureau

almost any crop; storage of seeds, sweet potatoes, fruits and vegetables is difficult; and spoilage after harvest is generally high. Economically, the fact that many kinds of crops can be grown in Taiwan makes farmers highly selective in the kinds of crops which they would grow in any given year. They respond quickly to the change of prices of various crops.

Going up hills and mountains, the temperature, of course, decreases with increase in altitude. But as high as the crop land goes, temperature is usually not a limiting factor. Deciduous fruit trees can be grown on higher latitude of Taiwan. Introduction of deciduous fruit species has recently been undertaken by JCRR. Highland is being used for production of summer vegetables and vegetable seeds.

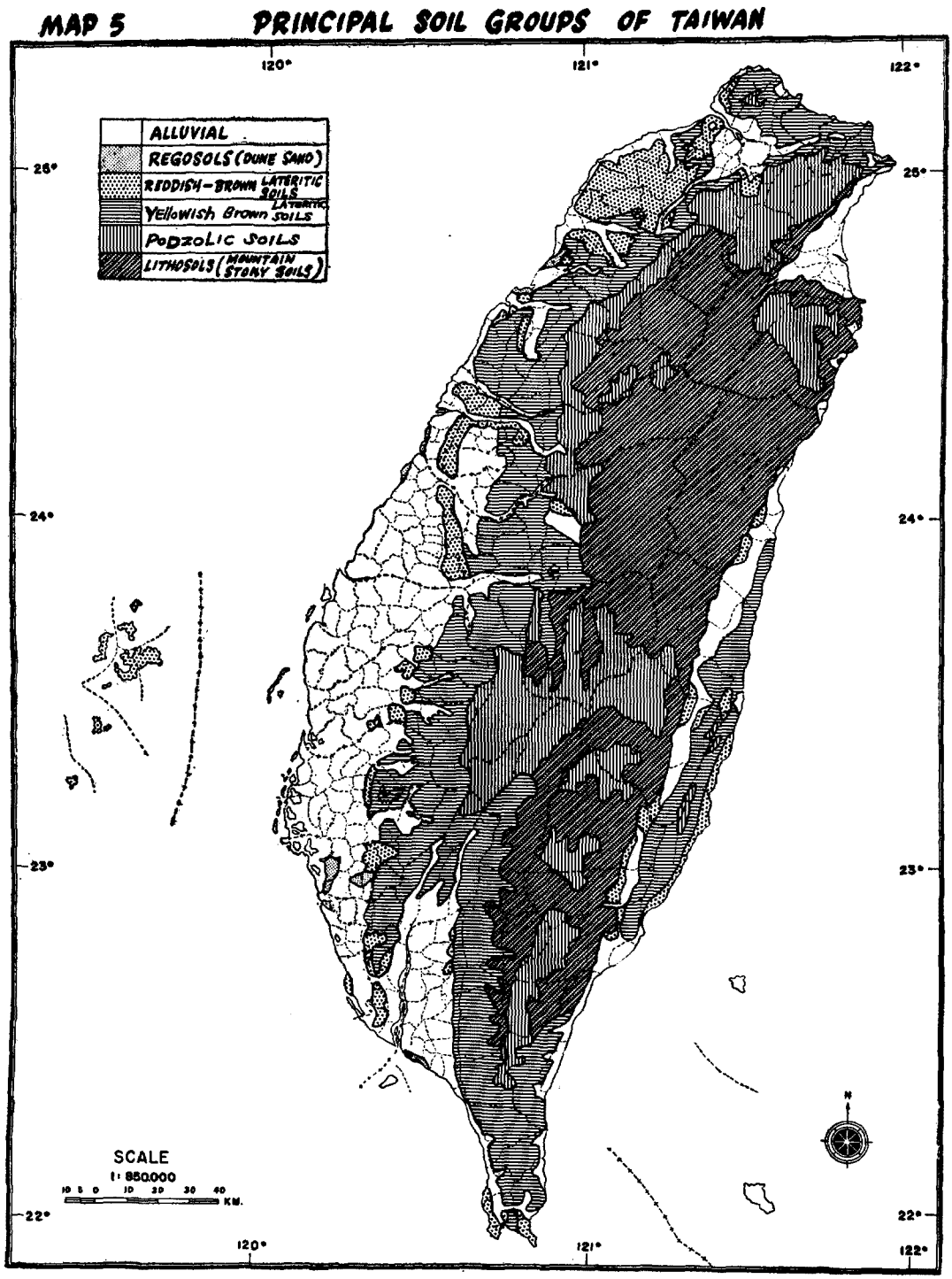
In short, the year-round growing season on the plains and the wide range of temperature at different altitude make the cropping systems in Taiwan highly complicated and dynamic. They offer many opportunities, but also demand precise, skillful and intensive farming operations. It is with such a background that the rural reconstruction program of Taiwan is looking forward with optimistic anticipation to the further development of agricultural resources through technical improvement.

5. Soils of Taiwan

Map 5 is a generalized map of the principal soil groups based on Mr. L. T. Hsi's original Soil Map of Taiwan (Reference 3, 4 and 5). From the map, it may be seen that from the agricultural point of view the most important soil group is the alluvial soil. Most of the rice, sugarcane, sweet potato, peanut, soybean, jute, wheat, tobacco, etc. are grown on this soil group. The lateritic soils (reddish-brown and yellowish-brown) are the second most important soil groups. Tea, citrus, pineapple, banana, citronella, sugarcane for brown sugar, cassava, etc. are mostly grown on the lateritic soils. The gray-brown podzolic soils, reddish-brown podzolic soils and Lithosol are forest soils.

A. Alluvial Soils

The alluvial soils vary greatly in their nature of parent material (slate, schist, sandstone, shale and marine deposit), texture (from sand and gravel to loams or clays) and pH (from very strongly acid to mildly alkaline). They are also under different rainfall types and different influences of irrigation, drainage, crops and vegetation. Irrespective of such wide variations, the alluvial soils as a major group are successfully and fully utilized by the farmers of Taiwan in raising rice, sugarcane and other upland farm crops, with the exception of two groups, the "Planosols" and the saline soils.


MAP 5
PRINCIPAL SOIL GROUPS OF TAIWAN
120°
121°
122°
26°
25°
24°
23°
22°
ALLUVIAL
REGOSOLS (DUNE SAND)
REDDISH-BROWN LATERITIC SOILS
YELLOWISH BROWN LATERITIC SOILS
PODZOLIC SOILS
LITHOSOLS (MOUNTAIN STONY SOILS)
SCALE
1: 850,000
10 5 0 10 20 30 40
KM.
N

Reference (3)

1. *The "Planosols"* are Marine Deposited Soils scattered in larger or smaller patches throughout the Plain of Chiayi, Tainan and the northern part of Kaohsiung Prefectures. They are characterized by lighter textured surface layers of light gray color and heavy textured compact clayey subsoils usually mottled with grayish-yellow or olive, varying from medium acid to neutral in reaction. They are not the typical planosol, but are planosol like soils.

These heavy textured soils are mostly not benefited by good irrigation facilities and depend mainly on rainfall. They are called by local farmers as the "weather-depending field". One crop of rice may be grown during the rainy season from June to October. After that, the prolonged dry winter sets in and the soil turns rock hard, on which not much of any crop can be grown successfully. The winter and spring barrenness of these soils is in contrast with the neighboring alluvial soils of lighter texture and of sandstone and shale origin which are green in the winter with sugarcane, sweet potatoes and vegetables. The failure to grow even green manure crops in the winter and spring makes these soils low in organic matter, which further aggrevates the heaviness of the texture. The rice yield on such soils is below average. Farmers in this area are generally poor. In recent years, a soil improvement method through the adoption of a method of planting sugarcane between rice rows before the rice is harvested (enough soil moisture to enable sugarcane to send roots down deep enough before the dry period sets in), and generous application of filter cake from the sugar mills and compost manures has proven effective. This method enables farmers to grow one crop of rice and one crop of sugarcane in two years instead of two crops of rice in two years, thus significantly increasing the income of the farmers. There are some 30,000 hectares of such "Planosol" soils in the Chiayi-Tainan-Kaohsiung area. To improve and utilize these soils to a fuller extent is one of the major agricultural undertakings in recent years. Continuous and generous application of organic fertilizers is the surest way to improve the soil texture of these heavy soils.

2. *Saline Soils*

Also problematic are the saline soils, which occupy the low, flat western coastal plain along the Taichung, Yunlin, Chiayi, Tainan and Kaohsiung Prefectures, ranging from 5 to 20 km. in width from the coast line. They are formed through the action of the salts in the tidal water and those released from the base bearing parent material. Sulfates and chlorides of calcium and sodium are the main salts present in these saline soils. They are commonly gray colored, lack in organic matter, mildly alkaline in reaction, and of medium to light structure.

Land having high content of salt is used as salt flats for making salt. Those degraded are used for fish culture. When sufficiently washed, rice, sweet potato, sugarcane, peanuts and cotton may be grown. Crop yield on such soils is generally low. There are estimated to be at least 50,000 hectares of saline soils in Taiwan. Their improvement will constitute another major agricultural program in the near future. Preliminary survey has been started in 1956 under a JCRR financed project.

B. Lateritic Soils

1. *Reddish-brown lateritic soils*

The reddish-brown lateritic soils are generally found on flat or gently undulating tablelands mostly on the west coast, rising 100-500 meters above sea level amid low laying alluvial soils or adjoined on the east side by the yellowish-brown lateritic hill foot soils. Pedologists claim that these reddish-brown lateritic soils were widely formed by sedimentation during the Pleistocene time under hot humid conditions, and the tablelands as found to-day are relics left from that time. In other areas, the same formation had been washed away.

The reddish brown lateritic soils are generally red clay loams of clayey texture, with well defined structure and a thickness of 2 meters. Those formed from igneous rocks are only about 1 meter thick. They are strongly acid in reaction. Below the soil layer, pebbles are found. The tablelands in northern Taiwan are widely planted to tea, and to a less extent, citrus fruits. When irrigation is available, rice is grown. Those in central and southern Taiwan, because of the dry winter, are planted to miscellaneous upland crops, with pineapple gaining popularity in recent years.

2. *Yellow-brown lateritic soils*

Yellow-brown lateritic soils occupy the hill foot area throughout the length of the Island on the west side and also the hills lining the east coast rift valley. The topography is from undulating to hilly. The soils are commonly shallow, rarely exceeding 1 meter in depth, frequently skeletal or gravelly, generally deficit in nutrient, and vulnerable to soil erosion. The hills of Miaoli Prefecture where citronella grass prevails, those of Taichung and Nantou Prefectures where banana grows extensively, and the long stretch of hillsides from Yunlin to Pingtung where miscellaneous upland crops are grown are examples. This group of soil constitutes the main body of the crop/forest marginal land, for which soil conservation problem needs the most serious consideration.

