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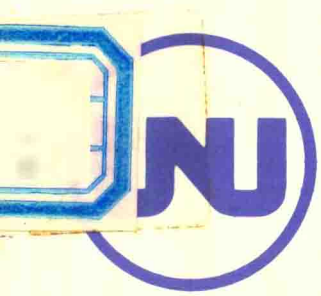
Land Resources of the People's Republic of China

Edited by Kenneth Ruddle
and Wu Chuanjun

RESOURCE SYSTEMS THEORY AND METHODOLOGY SERIES, NO. 5



THE UNITED NATIONS UNIVERSITY

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From the CHARTER OF THE UNITED NATIONS UNIVERSITY

ARTICLE I

Purposes and structure

1. The United Nations University shall be an international community of scholars, engaged in research, post-graduate training and dissemination of knowledge in furtherance of the purposes and principles of the Charter of the United Nations. In achieving its stated objectives, it shall function under the joint sponsorship of the United Nations and the United Nations Educational, Scientific and Cultural Organization (hereinafter referred to as UNESCO), through a central programming and co-ordinating body and a network of research and post-graduate training centres and programmes located in the developed and developing countries.

2. The University shall devote its work to research into the pressing global problems of human survival, development and welfare that are the concern of the United Nations and its agencies, with due attention to the social sciences and the humanities as well as natural sciences, pure and applied.

3. The research programmes of the institutions of the University shall include, among other subjects, coexistence between peoples having different cultures, languages and social systems; peaceful relations between States and the maintenance of peace and security; human rights; economic and social change and development; the environment and the proper use of resources; basic scientific research and the application of the results of science and technology in the interests of development; and universal human values related to the improvement of the quality of life.

4. The University shall disseminate the knowledge gained in its activities to the United Nations and its agencies, to scholars and to the public, in order to increase dynamic interaction in the world-wide community of learning and research.

5. The University and all those who work in it shall act in accordance with the spirit of the provisions of the Charter of the United Nations and the Constitution of UNESCO and with the fundamental principles of contemporary international law.

6. The University shall have as a central objective of its research and training centres and programmes the continuing growth of vigorous academic and scientific communities everywhere and particularly in the developing countries, devoted to their vital needs in the fields of learning and research within the framework of the aims assigned to those centres and programmes in the present Charter. It shall endeavour to alleviate the intellectual isolation of persons in such communities in the developing countries which might otherwise become a reason for their moving to developed countries.

7. In its post-graduate training the University shall assist scholars, especially young scholars, to participate in research in order to increase their capability to contribute to the extension, application and diffusion of knowledge. The University may also undertake the training of persons who will serve in international or national technical assistance programmes, particularly in regard to an interdisciplinary approach to the problems with which they will be called upon to deal.

ARTICLE II

Academic freedom and autonomy

1. The University shall enjoy autonomy within the framework of the United Nations. It shall also enjoy the academic freedom required for the achievement of its objectives, with particular reference to the choice of subjects and methods of research and training, the selection of persons and institutions to share in its tasks, and freedom of expression. The University shall decide freely on the use of the financial resources allocated for the execution of its functions . . . .

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PREFACE

The agricultural mobilization of land resources has played a fundamental role in shaping both the civilization of China and its cultural landscapes and since ancient times has formed the foundation of the Chinese economy. In China, as elsewhere, agriculture is at once a craft, a business and a way of life, and, notwithstanding the tremendous transformations that have taken place in the structure of the national economy since the founding of the People's Republic in 1949, the agricultural traditions of the nation have remained strong.

Further, China's land resources are complex and varied, as befits a vast territory of 9.6 million km^2, which extends from the cold, continental zone, near Siberia, to south of the Tropic of Cancer, embraces a wide range of climatic and biotic zones, and includes a great variety of topographical types. The diversity of environments thus formed is reflected in the areal differences in natural resource endowment and land use, and in the regional imbalance in the development and use of primary resources. The fertile and well-watered deltas of the great rivers, such as the Yangzi and Zhu, for example, are among the most intensively cultivated, highly productive, and densely populated regions on earth where almost every inch of cultivable land is made to produce food, vegetable oils, fibres, and fuel, and the waters are intensively used for raising fish and aquatic macrophytes. But, on the other hand, China has vast, virtually unused tracts of desert and mountains covered with perennial snows, categories of land which together account for more than 19 per cent of the nation's territory.

