International Comparison and Implications of Agricultural Development in Foreign Low Latitude Plateau Regions for Yunnan Province

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Abstract Climatic characteristics of foreign low latitude plateau regions are firstly introduced. Then, experience and lessons of major foreign low latitude plateau countries in developing modern agriculture are analyzed, including Indian three agricultural revolutions and agricultural informationization development, application of agricultural biotechnology in Brazil, trade liberalization and economic de-agriculture of Mexico, and Argentina, Saudi Arabia and South Africa attaching great importance to developing modern agriculture relying on science and technology and paying close attention to resource conservation and environmental protection. Combining natural and social resource characteristics of Yunnan plateau agriculture, pertinent implications and recommendations for modern agricultural development in Yunnan are put forward. Specifically, these include strengthening agricultural sci-tech research and development, and extension and application; transforming agricultural development model; enhancing agricultural resource conservation and environmental protection; accelerating developing mountain organic ecological agriculture and autumn agriculture; reinforcing urban and rural integration to develop plateau characteristic agriculture on the basis of local actual conditions.

Key words Low latitude plateau regions, Characteristic modern agriculture, Implications, Yunnan

Geographically, low latitude generally refers to spatial regions between 30°S - 30°N, including tropical and subtropical zones. It is the region with relative concentration of solar radiation and heat in the world. Plateau generally refers to a large uplifted area with an altitude above 1000 m, surrounded by steep slopes. In this study, low latitude plateau refers to areas with altitude above 1000 m in low latitude regions. Such region is vastly distributed in the world, except Europe and Antarctica. There are 10 top influential low latitude plateau regions: Yunnan - Guizhou Plateau in China, Deccan Plateau in Indian Peninsula, Hejaz-asir plateau in Arabian Peninsula, Ethiopian highlands, East African plateau and South African plateau in Africa, Mexican plateau in North America, Andean plateau, Brazilian Plateau and Guyana plateau in South America[1]. Chinese low latitude plateau refers to Yunnan - Guizhou plateau region to the south of 30°N, including border areas of western Guizhou and southern Sichuan. This region has high altitude, high elevation difference, distinct cutting plateau feature, complex and diverse terrain and landform, distinct diverse climate, abundant sunshine, rich species, and superior natural talent for energetic development of characteristic plateau agriculture. Situated in less developed regions, Yunnan - Guizhou plateau has many common features in natural environment and socio-economic conditions with other low latitude plateau regions in the world.

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1 Climatic characteristics of low latitude plateau regions

1.1 Climatic characteristics of low latitude regions With high solar angle and controlled by tropical air masses and equatorial air mass for the whole year, low latitude regions have high temperature throughout the year, and the seasonal variation is not distinct. Besides, violent monsoon activities bring abundant precipitation. But the precipitation varies sharply in dry and rainy seasons.

1.2 Climatic characteristics of plateau regions Plateau regions have high solar radiation but low radiation difference. Since air temperature of the earth surface is deeply influenced by altitude, so air temperature in plateau regions has 6 - 10 ℃ lower than that in plain region in the same latitude regions. Besides, the day - night temperature difference is distinct, generally 1 - 2 times higher than plain areas in the same latitude regions. In addition, rainfall is obviously influenced by terrain. Generally, plateau edges facing wet air flow are rain belt, while the other edge and plateau inside will have less rainfall. Plateau regions also have other harsh weather, such as strong wind, storm and hailstone[1].

1.3 Climatic characteristics of low latitude plateau regions Climatic characteristics of low latitude plateau regions combine climatic characteristics of low latitude regions and plateau regions. These mainly include: (1) outstanding mountain climate, *i. e.* distinctive vertical zone spectrum, without tropical desert climate. (2) The annual amplitude of temperature change is generally 0.3 - 12.7 ℃, and mean annual temperature is 13 - 21 ℃. Moderate temperature takes on spring and autumn characteristics. In these regions, there are no hot summer and cold winter. But the

difference of daily temperature is bigger. "Four seasons appear just in one day, day is like summer and night like winter". (3) Rainfall is moderate to abundant, but not uniform in time and space. In most regions, the annual rainfall reaches 700 – 1500 mm, but no distinct variation in seasons. The dry and rainy seasons are distinct. Rainy days come in summer and dry days come in winter. Rainfall is deeply influenced by terrain. Generally, plateau edges facing wet air flow are rain belt, while there are less rainfall in the other edge and plateau inside[1].