C. The Podzolic Soils and Lithosols

Since these are forest soils, they will not be discussed in the present paper. The areas of different principal soil groups as measured by the map are given in Table 5.

Table 5. Principal Soil Groups of Taiwan

Soil groups	Area sq. km.	% of total
Lithosol (Mountain stony soils)	10,722	29.8
Gray-brown and reddish-brown podzolic soils (Mountain forest soils)	8,495	23.6
Yellow-brown lateritic soil	5,685	15.8
Reddish-brown lateritic soil	2,404	6.7
Regosols (Dune sand)	83	0.2
Alluvial soils (Paddy soils, solonchaks and "planosols")	8,572	23.9
Total:	35,961	100.0

Source of data: Reference (3)

6. Cultivated Land of Taiwan

The Land Use Type Map produced recently (April, 1956) by the Aerial Land Use and Forest Survey sponsored by JCRR and the Taiwan Forestry Administration gives a clear overall picture of the distribution of the land under agricultural use as in contrast with those under forest, grasses and other non-crop uses (Map 6 and Reference 6).

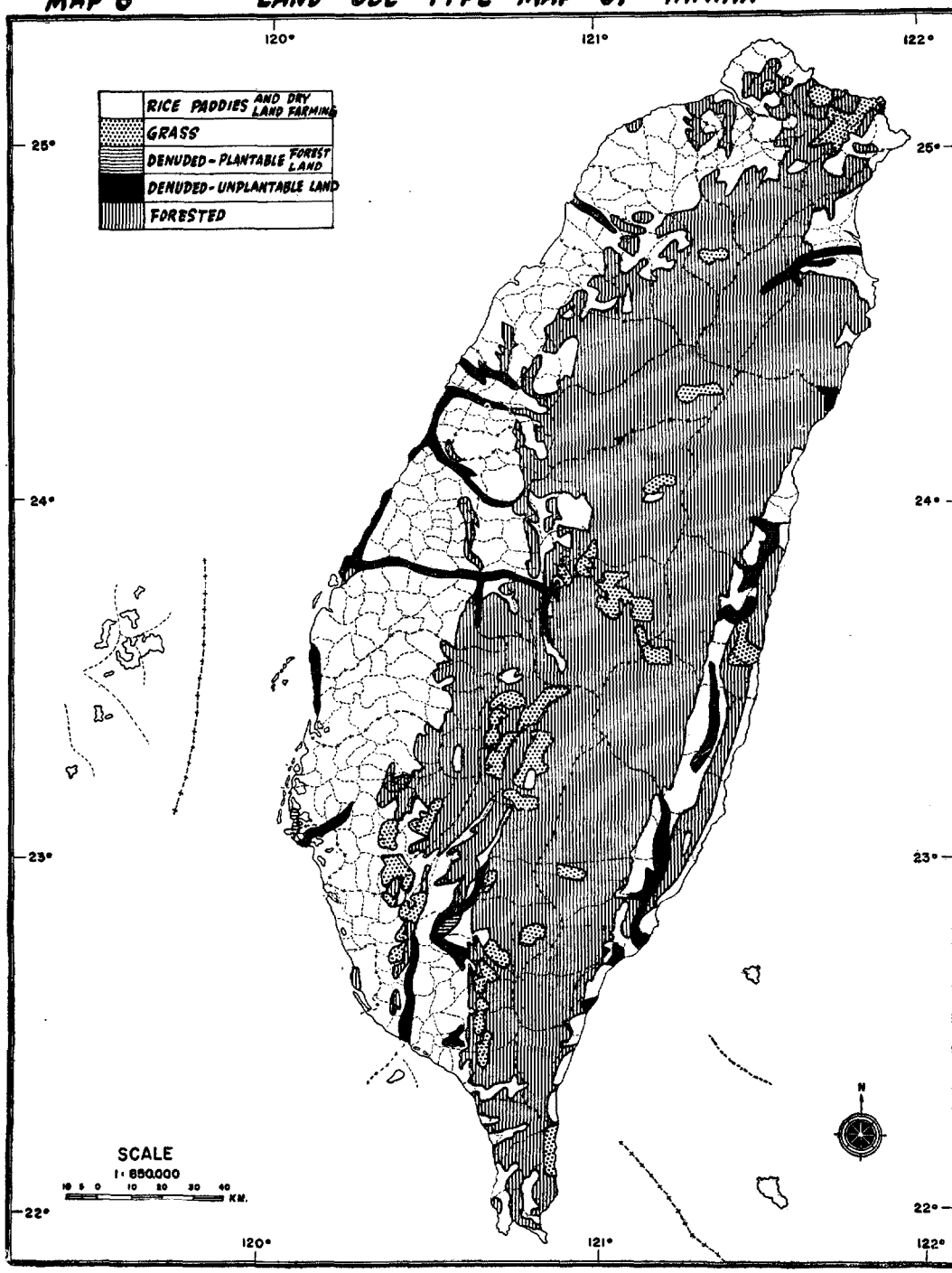
Generally speaking, the agricultural land as shown in the map covers the land below 500-meter contour line, with alluvial, reddish brown lateritic, or yellowish-brown lateritic soils and annual rainfall that ranges from 1,000 to 2,000 mm.

A. Area of Cultivated Land

As we are primarily interested in crop production in the present paper, the area of agricultural land deserves more detailed discussion. According to the Taiwan Agricultural Yearbook (Reference 6), which contains the official agricultural statistics compiled and published annually by the Provincial Department of Agriculture and Forestry from data reported by the various Prefectural and Municipal Governments under the crop reporting program, the area of cultivated land has never exceeded 880,000 hectares. Thus far, the area reported for 1952, 876,100 hectares, is the highest ever reported. It is composed of 533,643 hectares of paddy field and 342,457 hectares of upland farm. When compared with the data reported by the Aerial Land Use and Forest Survey conducted in 1954 to 1955 (see Table 6), there are significant discrepancies, which may be shown as follows:

Area	Agricultural Yearbook 1952	Aerial Land Use and Forest Survey 1954-1955	Difference
	ha.	ha.	ha.
Paddy field	533,643	559,600	25,957
Upland farm	342,457	445,000	102,543
Total	876,100	1,004,600	128,500

MAP 6 LAND USE TYPE MAP OF TAIWAN



Reference (6)

Table 6. Land Use Type of Taiwan

Land Use Type	Area	% of Total
	(1,000 ha.)	
Agricultural	1,042.8	29.1
Paddy	559.6	15.6
Dry-farming	445.0	12.4
Farm woodland	38.2	1.1
Forest Land	1,969.5	55.1
Conifers	373.0	10.4
Conifer-hardwood	55.3	1.5
Hardwood	1,427.3	40.0
Bamboo	113.9	3.2
Other Land	563.7	15.8
Grass land	305.2	8.5
Denuded, plantable	20.0	0.6
Denuded, unplantable	117.4	3.3
Urban and industrial	74.1	2.1
Water area	47.0	1.3
Total of all land	3,576.0	100.0

Source of data: Reference (6)

The difference in the area of paddy field is not so large, but that in the area of the upland farm is as much as 102,543 hectares, which is very significant. Since the result of the aerial survey was released only very recently, careful comparative studies of the two sets of data have not yet been made. It is the author's personal opinion that the large discrepancies in the area of upland farm may be due to the following reasons: (1) The definition of the "dry-farming" land in the aerial survey is "all cultivated land other than paddy field, including all dry farming land under continuous, intermittent or shifting cultivation". The "upland farm" in the Yearbook means the area under cultivation of upland crops during any given year as reported by the local governments. The latter therefore does not include land area which was opened up for cultivation before but was idle during the year of reporting. From experience of field observations, the total area of such abandoned dryland is quite large. (2) Areas newly opened up for dryland farming in out of the way mountain areas may have escaped the notice of the crop reporters. In the Agricultural Yearbook, the cultivated land is listed under the so-called "Registered Land", the total area of which is recorded as 1,345,778 hectares (Total land area of Taiwan is 3,596,121 hectares). There is a large area of 2,250,343 hectares of "Non-registered Land". While it may be concieved that this "Non-registered Land" is mostly forest land, it may well contain also areas in mountains opened up for dryland farming.

Before thorough studies are made, the best we can generalize at present would be to say that about 29 percent of the total area of Taiwan has been placed under cultivation at one time or another, but only from 24 to 25 percent is under continuous cultivation of paddy and upland crops.

B. Crop/Forest Marginal Land

Another interesting observation could be made by comparing the elevation data (Table 2) and the land use data (Table 6). Table 2 shows that 19,711,000 hectares, or 54.8 percent of the total land area of Taiwan lie below 500 meters. However, even if we take the higher figure of the recent Aerial Land Use and Forest Survey, only 1,042,800 hectares or 29.1 percent of the total land area are under agricultural use. On land below 100 meters, much land is occupied by cities and towns, roads and railroads, irrigation systems and other water bodies, salt flats, fish ponds, river beds, windbreaks, farm sites, etc. For land between 100 meters and 500 meters, although upland crops and terrraced paddy fields are to be found in many places, they are actually imbedded in the general background of hardwoods, bamboos, assorted bushes, grasses, or newly reforested conifers. When agricultural writers name a certain area as "tea region" or "banana region",

actually it is an area where tea or banana is grown at a greater extent than other upland crops; and as is always the case, the general scenery of these areas is still dominated by trees, shrubs, bushes, bamboos, etc., among which land is opened up for crop production. It is such land that the term "crop/forest marginal land" is generally applied in Taiwan. It is also over such land that much improvement and increase in crop production can yet be made if soil conservation practices can be generally adopted.

A Crop/Forest Marginal Land Use Capability Survey was started by the Taiwan Agricultural Research Institute with the financial and technical support of JCRR in 1953 and is scheduled to be completed in 1957. The marginal land will be classified according to the land use capabilities. The result of the survey will serve as a basic reference for the soil conservation program which the Provincial Department of Agriculture and Forestry has already started also with JCRR assistance.