Yet, despite the historical and contemporary importance of its agricultural sector, no complete, official land survey has ever been conducted in China, hence consistently reliable land-use statistics do not exist for the nation as a whole, a deficiency that inhibits effective long-range planning. Only estimates rather than statistics, *senso strictu*, are available. To remedy this, and to provide a more realistic quantitative estimate of land-use categories in the nation, the Institute of Geography of the Chinese Academy of Sciences (Beijing) prepared a *Map of China's Land Utilization*, at a scale of 1:6,000,000. (This was published in 1980 by the Map Press, Beijing.) From that exercise it was estimated that of China's area of 9.54 million km^2, only 14.6 per cent is cultivated at present, while 40.8 per cent is in grazing, 8.6 per cent is under forests, 7 per cent is used for industry, communication, and urban purposes, and 6.6 per cent is devoted to other uses. Of the remaining 22.4 per cent, much is high and barren desert, or under permanent snowfields, or not yet in use, or unable to be used with available technologies.

In addition to the lack of reliable data for planning, other problems beset the development of China's land resources. One problem is that of the appropriate development and management of resources. Most of the nation's vast pastures and grasslands, for example, have been degraded, their area and quality having been reduced by over-grazing and lack of maintenance, and through desertification and the depredation of rodents. Another problem is that much cultivated land remains low-yielding, owing mainly to edaphic conditions. Slopeland in the Loess Plateau Region, for example, yields grain at a rate of less than 0.75 t/ha, owing mainly to serious soil erosion; some depressions in the North China Plain suffer from serious salinization or alkalinization; and hills south of the River Yangzi remain a fuelwood preserve, since the lateritic soils of that region are of limited fertility. Yet another problem is that most hilly and mountainous areas remain underdeveloped. China is essentially a mountainous country with about 66 per cent of its land surface classed as either mountains or hills. But China lacks comprehensive, nationwide resource planning, and agriculture, animal husbandry, forestry, fisheries, and the like are usually administered separately by different government agencies, thereby inducing a fairly low level of agricultural production and the improper use of upland areas. However, China's uplands are important since they are inhabited by about 30 per cent of the nation's population, contain about 40 per cent of its cultivated land, and produce some 90 per cent of its grains.

For China as a whole, cultivated land has been more intensively used since the establishment of the People's Republic in 1949. In large part this has been achieved through the wider application of multicropping and interplanting, which have significantly raised the nation's cropping index and greatly contributed to increases in agricultural productivity. The northern limit of double cropping has been pushed farther north beyond the Great Wall, and many places in the North China Plain previously under monocropping are now double-cropped with summer rice and winter wheat, as a result of better irrigation practices. And south of the River Huai there has been widespread application of the double-cropping system of rice plus winter wheat or rape-seed, thus permitting three harvests a year. However, there is always a limit to the increase in the cropping, and any attempt to raise the cropping index without careful consideration of limiting factors can only be unsuccessful.

To meet the needs of an expanding population, China must open up more land for farming. Approximately 32 million ha of arable land has been put under the plough since 1949, and about 2,500 State Farms have been established in reclaimed areas, thus enlarging the nation's food-production capacity. The State Farms in Heilongjiang Province and Xinjiang Uygur Autonomous Region have become the key components of China's new food bases, whereas those on Hainan Island and in southern Yunnan Province have become the nation's new tropical crop plantations. All potentially reclaimable land, however, has not been fully developed, and an additional 43 million ha may be suitable for reclamation and farming. But, as the bulk of the reclamation work has been undertaken in border regions, either along the margins of forest land or in the transitional zone between the farming and grazing regions, disputes among the farming, forestry, and animal husbandry sectors are frequent.

Thus there is a pressing need for a critical evaluation of the nation's land resources, a task that must be completed before appropriate policies for optimal land use can be made. To that end the Institute of Geography of the Chinese Academy of Sciences, assisted by other institutes of the Academy and by universities, is making a nationwide land-use survey. The project will be carried out in three stages: sample studies of areas with different types of land use and preparation of land-use maps at scales between 1:10,000 and 1:50,000; the compilation of land-use maps for each province and autonomous region at scales of 1:100,000 and 1:500,000, depending on the size of the area; and the compilation of a set of land-use maps for the entire nation on the scale of 1:1,000,000, based on the provincial maps. The important set of maps of national land use to be completed in the third stage will use a system of land-use classification that will become the standard for the nation. The completion of this set of maps will provide planners with more accurate areal figures for different types of land-use. It will also be an important benchmark in the modernization of Chinese agriculture. Maps of land types, geomorphology, natural vegetation, soils, and land potential are also being compiled by various institutes of the Academy, all on a scale of 1:1,000,000. When completed, these maps will also become basic tools for national agricultural planning.

This volume contains papers presented by the Chinese participants at the international conference on "Land Use Evaluation and Classification, with Special Emphasis on Wetlands," sponsored jointly by the United Nations University and the Chinese Academy of Sciences and held in Beijing and Heilongjiang Province from 15 to 25 September 1980. It documents several aspects of the critical evaluation of land resources now underway in China.

