



Impacts of historical socio-economic development policies on eco-environment in great Dunhuang region of China



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ABSTRACT

Through methods of historical literature research from 2 B.C. to 1934 A.D. (i.e. from Western Han dynasty to the Republic of China) in the Great Dunhuang region, the authors of this paper made a systematic research for the first time of the impacts that the historical socio-economic development policies had on the eco-environment in Great Dunhuang region in China. A conclusion is drawn that historical socio-economic development policies in Great Dunhuang region changed dramatically with evolution of feudal dynasties. Prior to Western Han dynasty, nomadic development mode dominated and gradually turned to semi-nomadic, semi-farming development modes. In later dynasties, animal husbandry was gradually reduced and farming became the major source for military and residential livelihood and income generation. Policies of Tun Jun (having garrison troops reclaim wastelands to gather grain), migration, taxation and farming were mainly responsible for the damage to the ecological environment in Great Dunhuang region. Moreover, evolutions of national culture in Great Dunhuang region were also one of the main reasons for the increasingly fragile eco-environment. When Great Dunhuang region was governed by nomadic peoples, animal husbandry was the mainstream and ecological environment remained stable with few sandstorm disasters. When nomadic culture was replaced by farming culture, grasslands and forests were intensively converted into farmland, leading to such disasters as soil erosion, land desertification and sandstorms. Consequently, farming civilization and nomadic civilization are two types of civilization created by human being in the process of development. They both need to adapt to the natural and climate conditions. Using one civilization to replace another would be a failure in natural resource management. The replacement of nomadic civilization might be one major driving factor for the present fragile ecological environment and frequent occurrence of natural disasters in Great Dunhuang region. Therefore, the stability of ecological environment has a close relation to a nation's traditional culture and its management behavior of nature.

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1. Introduction

Chinese researchers made a lot of researches on oasis farming since Han dynasty (200 B.C.) in Hexi Corridor and reached a conclusion that the oasis area in the past kept shifting in its location, and the desertification of the oasis was a combined result of human activities and climate changes (Li, 2001a). Tax collection had been one of important factors on human activities. During the late period of Emperor Xuanzong's reign (742–555 A.D.), the total amount of grain (tax) paid by each farmer to the feudal

government exceeded 1041.65 kg which was the total tax contribution to the government by each farm household in Wuwei, Zhangye and Jiuquan in 1983. Thus, per household tax contribution in the climax of Tang dynasty could be on a par with or even surpass that of each household in 1983 (Li, 1989). In Western Xia dynasty (1038–1227), Hexi Corridor was treated by its rulers as the rear base to fight against Song, Liao and Jin dynasties (Li, 2001b); in 1271 of Yuan dynasty, Genghis Khan ended over 200 years' control of Hexi Corridor by Western Xia. The early wars and exploitation by the feudal government and vassal state owners made agriculture in Hexi Corridor sink into recession. When the society was stabilized, mass migration was organized to Hexi corridor, laying a labor foundation for the Hexi's development. On such basis, massive lands were reclaimed throughout Hexi oases. The development of oasis produced grain surplus which could be partially stored for famine relief, and once the stockpile was used

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for famine refugees in other regions five times in a year (Li, 1990). In Qing and subsequent dynasties (1644–1934), the development of farming in northwest changed dramatically. Literature reviews revealed that the development of farming was gradually intensified, which fostered the formation of villages and communities as well as development of township economy in northwestern region (Yao, 2004). In short, most feudal dynasties in history attached a great importance to the farming development in Hexi Corridor (Wu, 1985; Zhou, 2000a).

In the early stage of human society development, the main production mode of human was animal husbandry and there were many forests and grasslands in the western region of China. During a period from Western Zhou dynasty, Qin and Han dynasties to Wei, Jin and the Southern and Northern Dynasties, there were large areas of forest-steppe in the western region with large stretches of primeval forests in Guanzhong Plain. During the Warring States period (480–221 BC), the forest recovery rate was about 53% in the middle reaches of the Yellow River and in Qin and Han dynasties the rate was around 42% in Guanzhong Plain (Yang, 2005). Large areas of forest destruction resulted in the growing incapability of mountainous areas to reserve and regulate water and destroyed the water balance in oasis areas, giving rise to desertification (Li, 2000).

Hexi corridor's sharp decline of 30% in forest area from Qin and Han dynasty to 2000 was caused by factors such as army farming, mass migration, conversion of pastureland to crop land, wood and bushes chopping, development of the salt industry and imperial wood procurement and other improper human activities. Consequently, problems such as desertification, loss of available land resources in oasis and sharp decline in biological production, even the destruction of a whole oasis arises (Wang et al., 2002a; Cheng, 2007; Li, 2003a,b). The over-exclamation of lands also made natural disasters occur more frequently, particularly the occurrence frequency and extent of sand-dust increasing with the development intensity of farming from Han dynasty to present days (Wang, 2001; Li, 2003a,b). In addition, *Tun tian* policy (having garrison troops or newly settled farmers reclaim 'wasteland' to harvest grain) further intensified the speed of desertification (Yu, 2001).