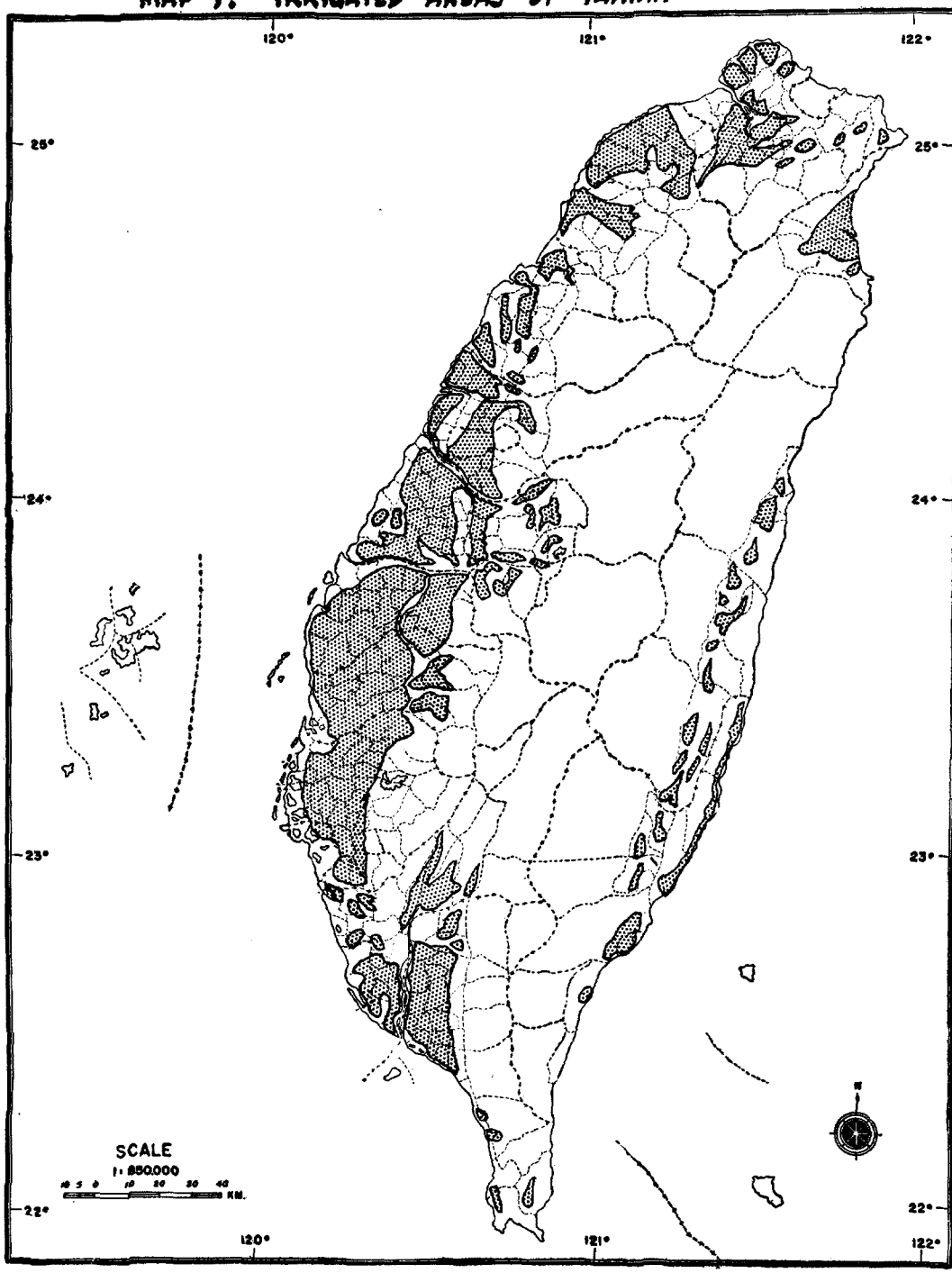
The Aerial Survey of the Forest Area and the Crop/Forest Marginal Land Capability Survey are two concrete steps taken by Taiwan towards the long range planning of the development of forest and crop resources over its vast hill and mountain areas. The successful development of such resources is essential to the upholding the Island's economy against the population increase in the future.

7. Irrigated Area of Taiwan

Because of the steepness of the mountain slopes, rivers in Taiwan are characterized by large unit discharge per unit area of watershed, large ratio between the minimum and maximum flows and steep gradients. On the other hand, the dry season flows are inadequate for irrigating all of the land commanded by its canals. Flood control and irrigation are therefore both important to the maintenance of the stability of agricultural production.

By 1940, 530,000 hectares of land were reportedly under irrigation, out of a total of about 860,000 hectares of cultivated land. In 1945, as a result of World War II, the irrigated area had been reduced to 500,000 hectares. During the postwar years, the cultivated land area has climbed up to the neighborhood of 880,000 hectares and the irrigated area is estimated to have reached about 550,000 hectares. The "total irrigated area" as given in Table 7 (491,049 hectares) is limited to the areas under the Hydraulic Associations as of January 1952 (Map 7, Reference 8) . The balance may be accounted for by the irrigated areas using private water sources.

MAP 7. IRRIGATED AREAS OF TAIWAN



Reference (8)

The irrigation canals in Taiwan, in general, obtain water from rivers, with or without diversion weir, or to a less extent, from reservoirs. The following are three cases where the feature of irrigation is different from the general canal irrigation system:

A. The rice field of the tableland and the adjoining Plain of Taoyuan is irrigated mainly by a network of small ponds. Some are connected to a canal system. Some are independent. In years of when the summer rainfall is insufficient, the ponds, especially those without a dependable water supply often dry up. Drought and failure of the 2nd rice crop are frequent. A multi-purpose reservoir construction project at Shihmen of Taoyuan Prefecture was started in 1956. When completed, a total of 54,560 hectares of land which now frequently suffer insufficiency of water will be provided with reliable irrigation.

B. The coastal Plain of Yunlin, Chiayi and Tainan Prefectures is the largest plain of Taiwan with the longest distance from the hill-foot to the sea coast. The water resource of the watershed area of this area is poor, and the capacity of the existing water reservoir is limited. It is insufficient to water the broad plain down below to turn it into a double rice crop area. A portion of the Plain with a total area of about 120,000 hectares is therefore placed under the famous "Chianan 3-year Rotational Irrigation" system. Its farm lands are divided into units of 150 hectares. Each unit is subdivided into three sub-units of 50 hectares each. At any one year, one of the sub-unit would receive irrigation water sufficient for growing rice; the second sub-unit would be given necessary irrigations only in winter and spring months for growing sugarcane; and the third sub-unit would receive no irrigation at all for growing miscellaneous upland crops (sweet potatoes, peanuts, jute, etc.). In the next year, the second sub-unit would be given water to grow rice, the third to grow sugarcane and the first to grow miscellaneous upland crops, and so on. Thus the differential water supply is applied to the three sub-units on a 3-year rotation basis, and thereon rice, sugarcane and miscellaneous upland crops are grown accordingly. In recent years, because of the increasing demand for rice to meet the need of the growing population, there is a notable trend for farmers in the 3-year rotation area to secure extra water supply so that the land earmarked for growing sugarcane or upland crops under the regular system could be used to plant rice. The deficiency of irrigation water in this general area is even more keenly felt than before. Future development of more water resources from the Choshui River on the north of the Plain and the underground water resources will help improve water supply to this area. The "Planosol" like heavy clay soils as mentioned in Section 5 also lie within this Plain. These soils are mostly devoid of regular irrigation.

C. On the Plain of Kaohsiung and Pingtung, increasing number of shallow wells have been sunk during recent years to provide irrigation to land without surface-water source, each well watering an area of a few hectares. Cumulatively, the well irrigation in that area has helped convert a considerable acreage of formerly dryland into paddy field.

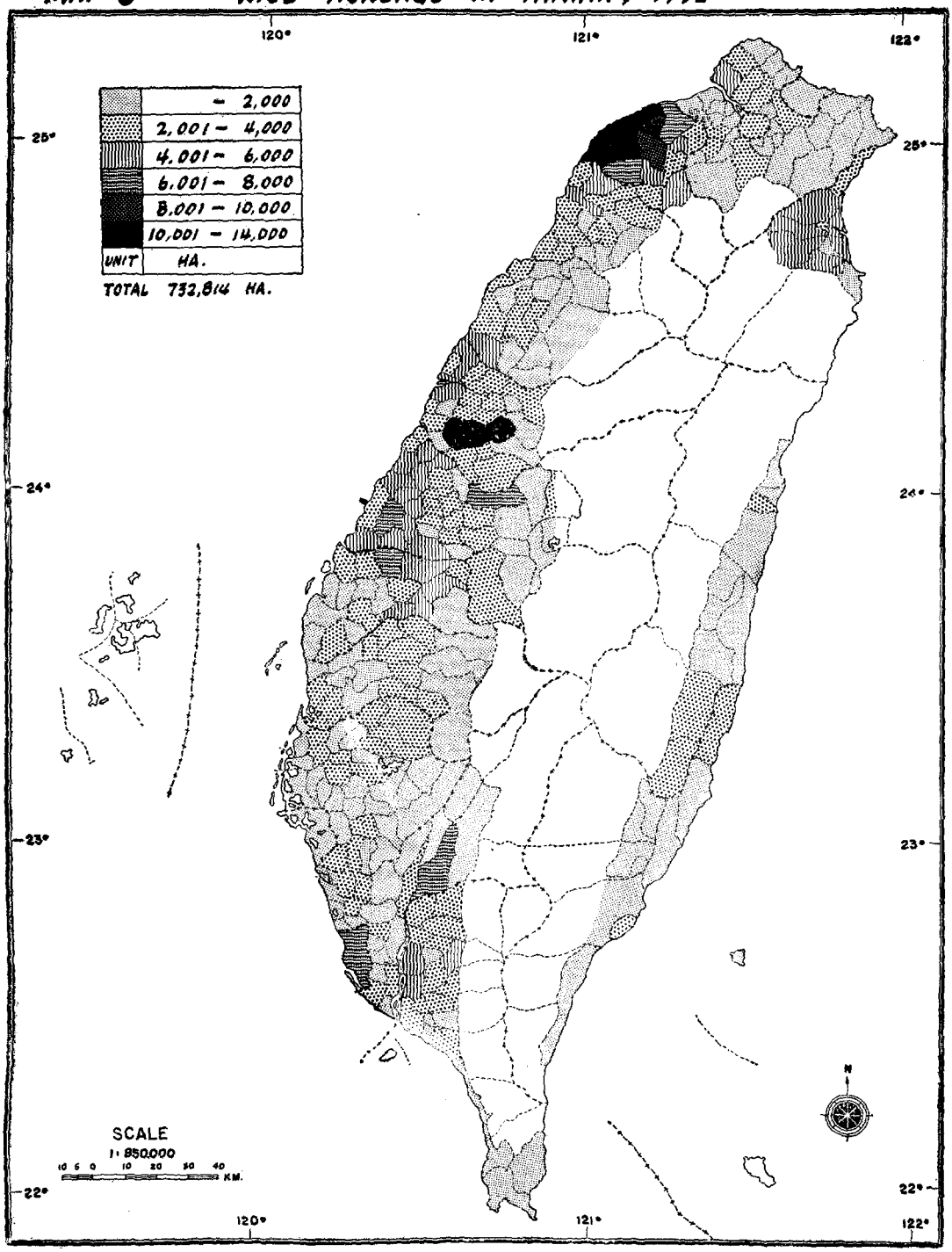
It is estimated by the Irrigation and Engineering Division of JCRR that, with new irrigation constructions, it is possible to change 100,000 hectares of single rice crop field into double rice crop field; 60,000 hectares of dryland into single rice crop field and another 60,000 hectares of dryland into double rice crop field. To attain this goal, reservoirs will have to be built to store water in time of rain for use during periods of water deficiency. The Shihmen Reservoir project under construction is a case in point.