2 Characteristics of agricultural development in major low latitude plateau regions of the world

2.1 Three revolutions of Indian agriculture and development of agricultural informationization India is the second populous country in the world, and it is a large agricultural country. Still as the primary industry in India, agriculture plays a decisive role in its national economy. India has superior climatic conditions, rich land and water resources. Its arable land ranks the first in Asia and the cultivated per capita is about twice that of China. Since its independence, India has been taking self-sufficiency of grain as its objective of agricultural policy. In addition, Indian government is committed to providing powerful financial support for agricultural development, implementing comprehensive control, and protecting domestic agriculture from influence of international competition, which greatly promotes agricultural development and makes India maintain a high rate of food self-sufficiency[2]. With the land reform at the beginning of independence, Green Revolution, White Revolution and Blue Revolution, and the second green revolution in the 21st century, Indian agriculture has realized considerable development.

2.1.1 Green Revolution. The great famine in the 1960s made Indian authorities realize the importance of grain security. Then, a vigorous Green Revolution was launched across India. The Green Revolution is a huge agricultural comprehensive development project guided by modern science and technology. It is the agricultural modernization of tropical and subtropical zones. The core objective is to promote agricultural modernization and intensive development, and realize high and stable yield of crops, especially grain production through popularizing high-yield seed, expanding irrigated area, developing agricultural machinery, and increasing application of fertilizer and pesticide. Since the Green Revolution, Indian grain output maintained an annual increase about 3.95%. In 1981, it reached 134 million tons, making a new record and bringing India become the third largest grain production country following China and the United States. In the early years since the turn of 21st century, in order to cope with grain security brought about by rapid growth of population, India launched the second green revolution. It was to increase overall benefit of agriculture through strengthening sci-tech application, increasing financial input, and protecting benefits of farmers. At present, India has become the second largest wheat and rice producer and the fourth coarse food grain producer in the world, and has the huge potential for expanding agricultural production[3].

2.1.2 White Revolution. India has rich animal husbandry resources, and animal husbandry is the pillar industry of its agricultural economy. In 2010, amount of cattle on hand reached 280 million (including 210 million milk cows). The buffalo in India accounts for 57% of the world, reached 111 million in 2010[4]. Due to the traditional idea of religion, most Indian people do not eat beef. In order to increase economic value of cattle and the production of milk, India launched the well-known White Revolution. They introduce, cultivate and popularize excellent buffalo breed, establish dairy production cooperative, and stop importing all commercial milk products, which increases greatly output of cow milk. Especially, the Operation Flood launched by Indian National Dairy Development Board was implemented in 3 steps in 1970 – 1996, greatly accelerated growth of cow milk production, making India becoming the largest cow milk producer in the world. The national cow milk output reached to 117 million tons in 2010 from 20.375 million tons in 1961, increasing about 4.7 times. In 2003 – 2004, Indian dairy industry realized a profit of 24 million USD, exceeding rice and wheat, so dairy products become the major agricultural product in the proportion of GNP (4.39%)[4].

2.1.3 Blue Revolution. The purpose of this revolution was to make use of river, lake and marine resources to develop the aquaculture. Surrounded by sea in three sides, Indian coastline stretches about 7500 km. With numerous bays, capes and straits, its sea area available for fishing reaches 2.02 million km^2, thus it has favorable condition for developing sea fishery and aquaculture. Besides, Indian inland there are 2900 km river system and more than 1.7 million hm^2 reservoir and pools, and also considerable potential for developing fresh – water fish-culture. To increase amount of fishing, improve people's living condition, create employment opportunities, and increase exchange revenue, India launched the Blue Revolution from the late of 1980s[4].