The publication is divided into two parts. The first deals with the nationwide classification, mapping, and evaluation of land-use categories, and its local application. The second is devoted to the wetlands of north-east China, a region largely closed to outsiders since 1949. The first four chapters deal with China as a whole. In chapter 1, Xi Chengfan discusses the physical and biological basis for the division of China into eight principal land-type regions and describes their agricultural usage. This is followed by Zhao Songqiao's chapter, which describes the basis for the subdivision of the natural regions of China into first- and second-order land types, identified mainly on the basis of macro- and micro-landforms and other surface features. Discussion of the natural sub-division of China is continued in chapter 3, in which Shi Yulin examines the classification of the national territory into orders (regions), classes, subclasses, groups, and types, on the basis of suitability, limitations, and potential for development for primary use, that was adopted for the 1:1,000,000 *Map of China's Land Resources*. The final chapter dealing with China as a whole, by Li Xiaofang, attempts to supplement an earlier national land-evaluation scheme with a simplified approach based on levels of land suitability for agriculture, animal husbandry, and forestry.

Part I concludes with two chapters of narrower geographical scope. Chapter 5, by She Zhixiang et al., illustrates some of the more generalized and theoretical points made in the preceding chapters via a study of land use on the Lake Taihu Plain in the southern Yangzi Delta, an area in which the application of complex systems of multiple cropping has resulted in greatly increased grain yields and where the cultivation of important speciality crops is carefully adapted to micro-climatic and other local environmental factors. Song Daquan's chapter on salt-marsh resources continues this illustration with a

discussion of the use of coastal wetlands for agriculture, aquaculture, and salt production, with emphasis on the northern Yellow Sea coast and that of southern Zhejian Province.

The three chapters of part II are devoted to the remote and hitherto marginal wetlands of north-east China — previously known to foreigners as Manchuria. Two deal with the wetlands of the Sanjiang Plain, while the last examines those on the south-eastern slopes of the Greater Khingan Range. Since large-scale reclamation of the Sanjiang Plain began three decades ago, multiple indicators of environmental deterioration have appeared. The authors of chapter 7 attribute these phenomena both to changes in the pattern of atmospheric circulation and to human activities. In this chapter important measures for regional economic development combined with environmental protection are advanced. Discussion of the problems of waterlogging and drought in the Sanjiang Plain continues in the following chapter, in which Zeng Jianping et al. describe their successful experiments with a well-pumping system that combines drainage with irrigation. The book concludes with a chapter by Chen Yongzong et al. that describes the biological and physical changes consequent upon human intervention, and the biological and engineering measures that are required to drain and reclaim the wetlands on the slopes of the Greater Khingan Range.

In many ways this book may be regarded as a measure of current geographical research in the People's Republic of China, since it embraces the main themes emphasized at present, namely agricultural regionalization, land evaluation and classification, and physical geography. In China most geographical and related research is applied to the development of the nation's natural resource endowment, and this publication provides a vivid illustration of the Chinese policy that research should be closely integrated with the needs of national development, since every chapter falls very clearly under the rubric of "applied geography." It is significant, too, that a large percentage of the contemporary national research effort has been directed at incorporating marginally productive and geographically peripheral areas more fully into the national economy, a direction exemplified here in all nine chapters, but particularly those dealing with north-east China.

In most of the original papers data were presented in traditional Chinese units. These have been converted as follows: 1 *mu (mou)* = 0.066 ha (or 0.165 acre); 1 *jin* = 0.5 kg (or 1.1 lb); 1 *dan* = 50 kg; and 1 *li* = 0.576 km (approx. 0.33 mile). Throughout the text binomials have been provided for only those plant taxa less familiar to Western readers.

The editors wish to express their gratitude to Dr. R.D. Hill, University of Hong Kong, Dr. J. Stadelbauer, University of Freiburg, Dr. J. Street, University of Hawaii, and several anonymous reviewers for their many invaluable suggestions regarding a first draft manuscript of this publication. Dr. L.J.C. Ma, of the University of Akron, Ohio, prepared a first draft of the conference proceedings.

Both to provide a degree of coherence to this volume and to avoid publishing already familiar material, the papers delivered at the 1980 meeting by overseas participants are not included here. Since no proceedings per se of the conference will be published, readers interested in obtaining copies of the papers presented by foreign participants should write directly to the respective authors (see the list of contributors at the end of this volume). Further, we confess to having exercised widely our prerogatives as editors, since, in the interests of clarity as well as to reduce the considerable repetitiveness inevitable in conference papers dealing with closely related topics, all chapters have been extensively edited. In so doing, we have deleted much non-essential material, and chapter 7 has been compiled from two previously separate chapters. Not everybody will be satisfied with the result, and surely errors still remain. But we accept sole responsibility for this.