Since 1950s, the deterioration of the ecological environment in Hexi Corridor has reflected in such respects as exacerbation of soil erosion, retreating of Alpine glacier snowline, decline of ice and snow reserves, significant changes in rivers and lakes, water shortage, and shrinking oases, all being influenced both by climatic aridity and by human activities (Zhu, 2002). Moreover, the so-called market economy in 1990s and the recent urbanization movement had further intensified environmental deterioration in Hexi corridor (Wang et al., 2003; Qiao and Fang, 2005; Fang et al., 2002; Bao and Fang, 2007).

Historical documents and updated studies show that public policies and traditional nomadic culture play an important role in balancing forest & grassland conservation and farming production (Mario et al., 2014; Dennis and Agamuthu, 2014; John and Arild, 2014; Frederick and David, 2006; Arild, 2010; Juan and Begona, 2005), and that strict enforcement of environmental policy and use of traditional nomadic grazing system would sustain environment-friendly agriculture (Wang and Liu, 2011; Peat et al., 2014; Mari et al., 2009; Larissa et al., 2012; Ballinger and Stojanovic, 2010). The literature study also indicates that the previous researches mainly focused on the dynamic relationship between changes in tun jun and demographics and changes in oases, barely analyzing the relationship between policy evolution of various dynasties and the ecological environment. Therefore, the paper aims at analyzing the effects of historic socio-economic policies on the evolution of ecological environment in Great Dunhuang in an effort to make up the empty in policy study, hoping the research results could

provide institutional reference for China's present ecological civilization construction.

2. Research methods

2.1. Research areas

The city of Dunhuang, covering an area of 31,200 km², is located at the west tip of Hexi Corridor, Gansu province. The "Great Dunhuang" refers to the Hexi Corridor area including Dunhuang city (as shown in Fig. 1).

2.2. Time span of the research

The historical documents in the Great Dunhuang region from 2 B.C. to 1934 (from Western Han dynasty to Republic of China) were reviewed to conduct the study, and the dynasties and corresponding ages are shown in Fig. 2

2.3. Research method

The research methods used in this paper are historical literature reviews and field visits. Existing published and inside information on historical socio-economic development policies on eco-environment in Great Dunhuang Region was heavily analyzed. The published information is from credible academic sources including An Original Interpretation of the Social and Economic Literature in Dunhuang (Volumes 1–5) ("敦煌社会经济文献真迹释录" 1–5 "集") (Tang and Lu, 1986), Dunhuang City Records ("敦煌市志" in Chinese) (Dunhuang City Compilation Committee, 1994), Dunhuang Records (Volumes 1–2) ("敦煌志") (Dunhuang Local Chronicles Compilation Committee, 2007), Dunhuang County Records (Xin Mao edition in Daoguang year, collation, intaglio printing, spiral binding) ("敦煌县志") (Su, 1999), The Western Regions' History (in Chinese "西域通史") (Yu, 1996), Jiuquan Literature and History (in Chinese "酒泉文史") (Jiuquan Municipal CPPCC Committee, 2006), New Evidences of History of Dunhuang Studies ("敦煌学史事新证") (Chen, 2002), Course of Northwest Boarder Archaeology ("西北边疆考古教程") (Li and Ma, 2011), Decryption of Dunhuang ("解密敦煌") (Hu and Luo, 2009), Dunhuang Literature and History ("敦煌史话") (Jiang, 2009), Jinchang Literature and History ("金昌史话") (Zhu and Li, 2007), Minqin Literature and History ("民勤史话") (Pan, 2010), Yongchang Literature and History ("永昌史话") (Zhu, 2004), Guazhou Literature and History ("瓜州史话") (Gao and Kang, 2011), Records of Guazhou Historical Relic and Archaeology ("瓜州文物考古宗录") (Li, 2008), Subei Literature and History ("肃北史话") (Ren, 2010), Akesai Literature and History ("阿克赛史话") (Yang and Zhou, 2011), Jiayuguan Literature and History ("嘉峪关史话") (Xue, 2007), Zhangye Literature and History ("张掖史话") (Zhang and He, 2007), Shandan Literature and History ("山丹史话") (Chen, 2004), Liangzhou Literature and History ("凉州史话") (Li, 2011), Ganzhou Literature and History ("甘州史话") (Zhang, 2010) as well as the statistical year books of Dunhuang, Jiayuguan, Jiuquan, Zhangye and Wuwei (1950s to 2014) (Statistical Bureau of Dunhuang City et al., 1950s–2014). Of which Dunhuang County Records, the Western Regions' History, An Original Interpretation of the Social and Economic Literature in Dunhuang (Volumes 1–5) and Dunhuang Records are most important and credible sources of information that record social and economic development and environmental changes from Emperor Hanwu to nowadays. It is worthy pointing out that Dunhuang County Records was edited and published in the 11th year of Daoguang era in Qing Dynasty (1831 A.D.), and was republished in 1999 with a cut-printing style and spiral-bound). Only 500 copies of the records were produced. Above reference materials provide reliable sources of impacts of historical socio-economic development policies on