2.1.4 Rural information technology develops significantly. Information technology plays a significant promotion and support role in national economy of India, and has important influence on development of rural human resources. In the 1980s, India was committed to rural information construction and has made considerable progress in two decades. Rapid development of software industry and important position of national economy promote development of rural information technology. Indian government also took other measures, such as expanding broadband connection in rural areas. Some federal government launched special regional information technological scheme and set up special rural Internet. Indian Ministry of Agriculture and Indian Council of Agricultural Research annually dispatch experts to rural areas to provide technical guidance and information service for farmers, and supply cheap but easily operating computer for farmers. Participation of social forces is another characteristic of Indian rural informationization. Capital sources for application of agricultural information technology mainly include local and state government, local and international organizations and private enterprises, and non – governmen-

tal organizations, education institutions, and business circles are cooperating to give play to advantages to solve financial difficulty in rural informationization[5].

2.2 Application of Brazilian agricultural biological technology Most territory of Brazil is in Brazilian Plateau. Situated in tropical and subtropical zones, most part of Brazil is temperate in climate, abundant in rainfall, flat in terrain, and few in natural disasters. Area of agricultural land is about 400 million hm^2, including 250 million hm^2 arable land. In addition, biological resources are plentiful. These indicate that Brazil has gifted conditions for agriculture and animal husbandry. Brazilian government encourages development of agricultural industrialized production organizations through credit, tax preference and direct subsidy, and implements "strengthening family agricultural plan" and "integrating urban and rural social welfare". Brazilian agriculture and animal husbandry have made considerable achievement. Application of agricultural biological technology and agriculture oriented for export and foreign exchange earnings are distinct characteristics. At present, Brazil is the first coffee producer and exporter in the world is named Kingdom Coffee. In addition, as the biggest sucrose producer and exporter, the second soybean producer and exporter, the third corn producers, Brazil is named as "World granary of the 21st century"[6].

Brazil values force of agricultural science and technology. In 1996 – 2006, agricultural production capacity of Brazil increased about 70%, while the planting area only increased to 39.7 million hm^2 from 37.8 million hm^2, which has to rely on science and technology. In the Decree 10.332 of Brazil issued on December 19, 2001, Paragraph 1 of Article 1 clearly stipulates that the state will annually allocate 17.5% of the total taxation amount for agricultural and animal husbandry sci-tech project. Introduction and application of foreign modern agricultural science and technology with representative of biological technology make enormous contribution to agricultural development of Brazil. In the middle of the 1980s, Brazil formulated the national biological technology program, and transgenic technology has become mature and been widely applied in agricultural biological technology. In 1999, Brazilian soybean transgenic technology became mature and received global attention. In 1983, Brazil implanted code gene of antibiotic kanamycin into tobacco and made great breakthrough in research of transgenic technology. By 1995, about 707 varieties of transgenic plants had been planted in large area. Varieties with gene control include soybean, corn, potato, tomato, cotton, and kidney soybean, while genetic modified varieties include watermelon, cabbage, carrot, rice, apple and peanut[6].

2.3 Trade liberalization and economic de-agriculture making Mexican agriculture lose comparative advantage

2.3.1 Trade liberalization makes Mexican agriculture gradually lose its comparative advantage. Before the 1990s, Mexican traditional agricultural products, such as corn, soybean, vegetable and coffee, have higher competitive edge in world trade. However, after accession to the North American Free Trade Area (NAFTA), agriculture was hit severely. Especially since the full liberalization policy implemented in 2008, the custom duty on agricultural products was discharged, which was further deteriorated. No matter in technology and production scale, or in agricultural subsidy, Mexico is incomparable with the United States. Numerous American agricultural products pour into Mexican market, leads to reduction of Mexican agricultural competitive power. For example, the most important crop in Mexico, corn had import price of 180 USD/ton from the United States in the first half of 2010, while the bulk transaction price of Mexican corn was 200 USD/ton.