Kenneth Ruddle
Osaka
July 1982

Wu Chuanjun
Beijing
July 1982

I. LAND-USE EVALUATION AND CLASSIFICATION

CONTENTS

1. MAJOR LAND-TYPE CATEGORIES OF CHINA

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Abstract

Because of its large size, China's natural environment and natural resources are extremely diverse and complex. The following major land use categories can be distinguished: eastern lowlands (further divided into four sub-regions), the arid north-west, and high mountain ranges and the Qinghai-Xizang (Tibet) Plateau.

One of the first requisites for understanding China's land resources is to classify the nation into major land-type categories, since a classification will contribute to planning for the better use of resources. This chapter presents a general overview of the major land types of China. Detailed, comprehensive systematic studies of each land-use type are urgently needed.

With an area of 9,600,000 km^2, China is a huge and physically diverse country. Hydrothermal conditions are varied, ranging from humid conditions in the south-east to the arid north-west (table 1.1). Thermal conditions change latitudinally (table 1.2), south-eastern China being either humid tropical or subtropical, whereas the north-west, in central Eurasia, is extremely arid with a mean annual precipitation of only some 50 mm, under warm continental thermal conditions.

TABLE 1.1. Regional Differences in Humidity

Region	Condition	Aridity index*	Average annual precipitation (mm)
South-east	Humid	>1.00	>1,000
North	Semi-humid	1.00–1.50	500–1,000
Loessal and Mongolian Plateaux	Semi-arid	1.50–4.00	250–500
North-west	Arid	<4.00	<250

* For definition see chapter 4.

TABLE 1.2. Temperature Regimes

Region	Climatic zone	Accumulated temperature >10 °C	Frost-free days
Hainan Island	Tropical	8,200–9,200	365
South China	Subtropical	4,500–8,200	216–365
North China	Warm Temperate	3,400–4,500	166–215
Mongolian Plateau	Temperate	1,700–3,400	90–165
Northern and North-east China	Continental	<1,700	90

China is predominantly mountainous, approximately 66 per cent of the total land area being mountains and hills, which attain their highest elevation in south-western China, where ranges culminating in Mt. Qomolangma (8,848 m) overlook the Qinghai-Xizang (Tibet) Plateau, which averages 4,000–5,000 m above sea-level. Adjacent to the Qinghai-Xiang Plateau is a series of ranges with elevations of 1,000–4,000 m. The chief intermontane basins are the Sichuan Basin, in the humid subtropical region, and the Tarim Basin, in the extremely arid, warm continental inland region. Among the major plateaux are the Yunnan and Guizhou Plateaux, in the south, and the Loessal and Mongolian Plateaux, in the north.

Eastern China is a lowland region with great plains and river valleys dividing low mountains. The vast Songliao Plain and the North China Plain both lie north of the River Yangzi. In the Yangzi and Zhu valleys are several large alluvial and lacustrine plains.

Such a diverse physical environment has given rise to various types of soils and vegetation. Consequently, the land-use types are varied, and eight major types are distinguished and described in the remainder of this chapter.

The Eastern Lowlands

Eastern China, including the islands in the South China Sea, occupies a vast territory extending from approximately 4°N to 53°30'N. It is mainly a lowland region with lakes, plains, hills, and scattered low mountain ranges that rarely exceed 1,000 m in elevation. In the eastern lowlands four sub-types of land use may be distinguished, as described below.

1. Tropical Rainforest and Subtropical Evergreen Area with Ferro-Allitic Soils (Oxisols and Ultisols)

This sub-type is characterized by rainforest and monsoon forest in the tropics and by evergreen broadleaf forest in the remainder of the region. Most of the soils are in different stages of allitic weathering (i.e. silica has been largely removed and the clay fraction is dominated by Al and Fe components). Latosols (Oxisols) with comparatively strong allitic weathering are found on Hainan Island and the Leizhou peninsula, where the mean annual temperature (>23°C) and the accumulated temperature (>10°C) approximates 8,000°C (up to 9,000°C in some years). The mean annual precipitation is >1,500 mm. Topographically, the lowland's coastline has rolling hills and terraces. The tropical islands in the South China Sea are geologically young, most being formed by coral reefs where phospho-calcic soils developed from guano are abundant.

Under hot and humid conditions, rice can be triple cropped, sweet potatoes grown all year round, cassava planted in most places, and rubber cultivated in the south. Tropical crops such as coffee, cacao and coconuts are produced.