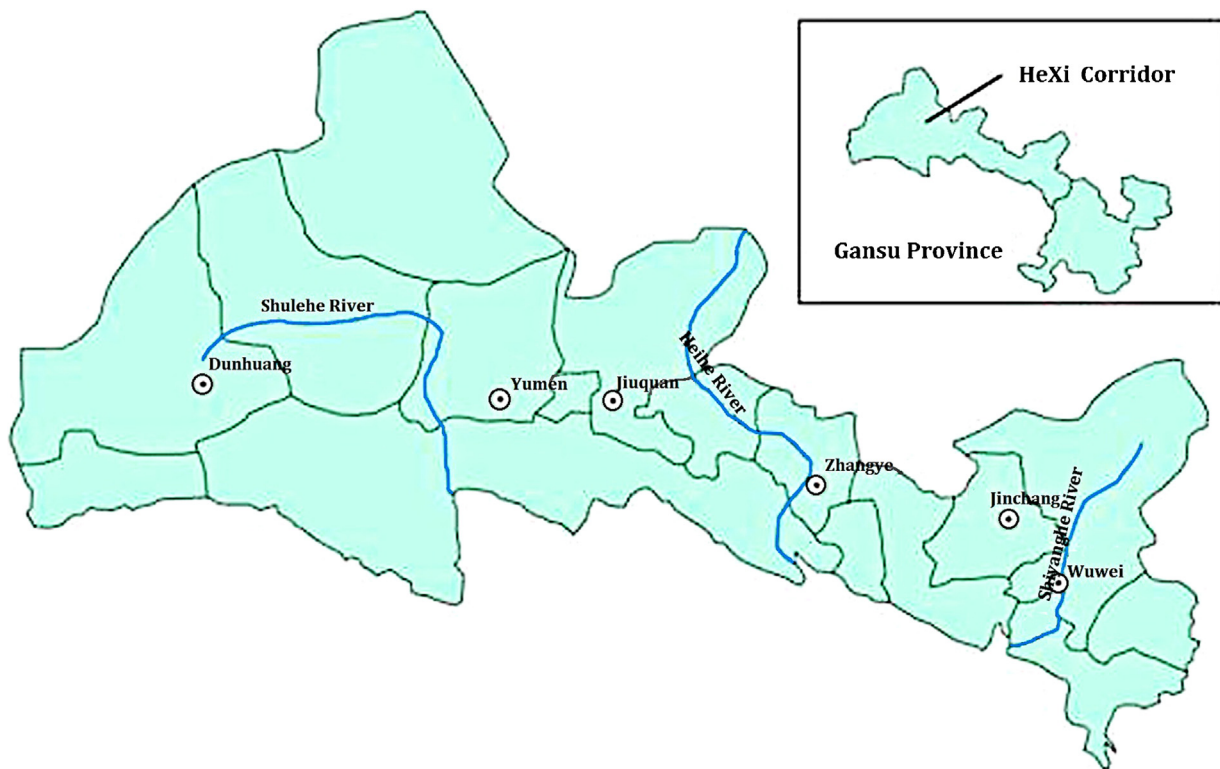


Fig. 1. Great Dunhuang and Hexi corridor in Gansu Province of West China.

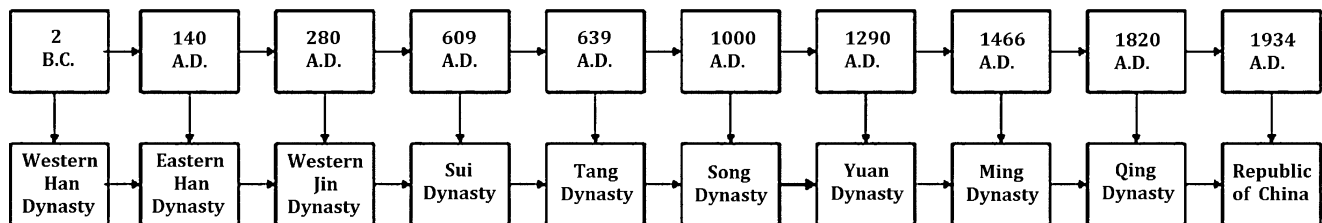


Fig. 2. The time span of the research.

eco-environment in Great Dunhuang Region. Moreover, in order to clearly mate the study area with the information from historical record, the authors brought their research teams to visit the study area for three times in Apr., Jul. and Oct. 2014. 30 senior people whose ages range from 80 to 92 were interviewed on the topic of local environmental changes.

3. Research results

3.1. Evolution of farming and animal husbandry in the Great Dunhuang region

Land utilization is constrained by both natural conditions and human activities, so the types of land utilized come from synthetic action between natural and human factors. Among all factors that affect land utilization types, social mode of production usually plays a decisive role. For example, the pastoral mode of production of nomadic people determines that pasture is their primary type of land use, while arable land is the main land-use type for a nationality with farming mode of production.

In history of the Great Dunhuang, there were mainly three types of land utilization, namely arable lands, pasture land and woodland. During Western Han dynasty to Qing dynasty, the

proportions of these types of land utilization kept changing in each dynasty.

During a period from warring States (475 B.C.) to Qin dynasty (B.C. 206), ethnic groups like Qiang and Rong, Yueshi, Hu, and Wusun were active in ancient Guazhou state. With aboriginal Qiang and Rong integrated into Yueshi, Hu and Wusun flying elsewhere under Yueshi's strong military force (*Annals of Dunhuang*, 2007, 1994), Yueshi, a nationality living on livestock, took control of the Great Dunhuang during this period.

However, since the emperor Wu of Han dynasty ruled the region, farming started to expand. The local history materials recorded that the Emperor Wu of Han dynasty "gained a divine horse from Wowa lake in the fourth year of Yuanding (113 B.C.)". In the second year of Taichu (103 B.C.), General Li Guang was defeated in wars against Da Wan and stayed in Dunhuang with 60,000 soldiers, 10,000 cattle, 30,000 horses and numerous camels (*Annals of Dunhuang*, 2007), which indicates that there were high land carrying capacity and sound ecological environment at that time.