Table 7. Irrigated Areas in Taiwan

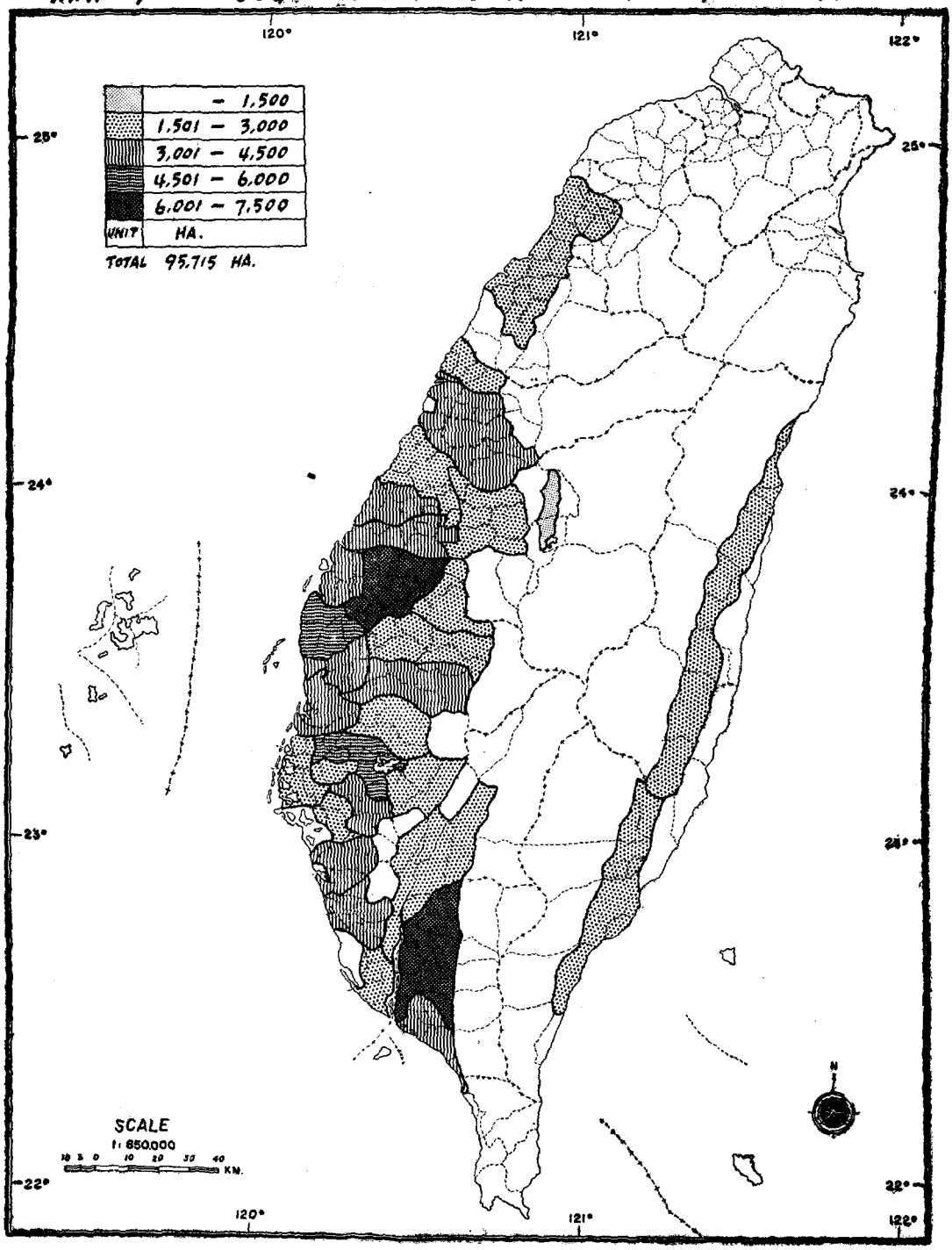
Prefecture	Area (in ha.)			
	Irrigated	Drained	Total	
Ilan	19,519	—	19,519	
Taipei	27,583	—	27,583	
Taoyuan	29,936	—	29,936	
Hsinchu	13,664	—	13,664	
Miaoli	13,706	—	13,706	
Taichung	40,653	—	40,653	
Changhwa	49,518	11,688	61,206	
Nantou	18,302	—	18,302	
Yunlin, Chiayi, Tainan	194,597	—	194,597	Chianan Hydraulic Assn. 182,621; Touliu Hydraulic Assn. 11,976)
Kaohsiung	23,747	89	23,836	
Pingtung	41,596	3,340	44,936	
Taitung	8,054	—	8,054	
Hwalien	10,174	—	10,174	
Total:	491,049	15,117	506,166	

Source of data: Reference (8)

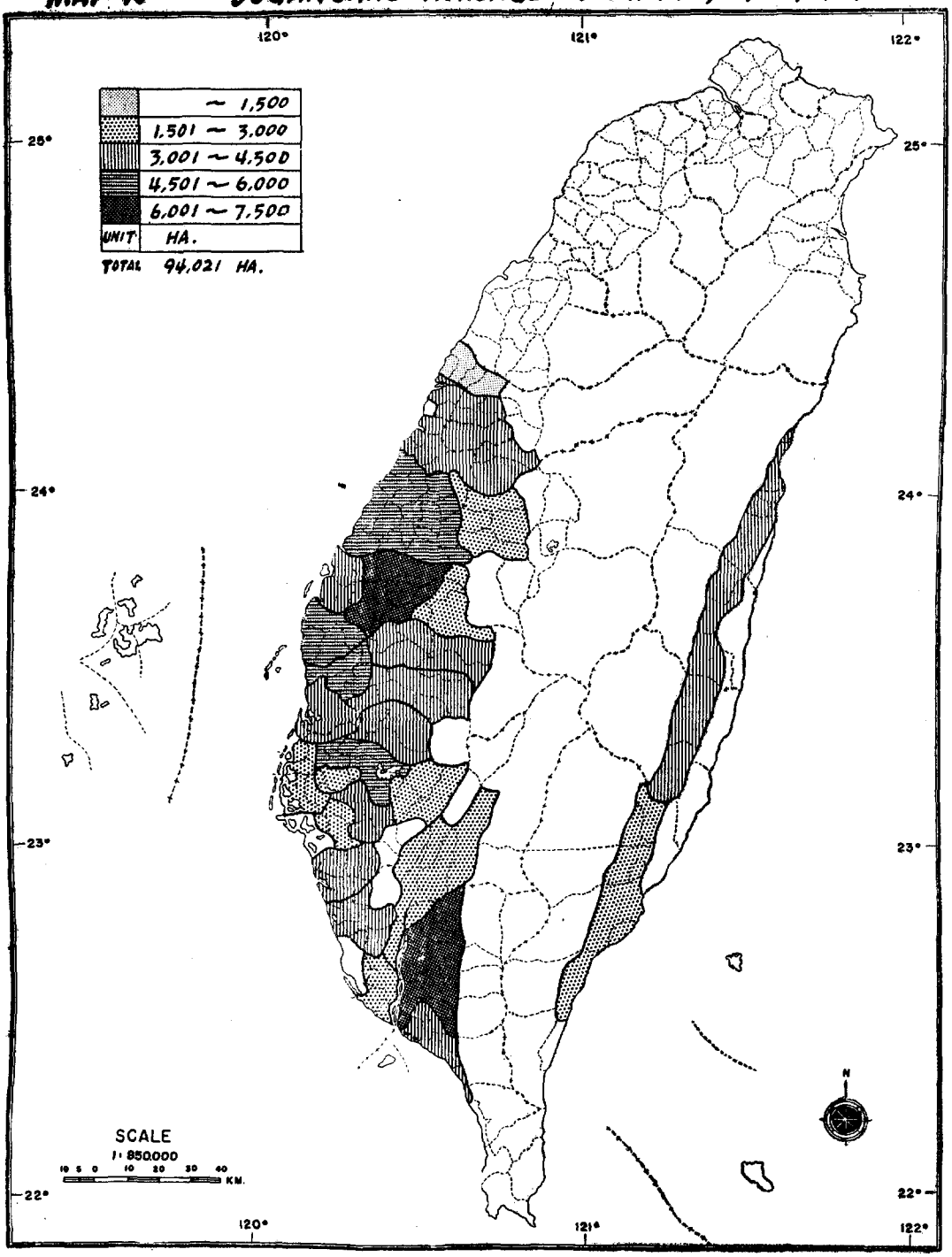
MAP 8 RICE ACREAGE IN TAIWAN, 1952



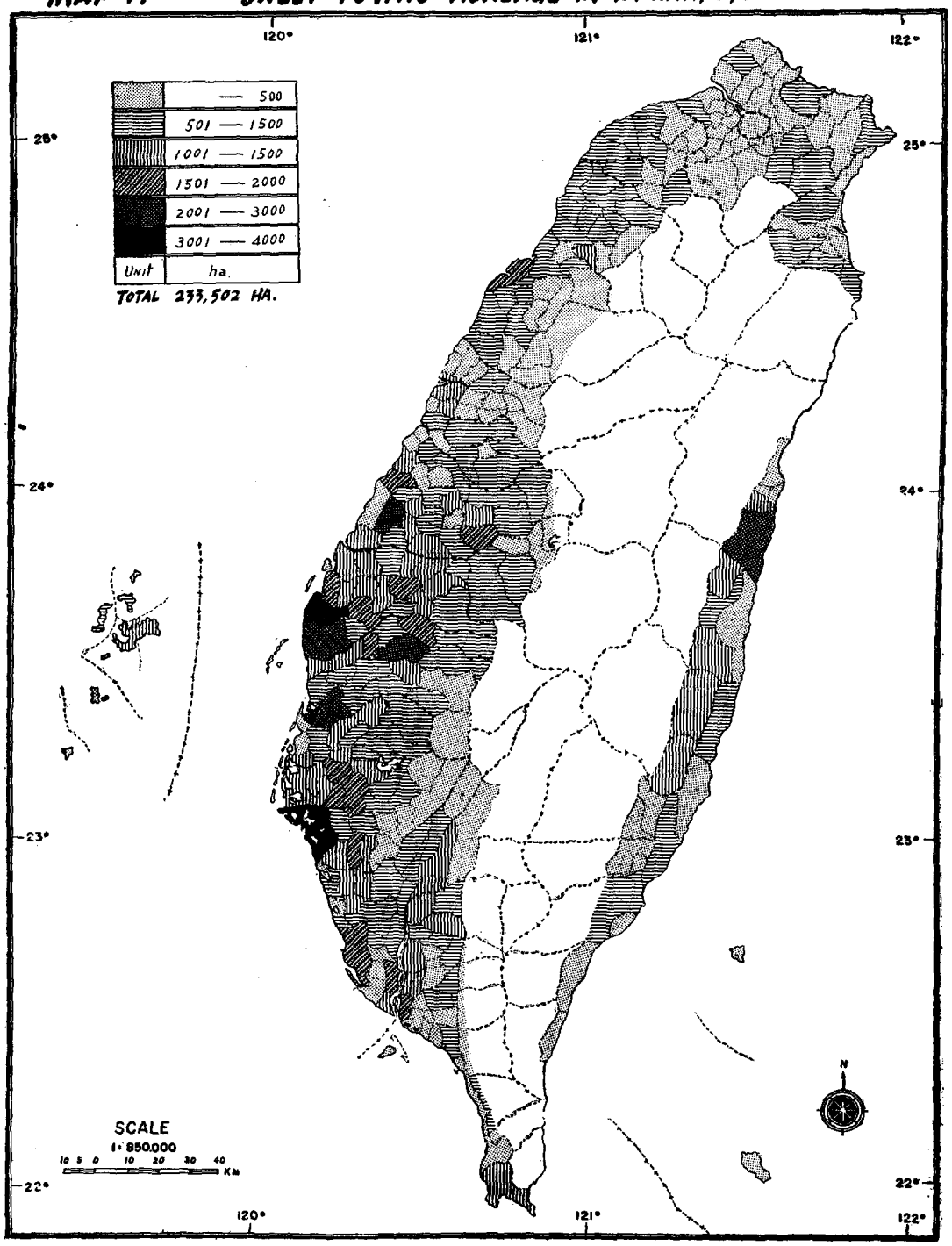
MAP 9 SUGARCANE ACREAGE IN TAIWAN, 1951/1952