The area from the Zhu Delta to the Yangzi Valley, between approximately 18°N and 30°N, is characterized by rolling hills and low mountains with ferro-allitic red and yellow soils (ultisols). It is an area of evergreen broadleaf forests, the major species of which are *Castanopsis* spp., *Schima* spp., *Cinnamomum* spp., and *Lithocarpus,* all mixed with *Calamus* spp. The main species of the mixed forests is *Quercus* spp., with ferns and rhododendron constituting the principal understorey plants. After deforestation, the trees *Pinus massoniana, Acacia,* and *Cyclobalanopsis,* and *Cunninghamia lanceolata,* mixed with the grasses *Miscanthus* and *Themeda* spp., grow as the major secondary plants. Various species of bamboo are also abundant in this area.

The middle Yangzi valley has a subtropical climate with a mean annual temperature of 16°C to 20°C, the accumulated temperature >10°C is between 5,000 and 7,000°C, the annual frost-free period is 220 to 300 days, and the average annual precipitation is 1,000 to 2,200 mm. The natural vegetation is dominated by evergreen broadleaf trees. Two crops of rice or a rice-wheat rotation characterize the region's intensive agriculture. Tea, tung oil *(Aleurites fordii),* and citrus are widely planted in this region, and longan *(Nephelium longana)* and lichee *(N. litchi)* are concentrated in its southern part.

The Sichuan Basin, situated in the middle course of the River Yangzi and surrounded by high mountains and plateaux, has climatic conditions and fertile soils that support a high agricultural productivity, especially in the Chengdu Plain, which has been irrigated for more than two millennia. Maize, millet, citrus and vegetables are grown on the hill slopes of the basin and rice is cultivated in the gullies.

In the Yangzi valley and its tributaries most plains and gully areas are in rice cultivation. As a result of the flooded-field rice agriculture that has been practised here for centuries, both the chemical properties of the soil and its morphological features have been greatly changed. Such changes are also found on the terraces where irrigation water is available and where the soil solum is thick. Terracing is one rational way to use slopeland in this humid subtropical region. In certain parts of this region the land is less productive, as in the many deeply dissected gullies where paddy fields suffer from waterlogging by underground cold springs, which reduces soil temperatures for rice plants and inhibits the aeration needed for their root development.

In Yunnan and Guizhou Provinces and the Guangxi Zhuang Autonomous Region, limestone areas totalling about 400,000 km^2 have been highly weathered and leached under the prevailing humid tropical conditions. Three types of karst landform are recognized in those regions. First are ridges and depressions characterized by round depressions distributed among high ridges and bare limestone outcrops. Surface water is scarce and the watertable deep. Rendzina and *terra rossa,* in the depressions, are the main soil types. They are characterized by a relatively thin solum and are used mainly to raise dry farming crops such as maize and beans. The problem of drought is quite severe and this type of land generally has a low productivity. Second are pillars (erosional remnants) and valleys where eroded depressions have coalesced to form narrow valleys with pillars along their sides. Maize, beans and sorghum are raised in the valleys, and the steeply sloping pillars are either forested, or planted with tung oil trees or bamboo. Sheep and goats are grazed on the shallower slopes. Third are flat, open plains with depressions, lakes, and rivers formed after further dissection and leaching. Those between the hills and lakes are used as rice paddies and the foothills are dry farmed for corn, beans and fruits.

2. Plains and Hilly Areas in North China with Semi-Humid and Warm Temperate Climate, Deciduous Forests, and Loessal Soils

North of the River Huai and the Qinling Mountains, the climate becomes semi-humid and warm temperate, with a mean annual precipitation of 500 to 700 mm, and a mean annual temperature of 9–13°C. The natural vegetation in the eastern part of North China is dominated by broadleaf deciduous trees, especially *Quercus* spp. and *Tilia* spp. The soils are luvic (i.e., leached and acidic) brown earths. The western part is drier with a mean annual precipitation of 500 mm or less. The natural vegetation contains mixed broadleaf forests, shrubs, and grasses. The soils are calcareous with a heavy surface accumulation of pseudo-mycelium, a threadlike deposit of $CaCo_3$, that looks like mycelium.

In much of North China, annual double cropping or biannual triple cropping is common. Wheat is the winter crop, and maize, sweet potatoes, and peanuts are the major summer crops. Apples, pears, peaches, chestnuts, walnuts, and jujubes (*Ziziphus* spp.) are widely produced.

The Shandong and Liaodong peninsulas are rolling and hilly with elevations from 200 to 400 m above sea-level. There the luvic brown earths are formed by the weathering of granitic masses. After denudation, the soils become sandy and skeletal, yet still suitable for apple-growing.

The immense, flat North China Plain was formed by the deposition of alluvia by the laterally shifting channels of the Yellow River. It consists of interbedded clay and silty materials. On the natural levées and alluvial fans are large areas where peanuts or pears are cultivated. Clay soils are common in lowland areas or depressions, and are normally used for planting wheat and sorghum. Between the natural levées and the clay depressions, the interbedding of clay and sand results in a complex solum, and the high water-table has led to salinization and alkalinization. Solonchaks occur along the coast.