With the promotion of Emperor Wu's policy of developing farming industry, farming techniques of Han nationality in Central Plains of China was introduced and animal labor had become the major driving force for farming industry. Except for military use, livestock was also raised by ordinary farmers and monasteries,

thus integrating planting industry with traditional animal industry and turning the mode of production in Great Dunhuang region from animal husbandry to a combined farming and livestock grazing.

In early Tang dynasty, Animal husbandry Regulatory Commission was established to manage horse affairs. The rulers of Tang dynasty belong to Xianbei ethnic group, a nomadic nationality, thus attaching particular importance to animal husbandry as well as the protection of ecological environment in grassland. In late Tang dynasty, horse market was active in border cities for trading teas with Qiang, Hu and Turk tribes. Moreover, Tang dynasty had banned the free kill of horses, donkeys, cattle and other big livestock in its prohibition and called up individuals to raise horses (Annals of Dunhuang, 2007). These policies greatly promoted the development of animal husbandry and restrained development of farming industry, thus protecting grasslands from being deteriorated.

During Guiyijun period (842–914), a headquarter adjutant was established by military governor to take charge of the production of horses, cattle and sheep herds. Both temples and individuals kept camels, horses, cattle and sheep herds. During the reign of Western Xia (1038–1227 A.D.), people were dressed in leather and fur and embarking on animal breeding, which made animal husbandry further grow. According to historical records, animal husbandry in Guazhou, Shazhou, Ganzhou and Liangzhou states topped the whole country and products of wool, coarse cloth, mat and blanket were widely renowned (Annals of Dunhuang, 2007).

Hence, historical records show that from Warring State Period to Western Xia dynasty (480 B.C.–1227 A.D.), the Great Dunhuang region was mainly controlled by nomadic peoples. Different nomadic governments attached great importance to the development of animal husbandry, treating farming merely as an ancillary industry, which ensured the sustainability and recuperation of grasslands through rotational grazing and there were few records of dust storm and grassland being damaged.

However, since Emperor Wu conquered the Hun, the traditional nomadic living style in Great Dunhuang region had been adapted to the policies of “Tun tian and migration to strengthen the frontier”. It is recorded that in the second year of Yuanshou (121 B.C.), King of Kunxie paid the vast area in Hexi corridor to Han dynasty as a tribute and Emperor Wu started to establish Jiuquan prefecture. Meanwhile, the Huns who lived a nomadic life were resettled to the north of Wuwei and Zhangye of Gansu province. In early Han dynasty, governmental troops were assembled to garrison Dunhuang region and policies of “Tun tian and migration to strengthen the frontier” kept on working so as to solve the military supply to frontier garrison. In the fifth year of Yuanshou (118 B.C.), “migrating deceitful officials and folks were moved to the frontier”. In the autumn of the fourth Yuanding (113 B.C.), “some officials in Nanyang and Xinye prefectures were punished to reclaim wastelands in Dunhuang at the reign of Emperor Wu”. In the sixth Yuanshou (111 B.C.), “prefectures Zhangye and Dunhuang were separated from Wuwei and they became independent administration authorities, which then consolidated with migration”.

Tun tian in Dunhuang was carried out step by step in Western Han dynasty. First, in wars against Hun, wastelands (grassland) were reclaimed to reap grain so as to solve the food shortage of the garrison. Later, defense systems such as barrier and beacon tower were set up in Hexi and a large number of soldiers were enlisted for the defense force and grassland reclamation.

In the time of Wei Jin, the sixteen nations and Northern dynasty (280–420 A.D.), people were separated by wars and regimes were changed frequently. For the sake of frontier armaments, various dynasties ruling Dunhuang had reclaimed grassland to gain military food. During this period, land resources in Dunhuang were intensively used and Dunhuang was at its best in terms of crop productivity.

During the Northern Dynasties (386–581 A.D.), due to frequent crises in border towns in late Northern Wei dynasty, the reclaimed lands were no longer in use for farming and gradually recovered as grassland. When Yuanfan was appointed as military officer of Liangzhou State, he organized local residents to reclaim grassland. During Western Wei and Northern Zhou, the reclamation in Dunhuang resumed as a result of several central governmental official's suggestion, which made traditional animal husbandry transform to farming.

In 580 A.D. during the reign of Emperor Wen of Sui dynasty (580 A.D.), the emperor issued decreed forcing residents in Hexi corridor to build fortresses and to reclaim grassland in order to defend against Tuguhun, but it was abandoned as apposed by Helou Zigan (a renowned general) concerning the border situation (Run, 2007). In the reign of Emperor Yang (569–618 A.D.), massive reclamation of grassland rose again in Yumen and Liucheng of Hexi Corridor.

In Tang dynasty (618–907 A.D.), grassland was intensively reclaimed throughout the nation. According to the record of Tang Liu Dian (a history book in Tang dynasty), in terms of the reclamation scale in Hexi state, there were 36 tun (approximately equals to current 240 ha) reclaimed by Chishui army in Liangzhou state, 50 tun (about 333.33 ha) in Ganzhou State and 12 tun (about 80 ha) with no records of Guazhou state and Shazhou state. However, records in Old Man in the East of the City, Taiping Collection read: “In Dunhuang, Hezhou, grasslands are reclaimed to provide grain for the frontier every year. The rest of the grain was transported to Lingzhou and into Taiyuan warehouse along the Yellow River in case of famine years”, which demonstrates that reclamation of Dunhuang not only guaranteed self-sufficiency, but also produced surplus grain to supply to other areas.