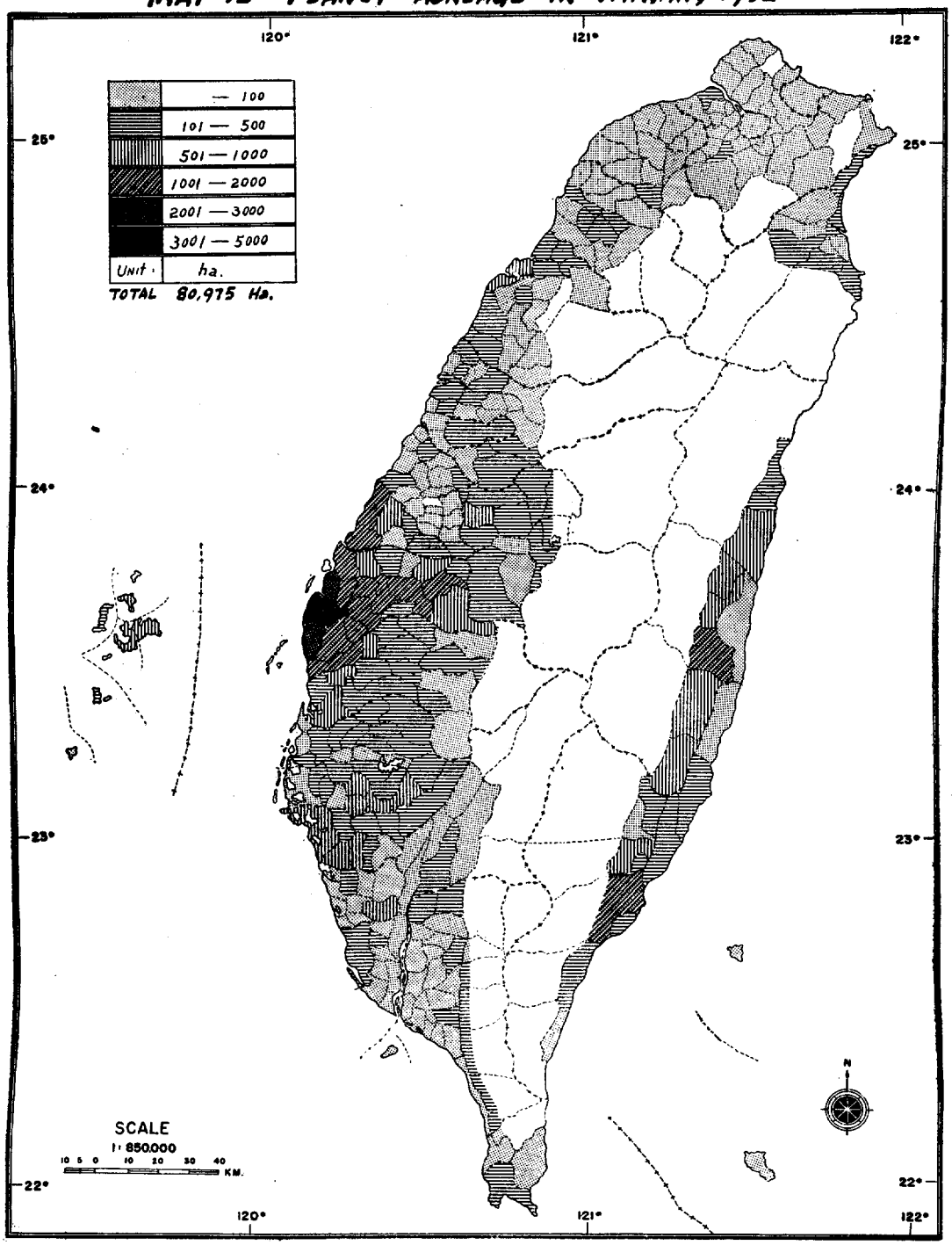
MAP 10 SUGARCANE ACREAGE IN TAIWAN, 1956/1957



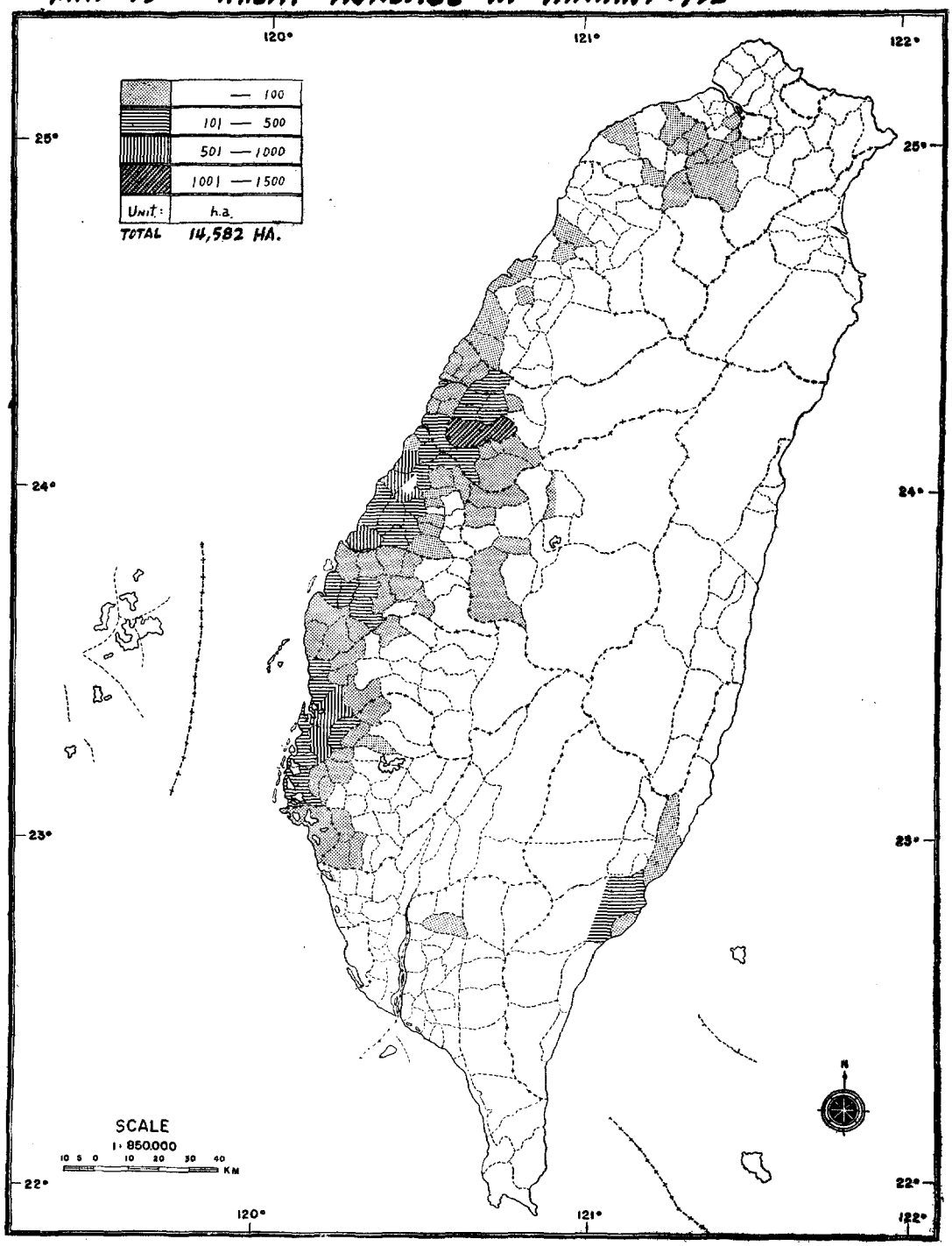
MAP 11 SWEET POTATO ACREAGE IN TAIWAN, 1952