The Loessal Plateau, in the middle course of the Yellow River, and exceeding 500,000 km^2 in area, may be subdivided into dissected loessal plateaux, dissected loessal ridges, and eroded loessal hills. On the dissected loessal plateaux the darker loessal soils form a solum 1.5 to 2 m thick, but which is low in organic matter (1–2 per cent). The dissected gullies may reach a depth of 100 m and on their steep slopes loessal soils have an even lower organic matter content (0.5 per cent). Over large parts of the Loessal Plateau the surface soil has been completely eroded, leaving only skeletal and immature soils. Owing to drought and the low organic content of the soil, the region's agricultural production is low and uncertain.

3. North-eastern Plains and Mountains with a Continental Humid and Semi-Humid Climate

The climate is continental and humid in North-east China. In the eastern section the average annual precipitation is 500–700 mm, with a frost-free period of about 120 days. The accumulated temperature >10°C is only 2,200°C. The two major plains in North-east China are the Songliao Plain and the Sanjiang Plain. In the former, the average annual rainfall is 450–600 mm, the frost-free period is about 110–150 days, and the accumulated temperature is 2,000–2,500°C. Although the growing season in the Songliao Plain is relatively short, rice, sugar-beet, soybean and sorghum can be cultivated, since rainfall and temperature maxima coincide in summer.

In the gently sloping Sanjiang and Songliao Plains, Baijiang soils with associated black soils are common. The black soils are lime-free and have a thick, mollic solum (30–60 cm) and high humus content (3–10 per cent). Meadow and swamp soils are common in low-lying areas. In the western portion of the Songliao Plain, the climate becomes semi-arid and chernozems occur. In low-lying areas soda-solonchaks are common.

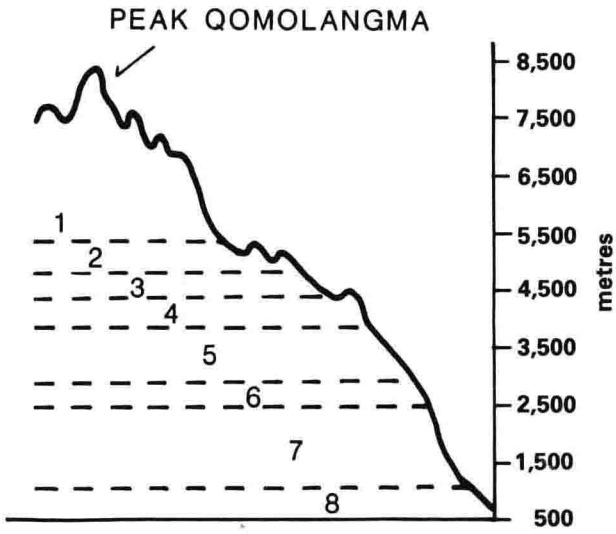
Bordering these two plains in the North-west are the Greater Khingan Mountains (Xiao Xingan Ling), a major timber-producing area. The Changbai Mountains run north–south between the Sanjiang and the Songliao Plains. In these highland regions coniferous and broadleaf mixed forests are widespread, the soils humusrich dark-brown earths. Some *Taiga* forests occur in the north.

4. Mongolian Steppe

South-west of the Greater Khingan Mountains lies the gently rolling Mongolian Plateau, where the climate is dry and the vegetation is dominated by short grasses. In this region the humus content of the soils decreases with the increase of calcium carbonate and salt content, and wind erosion in the Tarim Basin has resulted in many unique landforms.