In Tang dynasty, Dunhuang had jurisdiction over two counties and twelve townships, later combined to one county and thirteen townships with its arable lands all being used. According to the Pamphlet of Granary in August of the Ninth Year of Tianbao (numbered as P. 2832) in Dunhuang and the number of households as well as the area of lands owned by per household, it could be calculated that there were approximately 300,000 μm (about 20,000 ha) of arable land in Dunhuang in Tang Dynasty.

In 1280, the 17th Zhiyuan of Yuan dynasty, Yuan government conducted a check of the farm households in Shazhou state, prescribed the annual land tax, distributing unnecessary lands of rich farmers to Shazhou garrison for reclamation. At the end of 13th century, Guazhou and Shazhou were teeming with reclamation soldiers and camps, particularly in Danghe River basin and Shulehe River basin.

The grain tax paid by reclamation soldiers in Guazhou and Shazhou exceeded 22,000 *dan*¹ (about 1030 t of today). In the seventh year of Emperor Chengzong (1303), in order to strengthen the border, stationing troops in Gansu were moved to Guazhou and Shazhou to reclaim grasslands. Then garrison were sent to Guazhou and Shazhou, finally turning Guazhou and Shazhou into a military reclamation area throughout Yuan dynasty.

In Ming dynasty, due to geological importance of Hexi corridor and with the aim of preventing the southward invasion of Mongolia army and ensuring smooth tribute trade along the Silk Road, Ming government assembled around 100,000 soldiers in Hexi Corridor. In order to reduce excessive dependence upon imported grain, the government carried out a tun tian system combining jun tun (grassland reclamation and grain reaping by garrison troops) and min tun (grasslands reclamation and grain reaping by folks) and prescribed “seven tenth of soldiers cultivate lands, leaving the rest defend the city”, striving for grain self-sufficiency. Moreover, farmers were provided with free production materials including farm cattle, farm tools and seeds. In order to help migrant people

¹ Dan is an ancient Chinese weight unit.

cultivate lands, low-tax policy of “levying taxation in accordance with the land capacity” (There was 10–20% tax levied on newly reclaimed after three years instead of levying at the beginning) and a policy of reward were implemented. These policies greatly promoted farming and the Great Dunhuang region was once again massively developed (Gao, 2009). In 1395, the end of Emperor Zhu Yuanzhang’s reign in Ming dynasty, there were about 16,000 ha of reclaimed lands in Great Dunhuang region and the area was reaching to 46,000 in 1573 (the 1st year of the reign of Emperor Wanli) after Zhang Juzheng presided over land measurement (Tian, 2000).

In Qing dynasty, market-gear agriculture appeared. In the early Qing dynasty, 2404 households migrated from Shanxi, Gansu to Dunhuang and each farm household owned 50 μm of lands. After long-term reclamation, grasslands in Shazhou were cultivated into farmlands and there appeared large-scale farming activities. In the 7th year of Emperor Yongzheng’s reign, in order to encourage more farmers to immigrate to Dunhuang, the government provided the immigrants with travelling expenses, plowing cows, seeds and food as well as other production materials required for reclamation, thus making the area of arable lands exceed 120,000 μm throughout the entire Dunhuang county. The Governor of Shaanxi and Gansu reported such situation to Emperor Yongzheng and recommended to extend the tax exemption period to more years to benefit local immigrants. The Emperor Yongzheng approved the governor’s request. As a result, more grain were produced in Dunhuang area, driving grain prices down, which encouraged many peddlers and businessmen to transport grain produced in Dunhuang to other places for trading (Annals of Dunhuang, 2007).

3.2. Impacts of land utilization policies on the ecological environment in historical period

3.2.1. Reduction of forest area

In historical period, large areas of forests were chopped in Hexi Corridor due to a packet of “tuntian” policies. Wang Nai’ang’s research indicated that the forest coverage rate in primitive societies (1.7 million years B.C.–2070 B.C.) in Gansu province was 30%, down to 6% in 1948, 4.51% between 1984 and 1988 and 4.33% between 1989 and 1993 under the influence of human activities. The existing forest area is 19,473 km^2 (Wang et al., 2002b). According to historical records, Qilian Mountain was covered by primeval forests. In thickly wooded areas, pines and cedars grew vigorously and remained green through the year. “There are divine trees in Qilian Mountain, which can serve as food for people in need” (Annals of Dunhuang, 1994).

As recorded in Dunhuang County Annals during the reign of Qing Emperor Daoguang, animals such as leopards, tigers, bears can be seen in Dunhuang County, which clearly demonstrates that ancient Dunhuang were rich in forest resources, being a land of hidden leopards and crouching tigers. Nowadays, these beasts had vanished.

