博士文库

中国西北与东南土地利用变化及比较

全 斌 著

LAND USE CHANGES IN NW AND SE CHINA AND ITS COMPARISON

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荐 序

近年来，随着人们对全球变暖问题的日益关注，土地利用/覆被变化（LUCC）已成为国际学术界的重大研究领域和热点。中国西北干旱地区是一个自然和人文特征非常独特的区域，已引起许多研究工作者的兴趣。但是近几十年随着该区域人口的快速增加和人类活动的加剧，土地利用与土地覆被发生了巨大变化，并由此带来了巨大的环境效应，因此迫切需要对这些变化和效应进行深入研究。为了更好地揭示中国西北干旱区土地利用与土地覆被变化的特征与机理，湖南科技大学全斌副教授采用地理比较分析方法，在中国东、西部分别选取有代表性的宁夏南部六盘山区和闽东南厦门市，通过研究同时段土地利用变化并进行比较分析，数字化重现了两个区域的土地利用与土地覆被的演变过程，较好地揭示了土地利用与土地覆被变化的驱动力和驱动机理，其研究成果为经济相对落后的中国西北干旱区的经济社会发展提供了有一定参考价值的决策建议。该书主要有以下特色：

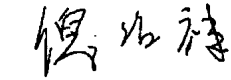
（1）在现有土地利用与土地覆被变化的比较研究中，对邻近区域的土地利用变化过程的比较研究居多，而从变化过程的共同性与阶段性对不同区域尤其是跨区域的土地利用与土地覆被变化进行研究较少。特别是中国东、西部区域的土地利用与土地覆被变化的比较研究几乎属于空白。本书进行中国东、西部区域的跨梯度比较研究，不仅有助于对不同区域的土地利用与土地覆被变化过程的深入理解与阐释，而且也有利于丰富区域性土地利用与土地覆被变化的研究内容。

（2）本书运用地学信息图谱理论和“3S”技术，采用图形思维、地学认知与信息思维相结合的方法，对作为黄土高原典型生态类型区的宁夏六盘山区的土地资源与土地利用变化进行了深入研究。在

提取三期 TM 遥感信息的基础上，结合野外调查，经过空间模型与地学认知的深入分析，揭示了六盘山区与厦门市在土地退化格局过程和特征上的差异性，不仅研究手段先进，而且较好地体现了多学科交叉、协同研究的发展趋势。此外，本书依据农业生态学和比较经济学原理，对不同类型区的三种生态农业模式（六盘山区上黄模式、闽东南低山丘陵区模式、日本“美多丽”（MIDORI）模式）的结构、功能及共同性与差异性进行了比较研究，并从国际和区域尺度探讨了进行环境友好型土地利用配置和发挥生态农业优势的途径，为六盘山区农业发展提供了理论依据和可资借鉴的经验。

（3）以往的土地利用与土地覆被变化研究基本集中于土地利用与土地覆被变化的本身，而对由其引起的土壤侵蚀等环境效应很少涉及。本书从土地利用与土壤侵蚀的相互作用机理入手，从遥感信息提取到侵蚀性环境变化效应推求均进行了较深入的研究，并将其与土地利用变化相耦合，体现了本书的一定新意。

本书是著者在多年从事相关领域研究工作的基础上写成的，内容充实，具有较高学术水平。本书为地理、测绘、环境和空间信息科学等相关专业的本科生和研究生提供了一部良好的教学参考书，也可为相关领域从事实际工作的专业人员参考。



（南京师范大学教授、博导，中国自然资源学会
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前　言

土地变化科学正在兴起。近几十年，土地利用变化影响了地表日照率、碳源碳汇、水循环、生态系统的服务功能以及其脆弱性，人类将地球表面精华的土地按其自身要求加以改变，导致出现土地利用/覆被变化（LUCC）及其生态安全问题。近年来，LUCC 及其环境影响成为自然地理学及其交叉学科竞相研究的重要内容。例如，天然森林、草地被转变为农业用地，这在全球气候变化中会产生重要的影响。而农用地，特别是耕地的流失常常又是城市化侵占土地的结果，进而引起人们对全球粮食安全的担忧。本书的研究目的就是通过研究不同区域土地利用变化的状况、驱动力、变化趋势以及生态效应，最终提出适宜的生态农业模式以解决土地利用中业已存在的问题。