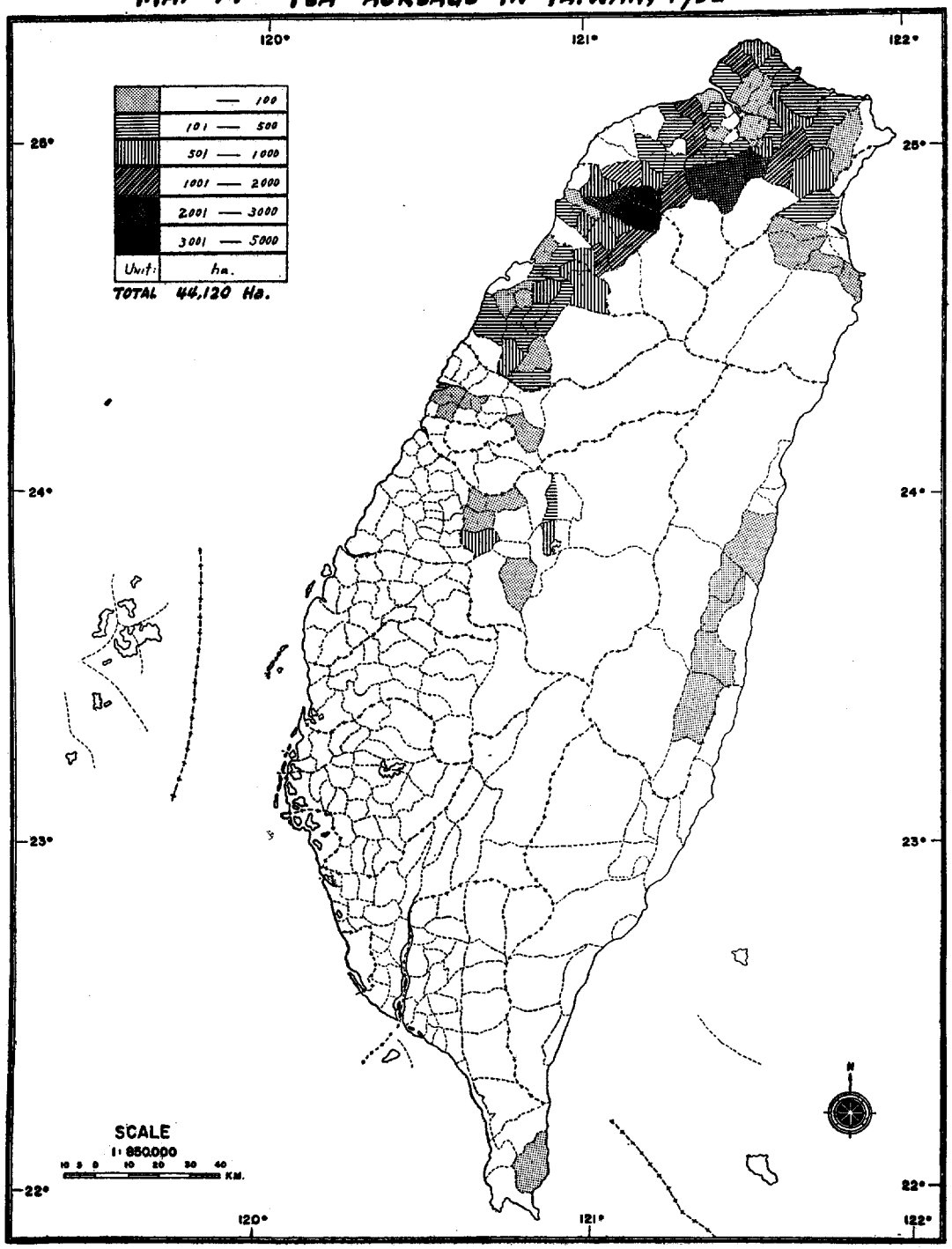
MAP 12 PEANUT ACREAGE IN TAIWAN, 1952



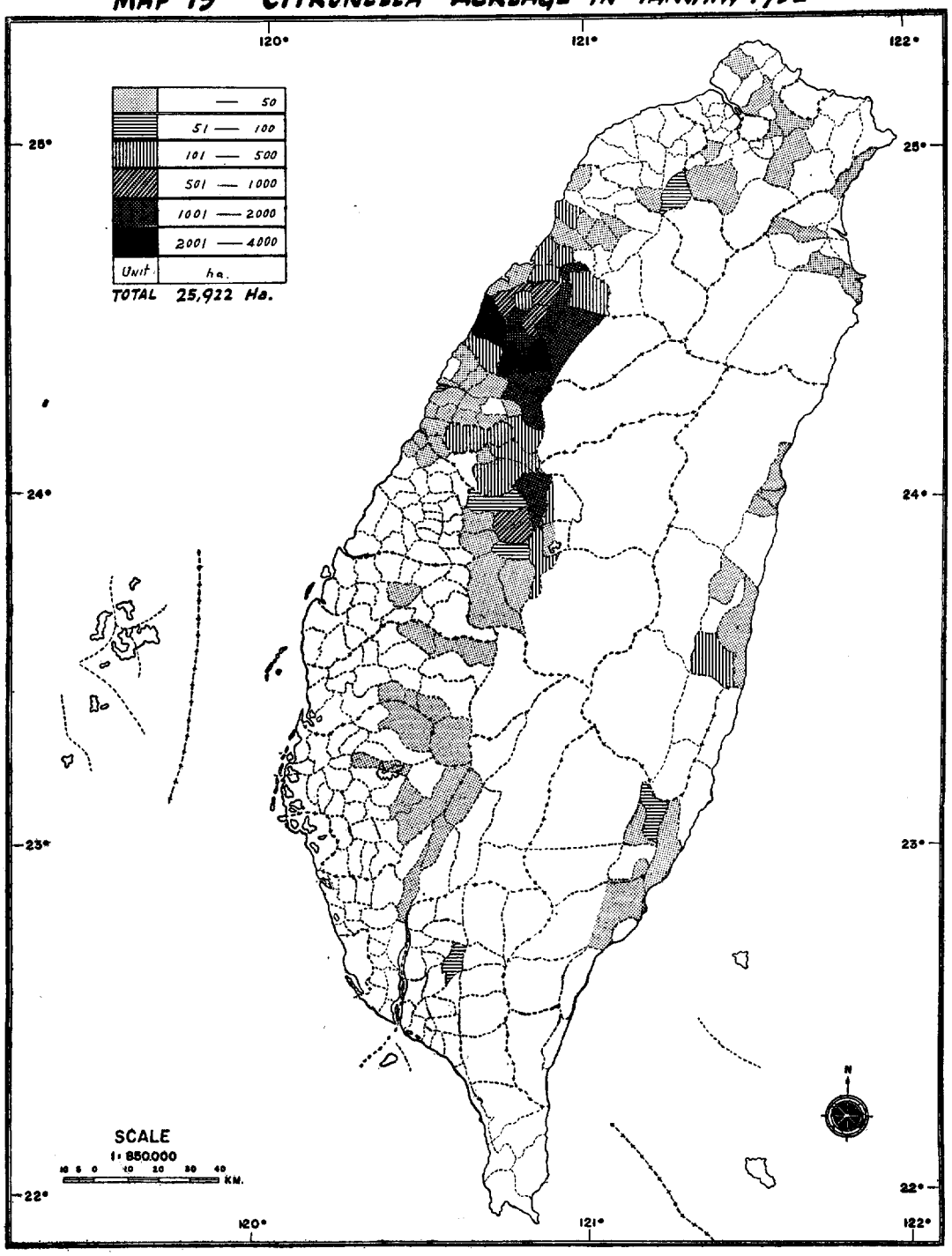
MAP 13 WHEAT ACREAGE IN TAIWAN, 1952



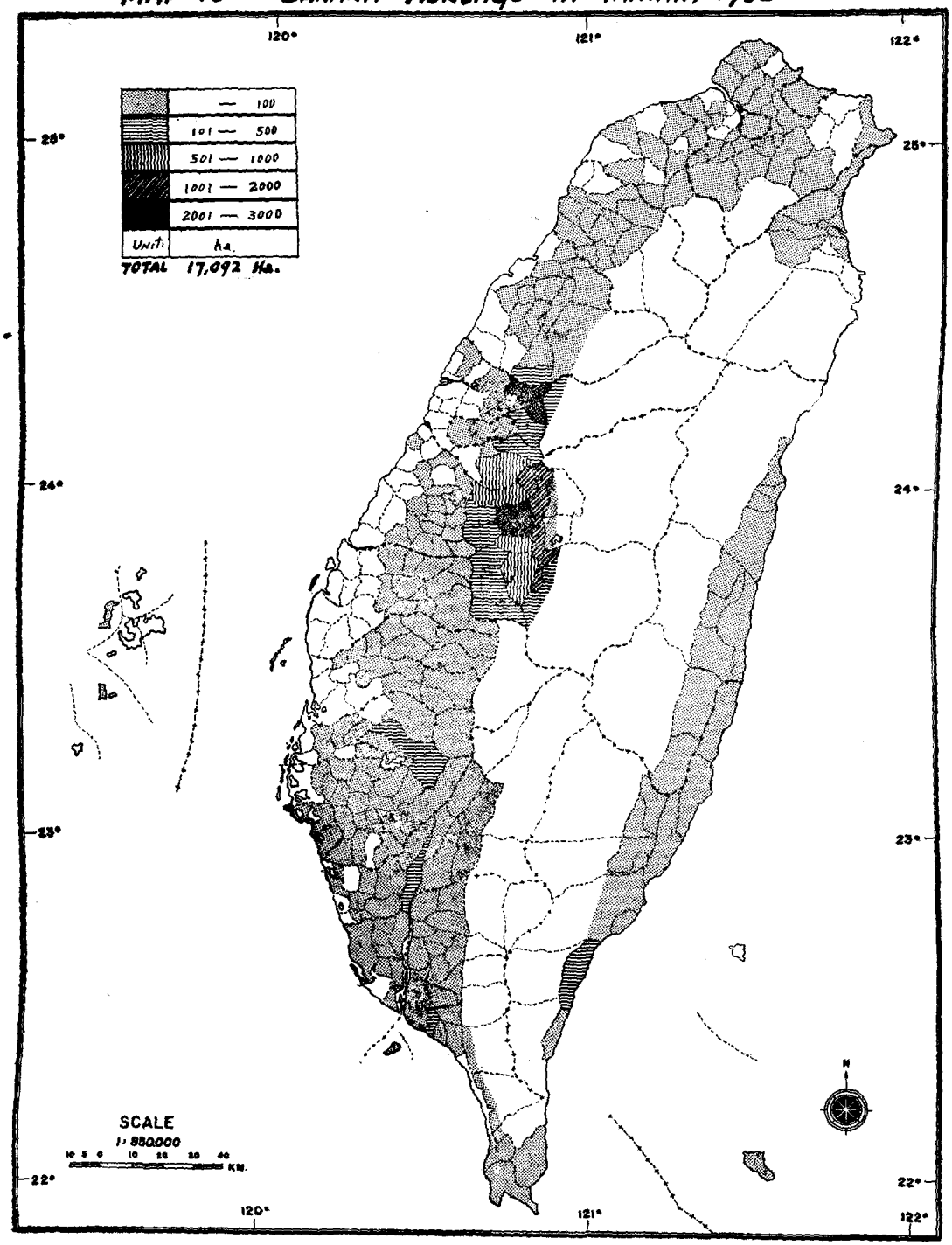
MAP 14 TEA ACREAGE IN TAIWAN, 1952



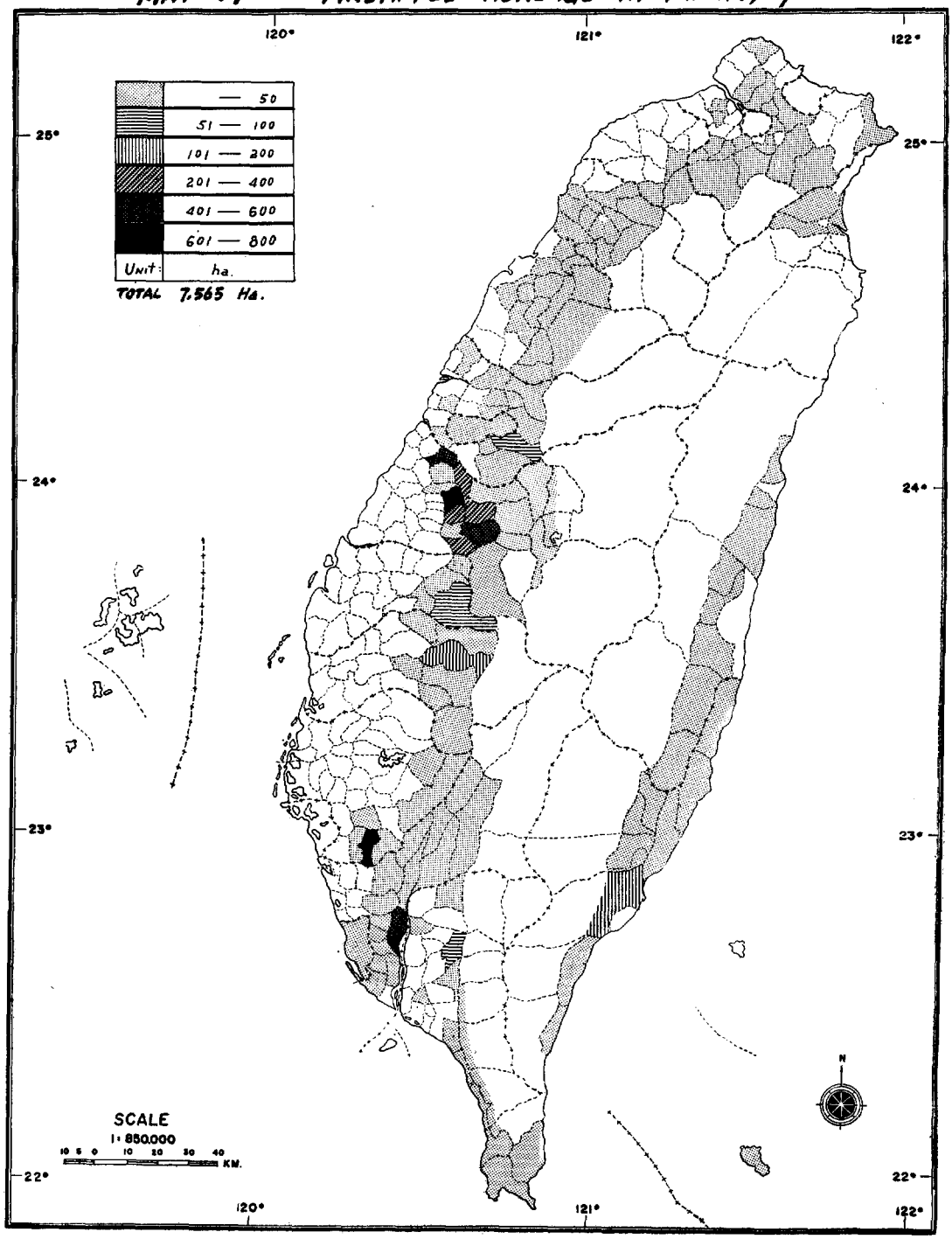
MAP 15 CITRONELLA ACREAGE IN TAIWAN, 1952



MAP 16 BANANA ACREAGE IN TAIWAN, 1952



MAP 17 PINEAPPLE ACREAGE IN TAIWAN, 1952



8. Distribution of Crops in Taiwan

Maps 8 to 17 show the distribution of nine important crops in Taiwan (Reference 9). An explanation should firstly be made of why the data of 1952 are used for mapping the distribution of crops instead of those of the more recent years. This choice is rather arbitrary. Before 1950, the distribution of many crops was not normal due to the effect of the War. From 1945 to 1950, there was a rapid increase in total cultivated land area and the acreage of almost all important crops. After 1950, the rates of increase of the acreage of the major crops have generally tapered off. It is the author's opinion that for showing the general crop pattern of postwar Taiwan, the data of any year after 1950 would do. The rice acreage actually has declined since 1952 due to the recurrence of drought in more recent years, especially 1954 and 1955. The recorded cultivated land area in 1952 is also so far the highest record. Furthermore, 1952 is also the year preceding the start of the Four-Year Plan (1953-1956) for Economic Development of Taiwan. It is thought that if the maps for crop distribution are made out for 1952, they may serve as a landmark for comparison with the crop distributions after the first Four-Year Plan is completed in future studies.

From Maps 8 to 13, it may be noted that most of the rice, sugarcane, sweet potato, peanut, and wheat are grown on land below the 100-meter contour line, with less than 2,000 mm. annual rainfall and of alluvial soils. Wheat, representing the winter crop, has the largest acreage in central Taiwan where the winter is neither too wet, like northern and northeastern Taiwan, nor too dry like southern Taiwan. From Map 14 to 17, it may further be noted that tea, citronella grass, pineapple and banana are distributed mainly on land from 100 to 1,000 meters in altitude, with 2,000 to 3,000 mm. of annual rainfall, and of reddish brown or yellowish brown lateritic soils which have little or no irrigation facilities. Tea and citronella are mainly in northern Taiwan; pineapple and banana are mostly in central and southern Taiwan.

In this booklet, it is not intended to discuss in detail the crop ecological adaptation in Taiwan. The maps are presented to give readers a bird's-eye view of the distribution of the major crops on this Island with general reference to the various elements of natural environment, as given in previous discussions and Maps 1 to 7.

The following is a brief account of the distribution of each of the nine selected crops, which will help explain why the crop regions as shown in Map 18 are so divided:

A. Rice –From Map 8, it may be seen that there are four areas of concentration. One is the northern Taiwan on the west coast, including mainly the Taipei Basin and the Plain of Taoyuan. The second is the Plain of Taichung and Changhwa. The third is the Plain of Kaohsiung and Pingtung. The fourth is the Plain of Ilan. The area of rice concentration along the west coast is broken by the hills of Miaoli, where citronella grass prevails, and again by the broad Plain of Yunlin, Chiayi, Tainan and northern part of Kaohsiung, where sugarcane, sweet potato, peanuts and jute concentrate.