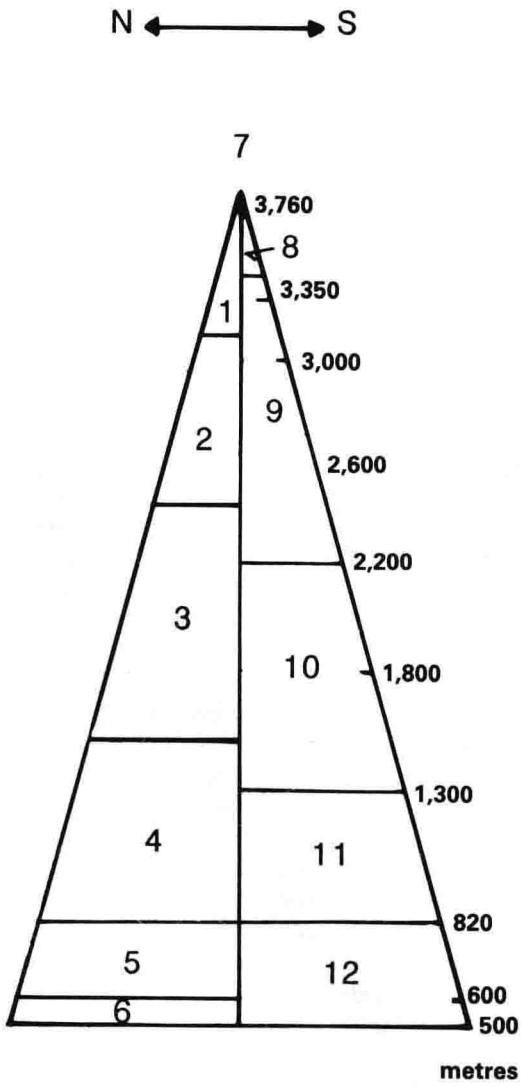
With an average annual precipitation range of 100–150 mm and occasional winter snow, the Junggar Basin is cooler and slightly more moist than the Tarim Basin. Most sand dunes are stable or semi-stable in the Junggar Basin.

In neither basin is agriculture possible without irrigation, but since both are surrounded by high mountains of 3,000–7,000 m, the Qilian and Altun Mountains to the south and the Tian Shan and Altay Shan in the north, meltwater from snowfields and glaciers is enough to support farming. Near the edges of alluvial fans, large oases with silty desert soils have been centres of irrigated agriculture for millenia. The principal crops are cotton, wheat, maize, grapes, pears, and melons.



1. Alpine glaciers.
2. Periglacial and cold "desert" soils.
3. Alpine meadow and felty soils.
4. Rhododendron shrubs and brown felty soils; Sub-alpine meadow and dark felty soils.
5. Coniferous forests – *Abies, Picea,* and podsolic soils.
6. Mixed deciduous – *Tsuga* and broad-leaf *Quercus* forests, and brown earths.
7. Evergreen broad-leaf forest – *Quercus, Castanopsis,* and yellow-brown earths.
8. Evergreen broad-leaf forest – *Dipterocarpus* and *Shorea,* and red-yellow allitic soils.

Fig. 1.1. Vertical Zonation of Vegetation and Soils on the South Slope of the Tibetan Plateau



1. Rhododendron, mountain meadow, and mountain black soils.
2. Coniferous forest and dark brown earths (dark luvisols).
3. *Pinus* and *Betula* spp. and brown earths (luvisols).
4. *Pinus* and *Quercus* spp. and luvic cinnamon soils.
5. Dry forests and shrubs and drab (cinnamon) soils.
6. Arable land and drab (cinnamon) soils.
7. Outcrops and immature, skeletal soils.
8. Rhododendron, mountain meadow and mountain black soils.
9. Coniferous forest – *Abies* and *Betula* spp.; dark–brown earths.
10. Mixed coniferous and deciduous forests – *Pinus* and *Betula* spp.; brown earths (luvisols).
11. Summer green broad-leaft – *Quercus* sp. and yellow-brown luvic earth.
12. Arable land and yellow brown earths with relic lime concretion.

Fig. 1.2. Variations in Vegetation and Soils to the North and South of the Qinling Mountains

High Mountain Ranges and Qinghai-Xizang (Tibet) Plateau

There are high moutains in various parts of China. In addition to the Tian Shan and the Qilian Shan in the arid north-west, the Himalayas lie to the south-west and the north–south trending Hengduan Mountains are in the south. In most of these highlands the vegetation and soils exhibit distinct vertical zonality, and some special soil types occur, such as a particular type of cold "desert" soil in periglacial regions. The so-called "desert" soil is in a physiologically dry state. Above the tree-line, soils under grasses and shrubs are dark and contain high levels of humus.

On the Qinghai-Xizang (Tibet) Plateau, with elevations of 3,700–5,200 m, agriculture is possible only in the river valleys. Most vegetation is either Alpine meadow or Alpine steppe, and Alpine steppe soils are common. Black soils and mixed tall grasses in the east give way to chernozems and steppe in the west. Grasses of the species *Grammisia* decrease and *Artemisia* increase westward, until in the western part of the plateau dry steppe and semi-desert vegetation occur. The soil types change westward from chestnut to brown-pedocal, and in the steppe region scattered soda-saline soils and patches of saline and alkaline soils associated with chestnut soils occur. Large areas of active, semi-stable and stable sand dunes occur in the steppe.

Arid Land in North-west China

The vast territory of the continental zone can be divided into two regions by the 250 mm annual isohyet. East of the line dry farming is possible without irrigation or with only supplementary, seasonal irrigation. To the west lies arid North-west China. Geographically, the arid areas are situated in central Eurasia where climatic conditions are extreme and where extensive, *gobi* (gravel) deserts and sandy deserts occur. Most of the sandy deserts contain mobile dunes, which may reach a height of 200–300 m.