为此，本书作者在中国东南部与西北部地区各选择一个城市或区域进行案例比较研究。宁夏南部六盘山区（原固原地区）与福建省厦门市分别代表我国北方生态脆弱贫困地区与南方经济发达的典型区域与城市。六盘山区位于我国黄土高原的西部，该区包括六盘山及其外围地区，其中，六盘山属石质山地，是国家级自然保护区和森林公园。六盘山外围是黄土丘陵区，区内沟壑纵横，地面切割破碎，黄土丘陵、黄土塬、谷地、山地相间分布，是黄土高原侵蚀地貌的典型缩影。2005 年宁夏回族自治区人民政府将六盘山及其周边地区规划为大六盘生态经济圈，以此建设西部生态屏障，促进宁夏南部山区经济社会发展。而位于闽东南的厦门市地处我国东南沿海福建省东南部，濒临台湾海峡。2001 年厦门市辖有七个区，分别是：思明区、开元区、鼓浪屿区、湖里区、集美区、杏林区和同安区。厦门是我国首批实行对外开放政策的经济特区之一，经济快速发展，城市化水平较高，故在这里作者将其作为我国经济发达区域

的代表。

为了探索这两个典型区——大六盘生态经济圈和厦门市的发展趋势与模式，作者选择二者皆适宜的关键典型代表性时段，在多期遥感信息分析处理和野外调查的基础上，运用地理信息系统（GIS），地学信息图谱与时空变化模型、方法对其土地利用/覆被变化进行了分析研究；通过建立驱动力模型寻求区域主要的驱动力，通过 LUCC 与土壤侵蚀的动态耦合来反映 LUCC 下的六盘山区侵蚀性环境演变，通过土地适宜性的动态评价与转化及遥感指数提取来跟踪其生态环境动态发展，探讨其生态响应与安全，在此基础上进行区域比较分析，并初步建立了土地利用变化信息系统。合理利用土地，保护生态环境，是当前国际上普遍关注的重点和难点问题，为此，还对两个典型区以合理利用水土资源为特征的生态农业模式进行了比较研究，即上黄生态农业模式（ASCF）——“黄土高原农牧果沼生态家园”模式和闽东南低山丘陵地区生态农业模式（UCCO）——“闽东南联户农果生态家园”模式，并借鉴日本“美多丽”（MIDORI）——“水土宜居家园”模式的长处。通过研究分析其共同性与差异性，以及各个模式的发展阶段与经验，为区域土地可持续发展提出科学依据，初步取得以下研究成果与进展：

代表性时段 1990—2000 年，六盘山区土地利用结构不合理、农林牧用地的比重失调、土地总体变动幅度除了耕地与草地变化较大外，其他都不突出。耕地、林地和城市建设用地分别增加 44 186 hm^2，9 001 hm^2 和 1 550 hm^2，而草地同期减少 54 025 hm^2。草地的减少引人注目，在失去的草地中，49.4%被转化为耕地。盲目开垦与草地迅速破坏是直接导致其形成侵蚀性生态环境的主要原因。最大的年度土地转化率小于 2%，表明不同土地间转化不大，城市化发展也较缓慢，但城市用地变化占据了精华的耕地，增大了区域生态环境的压力。通过土地利用变化前后期比较可以看出，变化趋向理性。系列图谱则反映出土壤侵蚀面积呈扩大趋势，比例不断攀升。中、低覆盖度草地以及旱地侵蚀强度均较大，是水土流失的主要来源区。就驱动力而言，土地利用变化主要受到人口、经济、