During Republic of China, for hundreds of kilometers along the North Lake and West Lake in Dunhuang, Chinese parasols, red willows and reed could be seen everywhere with cattle and sheep grazing in the wind. Farmers there gathered firewood for fuel supply. Nowadays in Dunhuang, neither thick pine forests in the distance nor high and lush Chinese parasols and red willows can be seen. In addition, oasis environment, biological resource and water resources are vulnerable to damage, causing a sharp decrease of plant coverage area (Annals of Dunhuang, 1994). The decline in forest area has a great bearing on “tun tian” policies (Li, 2000).

3.2.2. Shift and desertification of oases

The oasis is an artificial ecological system suitable for farming and animal husbandry built by human through irrigation in arid desert areas. With the introduction of farming techniques into the traditional pastoral areas in Great Dunhuang region, water

conservancy facilities were gradually set up by Han nationality. Since the 6th year of Yuanding during the reign of Emperor Wudi (111 B.C.) when Maquankou Weir was built over Ganquan River, successive dynasties began the construction of water conservancy facilities, which reached a peak during the Tang and Song dynasties (618–1279 A.D.). The construction of water conservancy facilities in Dunhuang area took full advantage of the local rivers and underground water, and the original marshlands and low-lying lands along rivers were also developed. Over a given period, the area of oasis had increased, but the policies of “tun tian” and human’s irrational activities led to over-exploitation and gradually desertification of these oases. New oases were formed elsewhere and thus constant geographic shift of oases occurred. The oases were shifted in one basic direction from lower reaches to the middle and upper reaches of ancient rivers. The desertification generally occurred in the lower reaches of the river (Annals of Dunhuang, 1994; Li, 2001a).

3.2.3. Exacerbation of land desertification

The core of border management policies in Great Dunhuang region in history was to emigrate people in farming region to pastoral areas and convert grasslands and forest lands into farm lands in an effort to expand grain production, which directly resulted in misuse of land resources.

Over-reclamation and misuse of lands gave rise to the exacerbation of desertification, making original oases turn to semi-desert or desert. In 1779, the 44th year of Emperor Qianlong’s reign, the desertification of farmlands had been extremely serious (Li, 2003c; Zhang, 2009).

3.2.4. Frequent occurring of sandstorms

Historical records reveal that sandstorm weather happened in an increasing frequency in Northwest China. From the 3rd century B.C. to 1367 A.D., sandstorm weather occurred 30 times, about once 50 years; from 1368 to 1911, it occurred 75 times, about once seven years, and from 1912 to 1949, it happened 43 times, about once a year (Wen, 2005).

Dusty weather imposed a huge impact on crop production, living, lives and property. For instance, in the 4th year of Chenghua of Ming dynasty, strong winds had been blowing from spring to summer and crops had been destroyed, resulting in volatile rice price, famine, people eating people events and strong fear among people (Wen, 2005). In order to analyze the frequency of dusty weather with the area of land reclaimed, we made an analysis of the correlation between frequency of occurrence of sand-dust weather and arable area during Ming, Qing and the Republic of China, and calculated that $r = 0.09$ according to the following formula:

$$r = \frac{\delta xy}{\delta_x \delta_y} \quad (1)$$

Our analysis illustrates that the occurrence frequency of sand-dust weather is increasing with the area expansion of arable lands. During the Republic of China, the sand-storm weather occurred more frequently although the area of arable lands was lessened, which demonstrates that vegetation in Great Dunhuang region had been seriously damaged. This further makes it clear when traditional nomadic system was replaced by farming techniques in the process of farming migration and *tun jun*’s demands for grain increased, mass grasslands and/or forest were converted to farm lands, causing sand-storm weather to occur more frequently.

3.3. Driving factors of policy affecting the utilization of lands in history

3.3.1. Tax policies

Ancient China’s tax policies required farmers to pay to the Imperial Court a certain proportion of grain, instead of cash.

Table 1
Tax levied from different crops based on land area (per mu) in Tang Dynasty (Unit: Sheng^a).

Types of crops	Millets	Rice	Barley wheat	Wheat	Soybean	Red bean
Tax standard/ μ	2	4	3	4	4	2

Note: The total revenue collected from each farm household was about 2.8 Dan, accounting for about 5% of the total annual production. Source: China's Economic History, volume in Sui Tang and Five Dynasties, p.41.

^a Sheng is ancient Chinese weight unit. 1 sheng = 0.625 kg.

Therefore, the tax rate determined the amount of grain left to farmers. If farmers had surplus grain that were sufficient for next year after paying the tax, most farmers would not go to reclaim lands; if not sufficient, farmers would go to reclaim “wastelands” (grasslands or forest lands) the next year. Thus, reclamation of wastelands directly aggravated the destruction of ecological environment.

Taxation was quite different in different dynasties. In Western Han dynasty, “bian hu zhi” system was promulgated, which stipulated that per capita whose age ranged from 15 to 56 should pay a tax ranging from 1 qian 6 li 4 hao to 2 qian² (about 0.12 dan of grain, equivalent to present 15.84 kg) (Zhou, 2000b). In early Tang dynasty, “zu-yong-diao-zhi” system was carried out, which was a combination of land tax, military service substitution tax and specialty tax levied on the basis of “equaling dividing land” system. For a family of four members, head tax means the grain paid by each to the government; diao means local products paid such as silk, cotton cloth and sackcloth; yong refers to cotton cloth or silk paid by those with military service, all the three being covering by a name “zu-yong-diao” system. In middle and late Tang dynasty, “zu-yong-tiao” system was changed to “two-taxation” system, which combined previous land tax and head tax.