2.3.2 Economic de-agriculture and investment of foreign capital lead to a series of structural conflicts in agricultural production, rural development and farmers' income, which greatly threatens grain security. In the early period of the 1980s, Mexican import substitution strategy failed and debt crisis broke out. Under the pressure of the World Bank and creditor country, Mexico started to implement Neo – liberalism economic reform, stressed function of agriculture in opening to the outside world, use of foreign investment, and giving play to function of market mechanism in agricultural field. After joining the NAFTA, the de-agriculture trend of Mexican economy becomes clearer. De-agriculture reform leads to catastrophic result. Capital flows to countryside and state subsidies are gathered by large farmers. As a result, agriculture is totally controlled by foreign capital, a lot of farmers are forced to quit from land management and enter urban slums. Agricultural production fails to satisfy domestic demand, and Mexico becomes a net importer from a net exporter of agricultural products. In the 1980s, 40% exchange revenue of Mexico relies on export of agricultural products. At present, more than 50% food needs import. To satisfy domestic grain demand, annual foreign exchange disbursement in imported grain is about the sum of the whole years' salary sent back by all Mexican immigrants in the United States, or equal to one year's revenue of Mexico from exporting oil.

A lot of small peasants go bankrupt or give up agricultural production. Mexican labor forces younger than 45 years old flow to cities or foreign countries. Those labor forces staying at rural areas have average education years of 5 – 6 years. Agricultural sci-tech extension is very difficult, rural poverty problem is increasingly prominent, farmers' willingness to invest in agriculture is greatly reduced, and grain security is threatened. At present, nearly 60% of Mexican people live below the poverty line. Among these, 80% come from rural areas, more than half have never invested in agriculture, and agricultural income only accounts for 30% of farmers' income[7].

2.3.3 The rapid urbanization lacking of inclusiveness caused some question to government administration. Mexican urbanization is passive urbanization due to rural economic depression. In addition, because an independent industry system was not established, most urban population concentrated in several large cities, the urban disease became progressively worse in Mexico and social problems, such as transportation and environmental pollution, are increasingly prominent. Financial revenue of government mainly

comes from middle and low income group, so it is insufficient to guarantee supply of public services.

Loss of agricultural advantages, unfair income distribution, and coexistence of urban poverty with rural extreme poverty are specific problems in Mexican development process. They have become persistent ailment restricting Mexican socio-economic sustainable development. Slum dwellers are victims of rapid urbanization of Mexico and are dissatisfied with government, which constitutes political unstable factor. According to statistics, slum dwellers in Mexico reaches 4.7 million, accounting for 20% of the total urban population. In recent years, many protest activities of Mexican people break out from slums. Big and small slums become independent kingdom, and drugs and violent crimes resulted from slums make the whole Mexico be in turmoil[7].

2.4 Characteristics of modern agricultural development in other low latitude plateau countries

2.4.1 Valuing development of modern agriculture relying on science and technology. Situated in Andean plateau in South America, Argentina implements state agricultural technological innovation development strategy, and attaches importance to sci-tech R&D, extension and application, making it ascend to a powerful agricultural country. To develop modern agriculture, Argentina establishes and improves organization and operation management model, such as high-effective agricultural sci-tech innovation, technological R&D, conversion and extension, technological transfer and institutional cooperation, and spares no effort in research, develop and popularize new technologies. Government focuses on investment, annually makes huge amount of investment, gives prominence to biological technology, and gives priority to development of transgenic technology and environment-friendly agriculture. Argentinean transgenic bean is famous for high yield, high protein content, high oil yield and high resistance against diseases, receiving high opinion of international market.

2.4.2 Valuing resource conservation and environmental protection, and developing organic ecological agriculture. With reference to relevant provisions of EU, Argentina formulates farsighted, feasible and practical guiding principle and management regulations for development of domestic organic agriculture. Besides, Argentina increases research on organic agriculture and gives prominence to development of anti-disease seeds and biological pesticides. Another measure is to popularize straw coverage and direct seeding without tilling[8]. Such method has advantages of yield increase, environmental protection, cost reduction, and energy consumption reduction. Thus, such technology represents trend of agricultural development both at economic level and from perspective of keeping land ecological balance and agricultural sustainable development. At present, Argentina is the second largest exporter of organic agricultural products, following Australia.