技术以及政策的影响。耕地变化则主要受总人口数量、经济（农民的富裕程度）以及技术状况（农业机械化状况、灌溉、施肥水平）的驱动。从土地利用变化趋势上看，在保持与 1990—2000 年土地政策没有大改变的情况下，耕地的面积和比重均将大幅度增加，而城市居民点工矿用地则将不断扩张。从环境效应上看，1990—2000 年的十年间，耕地、林地以及草地的最适宜面积与比例均减小，而不适宜的面积与比例则增加。草地转化为耕地过程中，被转化为不适宜与勉强适宜的耕地面积比例达 86%。尽管这段时期归一化植被指数 NDVI 部分趋于升高，优良植被覆盖状况部分有所恢复与改善，但从数量上看植被覆盖状况较差的比例占到近 80%，林草覆盖度下降，而坡耕地面积与比例却逐渐增大。

1988—2001 年，厦门市受城市化影响，城乡工矿用地的面积增加了 10 152 hm^2，耕地面积减少了 11 305 hm^2。由于填海造地工程的实施，部分滩涂用地转化为居民和工矿用地。受经济利益驱动，部分耕地演变为鱼塘，加上水工设施修建，水域的面积增加了 849 hm^2。1988—2001 年，失去耕地中有 52.5%被转化为城市工矿和建设用地。经济增长与快速城市化造成厦门市土地利用程度较高与土地利用转化率较大。厦门市各区中，土地利用变化最快的是湖里区和杏林区，变化最慢的是思明区和鼓浪屿区。厦门市政策、社会经济发展等对土地利用变化有较大的影响。

同时段对比分析六盘山区与厦门市土地利用变化及其驱动力，前者处于经济发展的初始阶段，土地利用程度较低；后者则处于工业化阶段的快速发展时间，经济增长方式出现重大变化，土地利用程度较高。从人口对六盘山区与厦门市 LUCC 的驱动比较中发现，耕地分布都主要集中在人口密度中等至较高的区域（＞20 人/km^2），但是变化方向却不一致，六盘山区人口增加，对耕地需求也增大，开垦耕地随之增加。而厦门市耕地主要分布在人口密集的村镇周围，同时，随着人口增加，占用了大量耕地，使耕地面积减小。六盘山区林地净增长最大的地方主要在人口密度中等的地区（20～50 人/km^2），在这一范围里，林地分布比例也最高。而厦门市林地则

主要分布在人口密度低的（<5 人/km²）和高的地区（>100 人/km²）两个区间内，减少也发生在这一区域。

通过比较六盘山区与闽东南生态农业模式，得出其共同性主要体现为：土地合理利用，质能循环高效转换；生态环境保护优先，水土资源精细利用；农业集约化经营，生产力不断提高；农村经济发展以农户为单元，进行适度规模经营。差异性表现为：发展阶段性不同；发展任务不同；区情不同。比较认为，六盘山区生态脆弱，水土流失严重，掠夺式的开垦与耕作使地力衰退，土地退化严重，导致“生态贫困”，制约着经济发展。针对现存的生态环境问题，提出控制人口与加快城市化建设、发展宁南特色农业与旅游业、实施生态农业工程体系建设、推广上黄村的“黄土高原农牧果沼生态家园”模式和进行可持续性水资源开发等对策。六盘山区在土地利用与农业发展上需要学习厦门的经验是：通过自身的区域经济优势加快经济发展与城市化建设，同时，注重自然资源的高效利用，借鉴和吸收具有闽东南特色的农业发展及其实施模式——“联户农果生态家园”模式。而吸取的教训则是在经济发展的同时，防止生态环境破坏，经济发展要适应“两型社会”建设的要求。

ABSTRACT

Land use/land cover change (LUCC) modifies surface albedo, sources and sinks of carbon, precipitation recycling, ecosystem services as well as vulnerability of places and people to natural hazards, social-economic and political perturbations. Human beings are transforming significant portions of the earth's land surface, which has been of central concern to the international research community for most of the past century. The conversion of natural forest biomass and grassland to agricultural activities plays a significant role in global climate change, while the loss of agricultural land as results of urban sprawl brings more concern about global food security. This work aims to improve the understanding of LUCC dynamics, to explore activities and factors that control LUCC processes at various regions, and ultimately, to build integrated ecological model as reference to future policy designs and practices.