In 766 (Tang dynasty), tax was levied through measuring the area of lands. Lands were classified into various grades and types and then distributed to farmers for tax levying (see Table 1) (Chen, 2002).

Therefore, in early and middle Tang dynasty, land distribution system was implemented, under which, if the individual were to cultivate extra land, severe punishment would be imposed on him. In this period, exclamation of the wasteland was restrained and forests and grasslands were protected. In late Tang dynasty, corruption appeared and the feudal government increased the scope of tax under numerous titles, such as ding zu su (which refers to the annual tax paid by each farmer with equally divided land, being 2 dan of millets), jiao qian (which refers to the labor expense for transporting tax grain, about 3 dan of millets), ying jiao qian (which refers to a kind of tax levied along with jiao qian on construction of granary and cellar, about 1.5 dan of millet). All these different types of tax increased the burden on farmers, forcing them to reclaim more wastelands for living (Chen, 2002b).

In 1724, the second year of the reign of Qing Emperor Yongzheng, new tax policy was made that head tax and land tax was combined into one single land tax. In 1725, the third year of Emperor Yongzheng's reign, 2.3 dan (about 115 kg) of high quality grain was levied on per household with the whole County totaling 5332 dan. In 1727, the fifth year of Emperor Yongzheng's reign, 2 qian (about 0.12 dan of millets, equivalent to present 15.84 kg) was levied on each farmer and apportioned into land tax. Meanwhile, grains produced from wastelands were distributed as 50% share by the government and the farmer after deduction of the seed cost. Over a period, the tax was re-classified and raised. The land was divided into three grades-superior land, medium land and inferior land. For superior land, one dou³ of wheat, 1 dan of millet plus 10 buckets of grass (horses' feed) were levied; for

medium land, 7 shengs of wheat and 7 buckets of grass were levied; for inferior land, 5 shengs of millet and 5 buckets of grass were levied. Later, Cha Lang'A, the governor of Shaanxi and Gansu, made a stipulation forcing per household to pay another 4 dan of grain as a purchase tax. In 1908, the 34th year of the reign of Emperor Guangxu, a total of 4340 dan of grain and 135,000 bundles of grass were levied through Dunhuang County. In terms of Haoxianliang (tax on rat consumed grain, which indeed served as granted salary of local officials) was one plus 10% dou of superior grain per mu. Moreover, in order to raise educational funding, an extra 10–20 dan of grain for redundant lands was levied each year.

In 1910, the 2nd year of Xuantong reign of Qing Dynasty, per farm household was required to pay a land tax of 3.4 dan, 70% of which was in the form of grain and the rest in the form of cash.

In the end of Qing dynasty (1840–1911), due to frequent famine, growing bankruptcy of rural economy and slack businesses and industrial industries, all being triggered by frequent wars, tax source was dried up and financial deficit was rising. In 1910, the 2nd year of Xuantong, when Qing dynasty was on the verge of collapse, Regulations on National and Local Taxation was promulgated, yet with no possibility of being put into effect.

In early Republic of China (1912–1928), taxation of Qing dynasty was still practiced. The tax levied on per land area ranged from a high level of 4–5 dou to a low level of no less than 1 dou. What's more, with local feudal forces armed with troops, the ordinary was exploited at their will (Annals of Dunhuang, 2007).

Hence, the heavy government tax did not even include various additional taxes, such as “ying jiao qian” and “jiao qian” in Tang dynasty, “hao xian qian” and “zhuang tian liang” in Qing dynasty. In addition, the lands distributed to farmers were all of poor quality or insufficient in actual area according to the stipulation (Wu, 1985; Cheng, 2007, 2007b; Zhou, 2000c; Tang, 2008). All the extra taxes and inferior lands added endless pressure to people's livings and they had to make deduction of their own proportion and reclaim more wastelands.

3.3.2. Population policy in history

Historical documents show that there inhabited such nomadic nationalities as Qiang, Rong, Wusun and Yueshi in Shang and Zhou, Warring States period, Qin and Han dynasties. Late, the western region was occupied by the Emperor Hanwu and the territory was expanded. Since then, Hexi Corridor region had become a place where different dynasties hoarded grain as well as a crucial battleground. According to Cheng Hongyi's study in 2007 (Cheng, 2007), there were changes in the size and density of population in Great Dunhuang region in history

Tun jun and tun tian policies implemented in different dynasties directly resulted in the rapid growth of population, which in turn caused quick expansion of arable lands (Fig. 3).

$$r = \frac{\delta xy}{\delta_x \delta_y} \quad (2)$$

According to formula (2), we worked out $r_{xy} = 0.97$, being the relative ratio of population size to the number of arable lands, which indicates that the size of population are highly relevant to the number of arable lands and the growth in population would make more grassland and/or forestland be converted into farmland.

² Qian is ancient Chinese currency unit. 1 qian is about nowadays' Yuan 0.2. USD 100 = Yuan 620.

³ Dou is ancient Chinese weight unit. 1 dou = 1/10 of dan, or 6.25 kg.