B. Sugarcane –The acreages of sugarcane of the 1951/1952 crop and 1956/1957 crop (meaning harvested form December 1951 to April 1952 and from December 1956 to April 1957 respectively) are presented in Maps 9 and 10 respectively to show the tendency of reduction of sugarcane acreage in northern Taiwan in recent years. It may be seen from Map 10 that the major cane producing area is on the Plain of Yunlin, Chiayi and Tainan, about one half of the sugarcane acreage is in this area. The second important area is in Pingtung and a part of Kaohsiung. But since this is also a prominent rice area, the relative dominancy of sugarcane here is not as significant as in the Chianan Plain. The third sugarcane area is the Plain of Changhwa and a part of Taichung, where sugarcane is even less dominant than in the Pingtung and Kaohsiung Plain.

C. Sweet potato and peanuts ·These two crops have similar pattern of distribution (Maps 11 and 12). They are grown almost all over the agricultural land of Taiwan, but are concentrated on the Plain of Yunlin, Chiayi and Tainan (about one-third of the total sweet potato acreage and over one half of the total peanut acreage).

D. Wheat—Wheat is a minor crop in Taiwan, but is representative of the distribution of winter crops. There are two main areas of wheat, i.e. a main area on the Plain of Taichung and Changhwa and a secondary one along the coast of Yunlin, Chiayi and Tainan. In recent years, wheat is expanding in the former area and contracting in the latter area.

	Total wheat acreage	Taichung, Changhwa		Yunlin, Chiayi, Tainan	
		Wheat area	% total	Wheat area	% total
	ha.	ha.		ha.	
1952	14,582	7,700	52.8	4,770	32.7
1956	12,843	8,669	67.5	982	7.6

The higher winter rainfall and the richer soil in the Taichung and Changhwa area make the yield of wheat there much higher than in the Yunlin, Chiayi and Tainan area (Map 13).

E. Tea—The distribution of tea is most clear-cut. It is mainly on the lateritic tableland or hills of the northern Taiwan (Map 14).

F. Citronella—The distribution of the citronella grass is also quite distinct. The area of concentration is over the yellowish-brown lateritic hills of Miaoli Prefecture. A second area is developing in the hills of Nantou Prefecture, which so far has been predominantly a banana country (Map 15).

G. Banana—The area of concentration of banana is the higher hills of Taichung and Nantou Prefectures. A minor center exists in Pingtung and Kaohsiung Prefectures where it occupies some of the rice land (Map 16).

H. Pineapple—At present, the main commercial producing center of pineapple is the low hills and tableland of Changhwa and the western edge of the hills of Nantou. A new area has developed in recent years in Tainan, Kaohsiung and Pingtung as a result of the successful control of the pineapple mealy-bug. A third area will be formed in the vicinity of Taitung Municipality where a large pineapple cannery is scheduled to operate by the summer of 1957 (Map 17).

9. Crop Regions of Taiwan and Their Problems

Based on the distribution of the major crops, the crop regions of Taiwan may be classified as follows (Map 18):