Case studies are carried out in the Liupan Mountains region and Xiamen City. As an ecology fragile area, the Liupan Mountains region is chosen to be a representive case to study the consequences of agricultural activities on a primary grassland landscape. In contrast, Xiamen City is a rather developed area, which is selected to be a case for studying the change of agricultural landscape in highly urbanized areas. The Liupan Mountains region is located in the southern part of Ningxia Hui Autonomous Region, China, with an area of 16,775 km^2, and consists of Guyuan, Jingyuan, Pengyang, Xiji, and Longde and Haiyuan counties. These Liupan mountains form an important divide between landforms and bio-geographic zones in China. This region has a

temperate semi-humid climate in the south and a temperate semi-arid climate in the north. The mean annual temperature fluctuates between 5℃ and 8℃, while the mean precipitation varies between 240 mm and 760mm and decreases gradually from the southeast to the northwest. Because the region is situated in a transition zone between the humid and arid regions, there exist different ecosystems and large biodiversities. Vegetation changes gradually from forest in the southeast to desert in the northwest. A large part of the deciduous broad-leaved forests extends in this mountain range making it one of the most important forested headwater conservation areas of the Loess Plateau. More than 60 rivers and streams make up the river system in the mountainous region. In 2000, its population was 1,868,528, and the net annual income per farmer was only 928 yuan (RMB), indicating that it was still difficult to provide sufficient food and fiber for the population. In 2005, the Government of Ningxia Hui Autonomous Region designated the Liupan Mountains and surrounding areas to be a "Large Liupan Eco-economy Circle" (LLEC). In this area, green shelter belts will be established that will promote social and economic development of the southern Ningxia. However, Xiamen, with an area of 1,638 km^2, is located in the southeastern part of Fujian Province, facing the Taiwan Straits. It has a southern subtropical monsoon climate, annual mean temperature of 20.8℃, and annual precipitation of 1,143.5 mm. The natural vegetation is a south-subtropical monsoon rainforest, but most has been destroyed by human activities. Masson Pine (*Pinus massoniana Lamb.*) and Taiwan Acacia (*Acacia confusa Merr.*) are planted in the upland and bottom flat land, under which a lateritic red soil has developed over time. In 2001, Xiamen consisted of seven administrative districts including Siming district, Kaiyuan district, Gulangyu district, Huli district, Jimei district, Xinglin district, Tongan district, and had a total population of 1.312,7 million. Because of its advantageous location, Xiamen became one of

the first four special economic zones in China, when the country began a policy to open up to the world. The economy has developed quickly. The ecological environment also changed, especially agricultural fields that were converted to industrial and commercial use.

In order to determine future trend of economic development and the performance of LLEC model, romote sensing (RS) technique, geographical information system (GIS), Geo-informatic TuPu and spatial modeling method are applied to measure the magnitude and rate of land use/land cover change based on three time period TM image and field works. A regression and model method is developed to explore the main driving force of LUCC in the two hot-spots. And, effects of LUCC as well as coupling of LUCC and soil erosion were evaluated across space and over time. Moreover, comparative analysis was conducted between the Liupan Mountains region and Xiamen City. Finally, I compared the three ecological models of agriculture in the Shanghuang village of the Liupan Mountains region (ASCF Model), southeastern Fujian Province (UCCO Model) and Japan (MIDORI Model). And I propose suitable and comprehensive measures for the sustainable development, which will be of most importance to decision-making of land utilization of the two regions.

Results indicated that cropland, forestland, and urban areas have increased by 44, 186 ha, 9,001 ha and 1,550 ha, respectively while the grassland area has appreciably decreased by 54,025 ha in the typical study time period of 1900 to 2000. The decrease in grassland was most notable. Of the grassland lost, 49.4% was converted into cropland. The largest annual land conversion rate in the study area was less than 2%. These changes are attributed to industrial and agricultural development and population growth. Land use change was closely related with the increase of the population, economy condition such as investment in fixed assets and industrial structure adjustment, technology as well as