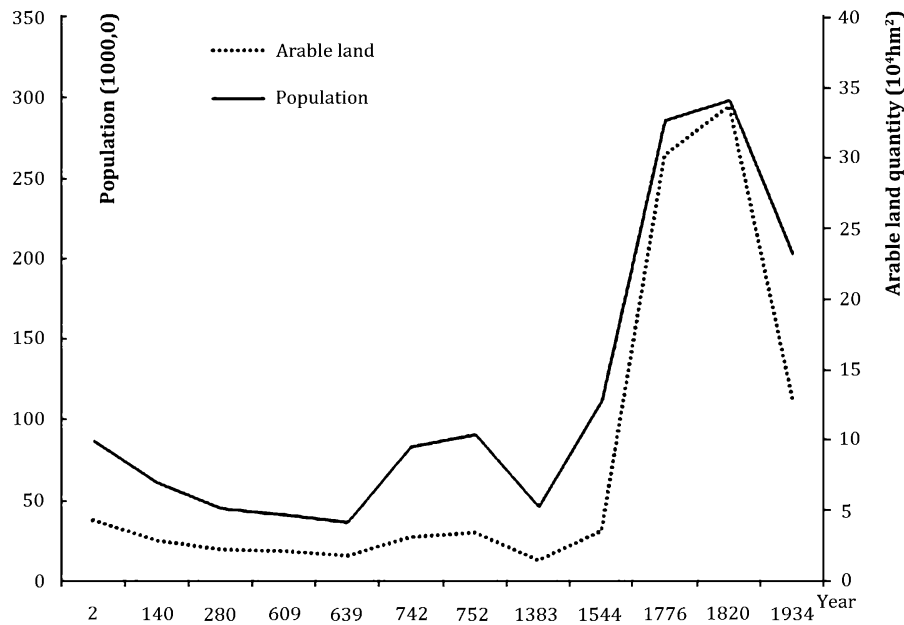


Fig. 3. Population and arable land area in Hexi Corridor in history.

3.3.3. Reclamation policies in history

Reclamation in history was mainly caused by stationed troops (jun tun) supplemented by civilians (min tun). The labor source of jun tun was mainly garrison soldiers, who ploughed at peace time while fighting during warring times. The grain reaped was for military use. Min tun was mainly carried out by land servants and migrants. Jun tun originated in Han dynasty and followed by successive dynasties.

During Wei and Jin dynasties (around 220 A.D.), the size of tun tian was narrowed compared with Han dynasty, but a lot of irrigation canals such as Beifu Canal, Yangkai Canal and Anyang Canal were constructed in Dunhuang region in Western Jin dynasty (266–316 A.D.).

During westward inspection, Emperor Yangdi of Sui dynasty defeated Tuyuhun, a northwestern ethnic minority, and contained the most part of present Qinghai and the southwestern tip of Xinjiang into Sui dynasty. Meanwhile, criminals across the country were dispatched to Great Dunhuang region to reclaim wastelands.

In Tang dynasty, tun tian was energetically carried out in Great Dunhuang region. During the late period of Emperor Xuanzong's reign, *Tun Jun* policies were promulgated to expand farming land. For instance, in the 26th year of Zhiyuan, the gaining from jun tun in Shazhou was not only sufficient for troops but also able to provide relief for famine refugees. Around 1303, the 7th year of Dade, the grain reaped from Shazhou jun tun reached 25,000 dan (Annals of Dunhuang, 2007).

In both Ming dynasty and Qing dynasty, due to successive wars and natural disasters, large patches of farm lands were devastated (Yu, 2003; Cui, 1990; Zhou, 2000d).

There were some similarities in tun tian in various feudal dynasties in history. First, as local livelihood was generally damaged in wars in previous dynasties, the newly-built government would usually take a policy of migration, emigrating people to Great Dunhuang region and reorganized them to cultivate the lands. The government also provided them with energetic policy support, such as exemption or reduction of tax, extending the year limit for tax. Such policies brought about rapid expansion of local farming, which then caused damage to grasslands and/or forests and made the population rise quickly. When steady agricultural development was maintained, the government would raise the tax level. Supposing the land output remained constant, people would

have to reclaim more grasslands and forest lands to meet the needs of living, which in turn caused great damage to local ecological environment. With corruption among officials being more serious, the tax rate was raised year by year. And a new revolution would be triggered when people found it hard to make a living.

4. Conclusion

Above study results show that the socio-economic development policies in Great Dunhuang region had been changed dramatically with feudal dynasties. Prior to Western Han dynasty, nomadic development mode dominated, and it gradually turned to semi-nomadic and semi-farming development mode. In later dynasties, animal husbandry was gradually reduced and farming became the major source for livelihood and income generation. Policies of tun jun, migration, tax and conversion of grazing to farming were mainly responsible for the damage of ecological environment in Great Dunhuang region. Moreover, evolutions of culture in Great Dunhuang region were also one of the main reasons for the increasingly fragile eco-environment. When Great Dunhuang region was governed by nomadic people, animal husbandry developed rapidly and ecological environment remained stable with few sandstorm disasters. When nomadic culture was replaced by farming culture, grasslands and forests were intensively converted into farmland, leading to such disasters as soil erosion, land desertification and sandstorms. Hence, farming civilization and nomadic civilization are two types of civilization created by human being in the process of social development, and both need to adapt to the natural and climate conditions. Using one civilization to replace another would be a failure in natural resource management. The replacement of nomadic civilization might be one major driving factor for the present fragile ecological environment and frequent occurrence of natural disasters in Great Dunhuang region. Therefore, the stability of ecological environment has a close relation to a nation's traditional culture and its management behavior of nature.

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