The oil kingdom, Saudi Arabia, is a typical country extremely short of agricultural resources. To effectively use scarce agricultural resources, increase agricultural production, and get rid of import-dependent situation of agricultural products, Saudi Arabian government takes effective water-saving measures. These mainly include huge investment in agricultural infrastructure, such as water delivery pipeline and dams, conservation and storage of mountain torrents, sea water desalinization, and research and extension of sprinkler irrigation technology, etc[9]. At present, self-sufficiency rate of grain in Saudi Arabia reaches 98%, and that of fruit is 70%. Date palm and vegetable not only meet domestic demand, but also can be exported. This preliminarily changes the import-dependent situation of agricultural products. Besides, Saudi Arabia attaches importance to developing loop-chain eco-agriculture using benign cycle, *i.e.* agricultural and forestry crops – grain and fruits – straw converted to feed – animal breeding – meat – animal manure converted to fertilizer – fertilizer returning to farmland. These agricultural products are competitive in EU market in nutrition, color and luster, quality and taste. Therefore, export of them increases value, and foreign exchange earned promotes rapid development of farms in return[10].

South Africa is rich in land resource and has superior geographical location, but it still values moderate development of resources and protection of ecological environment. On the one hand, it supports competitive superior industrial products. On the other hand, it forbids blind development and damage of eco-environment. In addition, South Africa focuses on developing organic agriculture. To prevent chemicals harming health and protect environment, South Africa completely or basically does not use artificial fertilizer, pesticide, growth regulator and feed additive, but use leguminous plants, crop straws, animal manure, organic waste and crop rotation to keep soil fertility, and biological prevention and control of plant diseases and insects[11].

3 Implication for development of characteristic plateau agriculture in Yunnan

3.1 Strengthening agricultural sci-tech research and development, and extension and application Foreign experience has proven that development of modern agriculture must rely on extension and application of state-of-the-art science and technology. With many years of effort, agriculture in Yunnan has made significant achievement. However, the traditional agriculture is still its main form, together with primitive and modern agriculture. There are prominent problems of insufficient sci-tech support and backward and extensive development model. Thus, we must learn from India and Brazil, attach importance to agricultural sci-tech, increase sci-tech input, enhance sci-tech extension and application, give full play to function of science and technology, as the first productivity, transform agricultural development model relying on sci-tech progress, and improve competitive power of agricultural products through science and technology.

3.1.1 Indian experience. Development of Indian modern agriculture proves that sci-tech development, extension and application are key factors for success of three revolutions. Information technology is an important characteristic in new century, and development rural information technology plays a decisive role in ag-

ricultural development. Drawing lessons from Indian practice, Yunnan can shorten the conversion process of rural information technology. Besides, India also energetically develops technological agriculture, transforms growth status of gain yield, *i. e.* increasing grain yield through improving agricultural growth rate rather than through increasing cultivation area. This has realistic significance for Yunnan to develop characteristic plateau agriculture in flat areas.

3.1.2 Brazilian experience. Brazil values sci-tech development. Apart from setting up special research institutions, Brazilian government also increases input into agricultural sci-tech research, and establishes agricultural sci-tech input mechanism and system. Agricultural sci-tech input accounts for 15% of expenses of federal government. Financial fund of federal government is mainly used to guarantee international agricultural scientific research projects, funds for agricultural scientific research institutes and agricultural universities; financial fund of state government is mainly used for development and application of new agricultural technologies; funds of cities for agriculture are mainly used for agricultural technological services. Close attention of government at all levels and guaranteeing measures for agricultural science and technology bring Brazilian agricultural development to stay at higher development level in the world. In addition, Brazil also sets up perfect agricultural sci-tech extension system[6]. Brazilian experience in modern agricultural development indicates that fundamental path for agriculture lies in transformation of production development model relying on science and technology, and improving competitive power through science and technology. Besides, state agricultural technological innovation development strategy of Argentina and water-conserving agriculture and loop-chain eco-agriculture of Saudi Arabia also depend on progress, extension and application of science and technology.