policy. In particular, cropland change was correlated closely with total population, economic condition (well-off conditions of local farmer population) as well as technology development (agriculture machinerization, irrigation facility and fertilization level). Moreover, in view of land use change in future, supposing the national policy on land is the same as before, cropland will increase greatly. From an effect perspective, the area and percentage of the most suitable cropland, forest land and grassland decreased while that of unsuitable increased between 1990 and 2000. In process of conversion of grassland into cropland, the ratios of unsuitable and the third class in converted cropland were very high. Although the NDVI partially tended to ascend during the similar time period of 1987 to 2001, the percentage of poor and bad vegetation condition still accounted for 80%. Also vegetation cover degree decreased and sloping cropland extended. In 2000 the soil erosion affected area was 1,260,787 ha which is 75.2% of the total area in the Liupan Mountains region. Soil erosion by water was the dominant mode of soil loss, while soil erosion by wind was only present on a relatively small area (2.16%). Soil erosion in the Liupan Mountains region increased between the late 1980's and 2000, both in terms of acreage and severity. Moderate, severe, and very severe eroded areas accounted for 60.7% of the total area. The lightly eroded area decreased, while the moderately eroded area increased by 368,817 ha or 22% followed by severe erosion with 146,552 ha or 8.7%, and very severe erosion by 970678 ha or 5.8%. Soil loss decreased in Pengyang and Xiji Counties, but increased in Haiyuan, Guyuan, Jingyuan, and Longde Counties between 1986 and 2000. Soil erosion was severe on grassland with a moderate or low grass cover and on dryland. Approximately 90% of sloping cropland was less than 15°. Human activities, the cultivation of steep slopes and overgrazing of pastures were the main reasons for the increase in erosion severity.

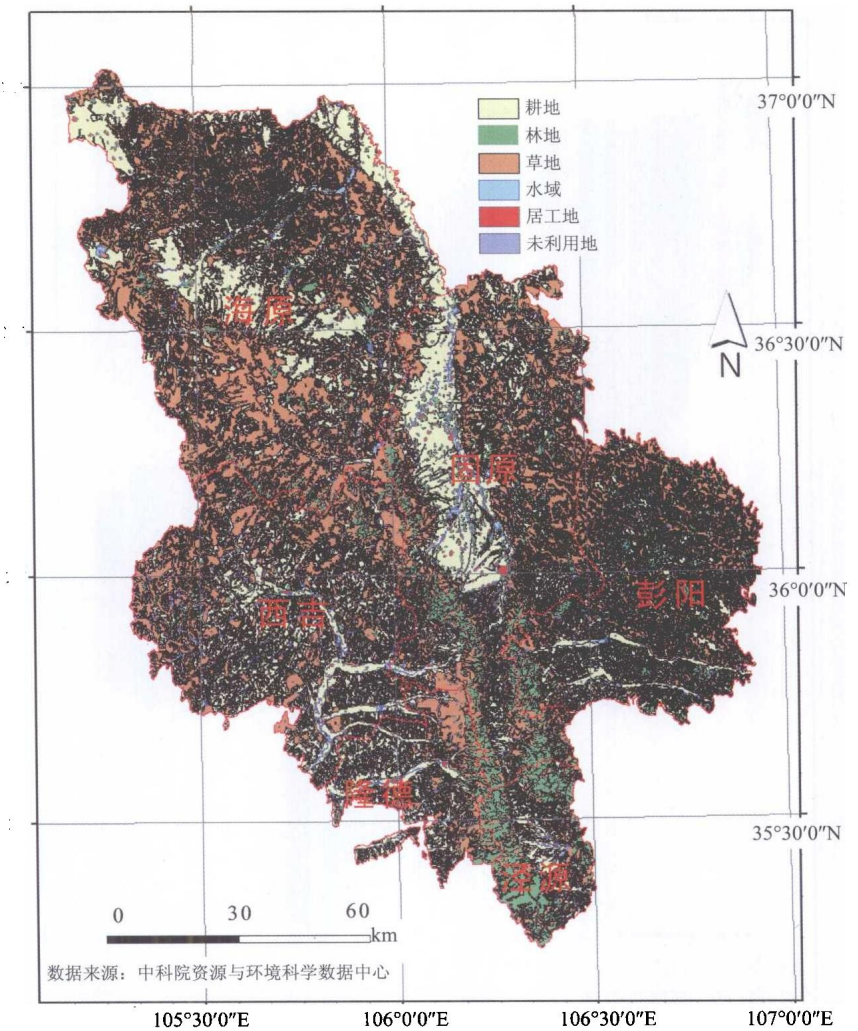
In Xiamen City, however, cropland decreased remarkably by nearly 11,305 ha, while the areas of rural-urban construction and water body increased by 10,152 ha and 849 ha from 1988 to 2001, respectively. During the same time period, 52.5% of the lost cropland was converted into rural-urban construction land. Rapid urbanization contributed to a great change in the rate of cropland land use during these years. Huli and Xinglin district experienced the greatest dynamic degree of land use change due to the development of industry and fast rate of urbanization. The construction of sea-filling and land-reclamation contributed to a water body decrease and sea ecology environment destruction. The land use changes in Xiamen City have been driven by urbanization and industrialization, infrastructure and policy factors.