The Tian Shan Range, 4,000–6,000 m above sea-level, divides the vast Xinjiang Region into two parts, the Tarim Basin in the south and the Junggar Basin in the north. With a mean annual precipitation of only about 30 mm, the former is among the driest warm continental deserts on earth. Its accumulated temperature >10°C is only 2,500–3,000°C, and the Tarim Basin contains extensive tracts of *gobi* desert. Where soils occur they are brown desert soils, which, in appearance, resemble salt- or gypsum-crust. The total soluble salt content in the soils may be between 50–60 per cent. Vegetation cover in the *gobi* areas is sparse, at less than 5 per cent coverage, and as a consequence, severe wind erosion has occurred.

The soils of the plateau are characterized by a low rate of decomposition. Thus plant roots form a closely interwoven, felt-like layer in the surface soils. These black, felty soils are fairly humid. By contrast, some soils formed under comparatively arid steppe conditions may contain very little organic matter.

The vertical zonation of vegetation and soils is well-exemplified on the south slope of the Tibetan Plateau (fig. 1.1), where the mountains rise to more than 8,000 m within a distance of some 10 km. Soils and vegetation may exhibit considerable differences on different sides of a high mountain range, in which case, the range may serve to delimit cartographically two distinct land types. The Qinling Mountains is a good example of this (fig. 1.2). North of the range is the Loessal Plateau with a warm climate, calcareous loessal soils, and deciduous forests. Wheat and cotton are widespread. South of the range is the subtropical region with luvic and slightly allitic soils under broadleaf evergreen forests, and an agricultural system based on a rice and winter wheat rotation.

In this brief chapter, the major land-use categories of China have been presented in a generalized manner. For a more detailed division, the reader should consult chapter 2.

2. LAND CLASSIFICATION AND MAPPING IN CHINA

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Abstract

A national land classification and mapping programme has been under way in China since 1978. The programme is designed to evaluate the nation's land resources. A scheme for land type classification and mapping is proposed on the basis of the physical attributes of the land. Seven natural regions are recognized in China, below which a number of first- and second-order land types are identified mainly on the basis of macro- and micro-landforms and other surface features.

Land classification in China has a history of 2,500 years. In the ancient classic, *Zhouli (The Rites of the Zhou Dynasty)*, five major land types were identified: forested mountains, hilly land, level plains, riverine lowland, and swampy depressions. A more sophisticated classification scheme was recorded in the *Guanzi*, a classic written during the Warring States Period (475–221 B.C.), in which China was divided into three first-order land-use types – plains, hills, and mountains – and 25 second-order categories. These schemes are among the earliest land-classification systems in the world. Land classification and evaluation continued to be of major interest to Chinese scientists in the ensuing dynasties, such research being closely related to agricultural production and land taxation.

Since the foundation of the People's Republic of China in 1949, scientific research on land classification and agricultural production has made rapid progress, and many studies on land classification and evaluation have been completed in different parts of the country. Since 1978, a serious and comprehensive land-classification and mapping programme has been in progress. The programme has the two basic purposes of providing reliable and detailed data on China's geographical environments and an evaluation of the nation's land resources and their agricultural capabilities. The programme will result in the production of a series of maps on land classification. The entire country will be mapped at a scale of 1:1,000,000, the major provinces and regions at 1:200,000, and sample study areas at 1:50,000. The programme is scheduled to be completed by 1985.

A Scheme for Land Classification and Mapping

Any land area can be classified into a number of types on the basis of physical attributes. The exact number of types to be determined depends on several factors, including the purpose of classification, and the financial and manpower resources and time available for the task. Since the ultimate purpose of our classification of land types is to use China's land resources more efficiently for national and regional economic development, and since we are still at an early stage of the national land-type study, we have tentatively divided China into the major natural regions. Within each major natural region a two-level scheme of land-type classification has been adopted.

The natural regions are the foundation of land-type classification and mapping. A natural region is characterized by a relative homogeneity of temperature and moisture conditions and of soil and vegetation types. The first-order land types within a natural region of China are identified mainly on the basis of macro-landforms and are listed according to the elevation of each type, from lowlands to high mountains. They thus approximate the "land systems" of the Australian CSIRO. The first-order land types are the major mapping units for the nation as a whole, at a scale of 1:1,000,000.

The second-order land types are generally identified and delimited by relatively homogeneous meso- or micro-landforms and surface materials in the hilly regions, and by similar soil and vegetation subtypes in the plains. Such units also have similar suitability and capability of land use. These second-order land types approximate the "land units" of the CSIRO. They are the major mapping units for China's provinces and large regions. Several