3.2 Enhancing agricultural resource conservation and environmental protection, accelerating developing mountain organic ecological agriculture In view of problems of shortage of agricultural resources per capita, restraint of cultivated land and water resources, severity of water loss and soil erosion, increasingly prominent water pollution in Yunnan, especially the plateau mountain regions, it must set up awareness of environmental protection in the process of developing modern agriculture with plateau characteristics. Developing characteristic eco-agriculture relying on diversity, climatic resources and excellent eco-environment of plateau mountain regions is not only favorable for controlling water loss and soil erosion, promoting protection and recovery of eco-environment in mountain regions, but also favorable for driving developing mountain economy, increasing farmers' income, and proving solid foundation for sustainable development of agriculture. In compliance with requirements of *Yunnan Provincial Party Committee and Provincial Government in Decisions on Accelerating Comprehensive Development of Mountain Regions and Promoting Coordinated Regional Development*, learning experience of foreign low latitude plateau regions in enhancing agricultural resource conservation and environmental protection, it should take following measures to accelerate organic agricultural development with mountain characteristics. (1) Attaching importance to R&D, demonstration and extension of key organic eco-agricultural technologies, and widely popularizing protective agriculture and circular economic model of agriculture – forestry and animal husbandry. (2) Continuing doing a good job in tree planting and afforestation, increasing forest coverage in mountain regions, conserving and cleaning water source, and gradually controlling ecological deterioration. (3) Strengthening construction of agricultural infrastructure, increasing agricultural productivity in mountain regions, transforming middle and low yielding farmland, fully exploring potential of cultivated land, increasing output rate of land, and guaranteeing grain security of the masses in mountain regions. (4) Developing and establishing superior group industries on the basis of characteristics of vertical agriculture, according to types of high and cold mountain regions, middle and temperate mountain regions and low and hot mountain regions, and focusing on market demand[12]. (5) Raising market competitive power of products with brands of organic eco-agricultural products.

3.3 Making the full use of natural resource of plateau regions to develop autumn agriculture For many years, Yunnan Province has made significant achievement in winter characteristic development with the aid of rich sunshine and heat resources. It has established the winter vertical development agriculture of tropical district and Jinsha River Dry and Hot River Valley of southern Yunnan, greenhouse in middle and northern Yunnan. Winter vegetable, potato and coarse grain are immensely popular with both domestic and foreign market. Plentiful rainfall in autumn and cool climate of high altitude region provide Yunnan Province with natural conditions favorable for developing autumn agriculture, and also give birth to unique advantage of diverse varieties of autumn agriculture. Autumn is an important season in the whole year's agricultural production, also an important season for Yunnan Province to cope with natural drought to promote increase of yield and farmers' income. Therefore, it is recommended to take advantage of characteristics of less plant diseases and insects in high altitude regions, plant harmless agricultural products, such as greenhouse vegetable, fresh corn, quinoa, tatary buck wheat, off-season potato, *etc*, which can make up for losses resulted from drought in winter and spring to some degree, and also can widen agricultural production channel and promote yield increase and farmers' income increase.

3.4 Reinforcing urban and rural integration to develop plateau characteristic agriculture on the basis of local actual conditions Consequence of Mexico copying modern agricultural model of the United States proves that consolidation of governing foundation should not neglect agriculture and rural areas, which are extremely important for developing countries with agricultural population accounting for absolute proportion. Primary task of agricultural development is to increase farmers' income. (1) It should further enhance importance, necessity, and difficulties of

modern agricultural development with plateau characteristics, attach importance to its status and function in comprehensive and simultaneous realization of well-off society of whole Yunnan Province, avoid tendency of de-agriculture, and avoid mistaken idea of simply taking characteristic plateau agriculture as developing agricultural production. (2) In the process of driving modernization of urbanization and characteristic plateau agriculture in Yunnan Province, it should stress coordinated development of urban and rural areas, make effort to make migrant workers become history, turn them to citizens, and avoid "urbanization pain" similar to Mexico and India. (3) It is recommended to highly value grain security in globalization, further enhance protection of cultivated land, increase input into agriculture, and arouse farmers' enthusiasm for planting grain. (4) It should increase financial investment and policy protection of characteristic agriculture in Yunnan Province, prevent excessive capital flow to countryside, maintain entity status of farmer household family in agricultural management, and develop regional characteristic agriculture and produce characteristic agricultural products in accordance with local situations.

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