From the comparison between LUCC of Liupan Mountains region and Xiamen City, the former was in the start phase of economy development and its output structure mainly depended upon agriculture so that its land use change degree was less. While the latter was in the later phase of industrilization in which economy increase method was high technology industry and service so that its land use change degree was high. The output of Xiamen City increased quickly and urbanization standard and land concentralization were both higher which led to higher land use dynamic degree and land use intensity. In the comparison between population driving force of LUCC, the moderate and highly populated regions ($>$20 persons/ km^2) contained larger cropland area and higher cropland percentage whether in Liupanshan Region or in Xiamen City. But there are some differences in trend of cropland change between the two regions. In Liupan Mountains region it showed positive correlation between high population density and rapid gain of cropland which suggests the cropland demand increases with population. While it showed negative correlation in Xiamen City which reflects that urbanization will speed up with the population growth, which made the

cropland decreases. Under-populated region (<5 persons/km^2) had widespread forests in Liupan Mountains region in which a further increase of forest land would have been difficult to achieve. While forests was easier to be destroyed in the populous region (>100 persons/km^2) in Liupan Mountains region. Thus, the largest net increase of forest land presented to the medium population density class (20 to 50 persons/km^2) in Liupan Mountains region. While forestry distribution in Xiamen City concentrated on the under-populated region and the populous region. The Liupan Mountains region should use referential experiences in Xiamen economic development.

Comparative study among different ecological agriculture model e.g. Agriculture-Stock breeding-Courtyard-Firedamp model (ASCF Model) in Loess Plateau, United Farmer Household- Cultivated land-Orchard establishment model (UCCO Model) in southeastern Fujian Province and "MIDORI" ("Mi" is "Mizu" in Japanese, which means water; "Do" is "Tsuti" in Japanese, which means soil and agricultural land; "Ri" is "Sato" in Japanese, which means agricultural and rural area. "MIDORI" means greenery homeland with harmonious ecological relationship between land and water) ecological model in Japan. Some common and differentia were analyzed. The intersections are: A. reasonable land utilization and high efficiency of material and energy flow in courtyard farming; B. Eco-environment protection is on the prior consideration and resource is made most use of; C. Intensive farming for land production raised; D. Agricultural management in favorable size based upon farmer household. While some differences are as follows: A. Different phase; B. Different task; C. Different condition of area. The references of the "MIDORI" model are as follows. (1) scientific protection of land resources; (2) soil and water resource is made most use of; (3) effective rural-urban interaction; (4) sightseeing agriculture development. These ecological models are the direction of

development for reasonable land utilization and ecology protection as well as harmonious relationship between human and land resource. At present, subsidy policy of returning land for cropland to forest and grass land is favorable chance to agriculture structure regulation in the Liupan Mountains region, which could make the agricultural labors transfer to other industries and promote the urbanization. To improve the eco-economic conditions in the Liupan Mountains region, population control, urbanization and development of an ecological friendly agriculture were suggested.



（a）六盘山区 1990 年土地利用/覆被