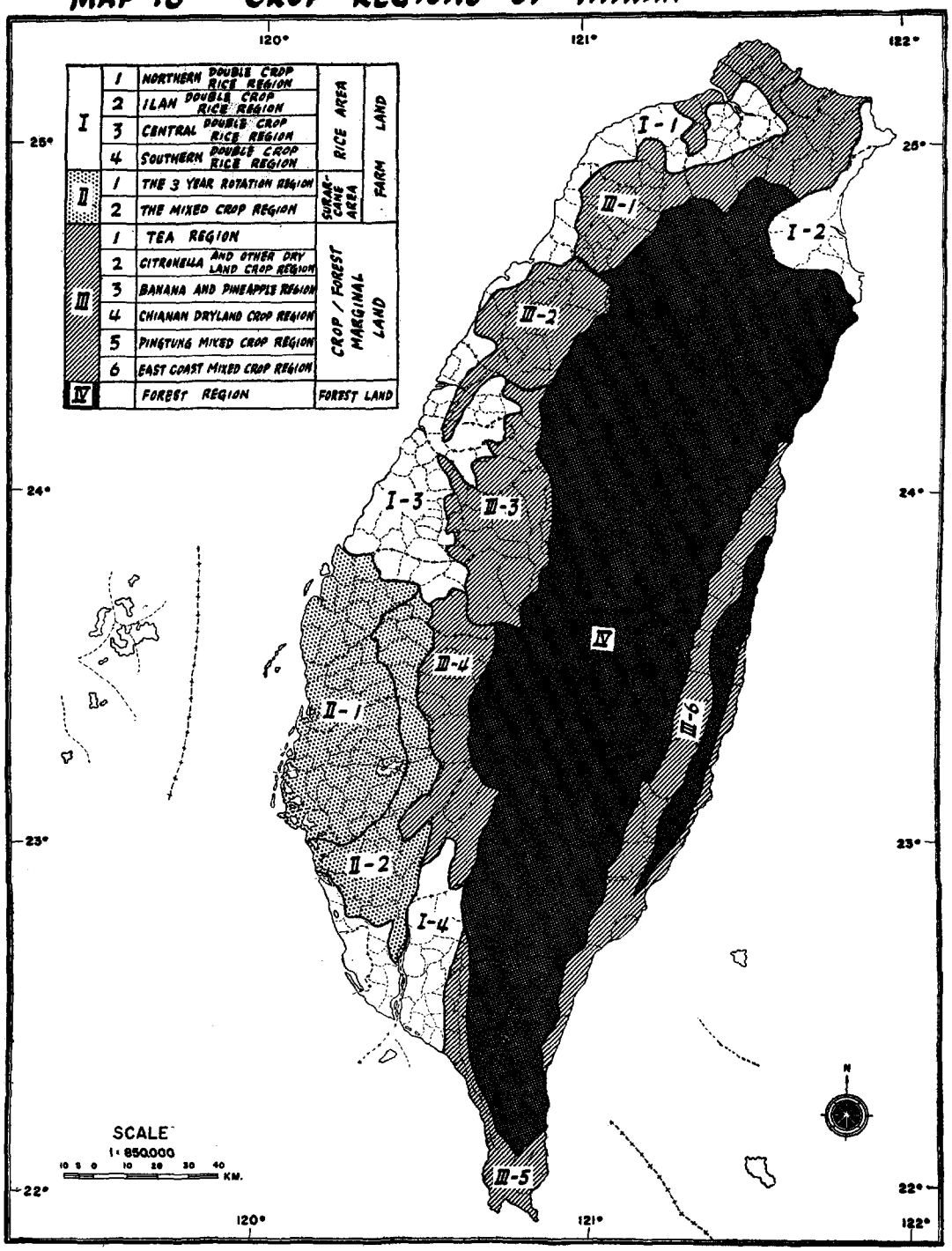
A. Farm Land

1. Rice area
   a. Northern double crop rice region
   b. Ilan double crop rice region
   c. Central double crop rice region
   d. Southern double crop rice region
2. Sugarcane area
   a. The 3-year rotation region
   b. The mixed crop region

B. Crop/Forest Marginal Land

1. Tea region
2. Citronella and other upland crop region
3. Banana and pineapple region

MAP 18 CROP REGIONS OF TAIWAN



4. Chianan dryland crop region
5. Pingtung mixed crop region
6. East coast mixed crop region

C. Forest Land—Forest region

The division of crop regions would be of little practical value unless it helps pin-point the major agricultural problems confronting each region so as to provide basis for more intelligent program planning. While such work as improvement of crop varieties, cultural method, pest control, etc. is basic to the agricultural improvement of any country and should be earnestly pursued in Taiwan, the different crop regions have the following practical and special problems which should be tackled in the future agricultural developmental program of Taiwan.

A. Rice Area

1. *Northern double rice region and Ilan double rice region:*

a. Improvement of irrigation of Taoyuan and Hsinchu area to do away with the frequently recurrent drought and failure of rice crop.

b. The selection and extension of a winter leguminous green manure crop which can make sufficient growth under the cool and rainy winter of Ilan and Taipei during the period from the harvest of the second rice crop in November to the land preparation for the first rice crop in February would generally improve the productivity of the whole region.

c. The provision of efficient means of drying paddy rice of the second rice crop would help reduce farmers' loss of paddy due to sprouting after harvest under the winter rain.

2. *The central double rice region:*

Comparatively speaking, this region has the least problem. Its soil is richest and its irrigation facilities are fairly satisfactory. The following, however, will help to further improvement.

Winter crops, i.e. wheat, tobacco, flax, sweet potatoes, vegetables, etc. are rapidly expanding their acreage in recent years and will soon compete for land. Future potentiality of these crops should be carefully studied from both ecological and economical points of view to provide reference to industries concerned, eg. flour mills, flax textile and tobacco factory, so their development may be gauged to the supply of raw material.

3. *The southern double rice region:*

a. Irrigation in some sections should be improved so that more Japonica rice could be grown in the place of the Indica rice varieties. The earlier harvest of the second rice crop will enable the farmers to grow a winter crop of soybean, which is already a common practice in areas of good irrigation.

b. Provision of drying facilities for quick drying of paddy of the first rice crop will help reduce the damage of the paddy by the summer showers.

B. Sugarcane Area

This area will see increasingly sharp competition for land among rice, sugarcane, sweet potato, peanuts, jute, etc. in the future. With the possible development of underground water resources, the potential of expansion of rice acreage in this area is larger than in any other areas where the double rice crop system already prevails. On the other hand, the necessity for maintaining the present production level of sugar, and for increasing the production of peanuts as a source of protein feed, and that of jute as packing material for rice and sugar, will also demand land in the area. Problems of readjustment among areas of these crops are bound to come up when the program for development of underground water resources actually gets underway. Increasing yield per unit area of the various crops and reducing loss after harvest through technical improvements are two requirements for any of such readjustment. The improvement of the utilization of the saline soils and "Planosol" like soils in this area will also play important role in making future crop readjustment possible.

The tendency might be (1) to gradually move a part of the sugarcane acreage to these soils with improved cultural technic and suitable varieties, (2) to withdraw some of the acreage occupied by jute to other regions or by seeking substitute fiber crops which might be grown in upland of other regions, (3) to save the tremendous loss of sweet potatoes after harvest to make it possible to reduce its acreage, while keeping up the total production. Under such readjustment, acreage and production of rice and peanut may be increased in this area to meet the increasing national demand.

C. The Crop/Forest Marginal Land

1. The overall problem for all crop regions under this broad category is soil conservation. It will be a long range program to educate the local farmers to adopt universally the modern soil conservation methods, but it is a basic program

which Taiwan must embank on with the sincerest effort. The potential of raising crop yield on these lands is larger than on the plains. Here also lies the hope of increasing the volume of export of agricultural products other than sugar and rice. To diversify the exportable goods should be an important element in the future economic planning of Taiwan.

2. Almost all of the crops grown on hillsides use very little chemical fertilizers at present, with the only exception of pineapple. The potential of increasing crop yield in this broad area through the application of more fertilizer should be also among the future efforts of Taiwan.

Reference

(1) Summary Statistics on the Administration of Prefectural/Municipal Governments and Township Public Offices of Taiwan Province, Provincial Department of Civil Affairs, May 1955 (In Chinese)

(2) Land Utilization in Taiwan, C. S. Chen, 1950 (In Chinese)

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(4) Soils of Taiwan, L.T. Hsi, Taiwan Fertilizer Company, Annual Report on Soils and Fertilizers in Taiwan, The Society of Soil Scientists and Fertilizer Technologists of Taiwan, 1952

(5) Agricultural Geography of Taiwan, Jen-Hu Chang, China Cultural Service, Taipei, Taiwan, 1953

(6) Land Use and Forest Survey of Taiwan, Forestry Division, JCRR, 1956 (Not yet officially published.)

(7) Agricultural Yearbook, the 1954 Edition, PDAF

(8) Map of Irrigated Areas in Taiwan, Provincial Water Conservancy Bureau, PDOR, January, 1952

(9) Data Based on PDAF Crop Reporting, mapping by the author

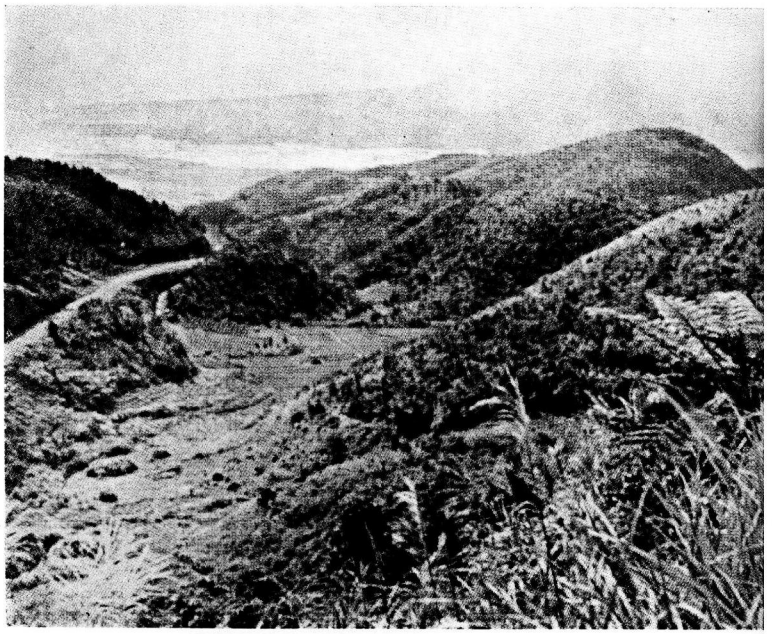
→ Picture showing the dominance of rice in Double Crop Rice Regions.

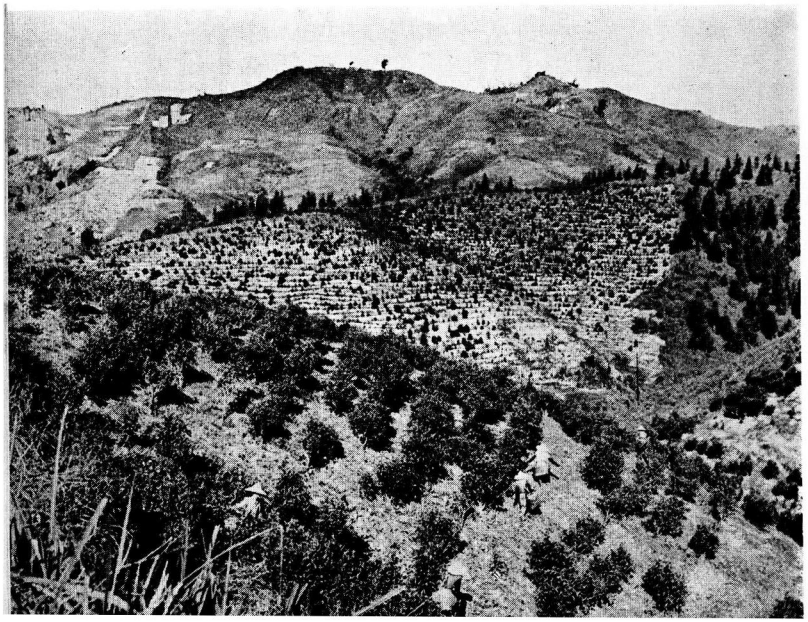
← Winter crops are widely planted after the harvest of the second rice crop in the Central Double Crop Rice Region.

→ In the so-called Sugarcane Regions, sugarcane, rice, and miscellaneous upland crops are of equal prominence or are grown in rotation according to availability of irrigation water.

← Intercropping of sugarcane and peanut in the 3-year rotation area.

→ The picture shows the general landscape of the Crop/Forest Marginal Area. Farm land lies beyond the hills shown in the foreground. In the valleys and on slopes farm crops meet and intermingle with trees and shrubs.





← Tea plantations on hillsides.

→ Hills after hills in Miaoli Prefecture have been planted to citronella grass in postwar years.

← Pineapple fields on hillsides, adjoining rice fields on the plain.

→ The forest of the Central Mountain Range.