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Original Research Paper

Dynamic Degradation of the Alpine-cold Wetland and Analysis of Driving Forces in Maqu, China

Liu Qingguang
Tourism Department, Hefei University, Hefei 230601, China

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ABSTRACT

Maqu wetland is located on the northeastern edge of the Qinghai-Tibet Plateau. As one of the important water conservation and recharge areas in upper Yellow River, it is of great significance for regulating the Yellow River water and sediment, maintaining biodiversity and regional ecological balance and to achieve sustainable socioeconomic development. In order to analyse the dynamic characteristics and regional differences of Maqu alpine wetland systems during the past 20 years, in this paper, 1990, 2000 and 2010 series of Landsat satellite data as the main data source, using remote sensing and GIS spatial analysis technology, adopting the method of multivariate statistical classification, dynamically monitored the distribution pattern changes of Maqu wetland. The results showed that: Maqu wetland area was overall in a downward trend in recent 20 years; in 1990, 2010, the wetland area of 1151.7km^2, 1049.32km^2 respectively, the area reduced by 02.38km^2, the average annual decline rate was 0.37%. In the period from 1990 to 2000 annual average shrinkage rate was 0.43%, significantly faster than the 0.31% of the 2000 to 2010 period. Analysis showed that global climate change and increasing human activities were the main drivers of the wetland ecological environment deterioration.

INTRODUCTION

Wetland has a reputation for "kidney of the earth". It is a multi-functional and rich ecological diversity ecosystem, has a strong regulating function to the river, plays an irreplaceable role in the maintenance and regulation of climate, water conservation, protection of biodiversity and ecological balance, etc. Maqu wetland is located upstream of the Yellow River, belonging to the Tibetan Plateau alpine wetland from the wetland classification, is an important component of the Zoige wetland, and the wetland area is 375,000hm^2. Maqu wetland as an important water source of the Yellow River upstream, supply water upto 45 percent of the total water of the Yellow River upstream, hence known as "the Yellow River reservoir", and the significance of the ecological environment is very important. In recent years, Maqu wetland was shrinking dramatically and drying up, the area dropped, the amount of water supply reduced. Especially along the Yellow River region appeared patches of sand, it had significant effect on the ecological security of the Yellow River, for this reason, causing some scholar's eager attention. Therefore, the study of Maqu wetland landscape pattern change is important for maintaining the stability of the ecosystems and protecting the water resources of the Yellow River source.

In this paper, Landsat 5 and Landsat 7 remote sensing images as the data sources, under the technical support of RS and GIS, based on the spectral information and terrain height as variable, using stepwise discriminant analysis method, screening can effectively distinguish between different types of surface features characteristic variables, building a discriminant equation. In this classification, achieved the purpose of wetland dynamic monitoring and analysis, and combined with the meteorological data to analyse the reasons for the changes.

STUDY AREA AND DATA

Study area: Maqu County is located in the eastern part of the Tibetan plateau, in the junction of Gansu, Qinghai and Sichuan provinces, between longitude 100°45'45"-102°29' 00" and latitude 33°06'30"-34°30'15", and the total area of Maqu county is 10109.8km^2. The elevation is 3300-4806m, with terrain sloping from northwest to southeast. The main features of the local climate are cold and humid, short summer and long winter, with an average annual temperature of 1.1°C and annual precipitation of 615.5mm. The upper reaches of the Yellow River show a U-shaped along the Amne Machin Mountain from the south, east and north, length of approximately 433.7km, formed "the Yellow River first bay" in Maqu County. This section of the river flows slowly, forming a large number of marsh wetlands, became a major area of water conservation in the upper of the Yellow River. The main type of grassland is alpine meadows and alpine steppe grasslands. Because the grasses grow well, and the yield is higher, it is famous as "Asia first ranch".

Maqu wetland is an important part of Qinghai-Tibet plateau alpine meadows, centering on Qiaorigan, mainly distri-

Fig.1: Geographic location of Maqu in China.

bution in Awancang village, Manrima village, Cairima village, Qiama village, Hequ racecourse, and Azi livestock experiment station. It is 97.8km long from south to north, 95km wide from east to west, with a total area of 37.5× 10^4hm^2, and its core area is about 12×10^4hm^2. Maqu wetland belongs to the Qinghai-Tibet plateau alpine wetland, its types such as swamp wetland, river and lake wetland. Among them, the swamp wetland located in the ancient depression, floodplain and valley depressions of the Yellow River. River wetlands located on the both sides and the main tributaries of the Yellow River, is the main part of Maqu wetlands. Maqu wetland has more lakes, but the area is small. Other types of wetlands include springs, ponds, reservoirs and tidal flats.

The soil types of Maqu wetland include alpine meadow soil, sub-alpine meadow soil, swamp soil, peat soil, meadow marsh soil, dark brown soil, etc. Among them, the sub-alpine meadow soil is the typical soil of this area. The vegetation types belong to the shrub meadow of western Sichuan and eastern Tibet Plateau. The shrubs are mainly *Rhododendron lapponicum*, *Salix cupularis*, *Potentilla fruticosa* and *Hippophae rhamnoides*, etc., and the herbs are *Artemisia feddei*, *Kobresia capillifolia*, *Kobresia tibetica*, *Polygonum viviparum*, *Gentiana algida*, etc.

Data sources: Remote sensing data in the study area are Landsat-5/TM and Landsat-7/ETM+ images, a total of 12 scene data, receiving time in Table 1. Because the wetland focused on 131/037 and 131/036 two scene, so the study time limited in 1990, 2000 and 2010. Meteorological data are the air temperatures, precipitation, sunshine time, evaporation and ground temperature of Maqu weather stations during 1981-2010, provided by Gansu Provincial Meteorological Bureau Information Center. Runoff data during 1956-2010 came from the hydrological stations of the Yellow River. In addition, there are ecological observation data of animal husbandry and national economy statistics data, 1: 100,000 topographic maps and 1: 250,000 digital elevation model (DEM) in the study area.

Table 1: Images of Landsat-5 and Landsat-7 in the study area.

Track No.	Receiving time (year-month-day)		
131/036	1990-07-05	2000-07-04	2010-08-12(ETM+)
131/037	1990-07-05	2000-07-04	2010-08-15(ETM+)
132/036	1990-08-12	2000-08-27	2010-08-17
132/037	1990-08-15	2000-08-27	2010-08-17

Data processing: In order to obtain the wetland area, three Landsat TM (ETM) remote sensing data in 1990, 2000 and 2010 were compared and analysed, supplemented by research methods of field investigation. Geometric correction is a prerequisite for complex multi-temporal remote sensing image composite analysis and remote sensing dynamic monitoring (Zhanjiang et al. 2001). This study, based on the TM (ETM) image geometric correction and radiation calibration processing, using the UTM geographic coordinates for image correction, and using a topographic map (1: 100,000) for figure correction. RMS test results show that the correct errors are less than 1 pixel. The scheme of RGB colour composite obtained the standard 432 band synthetic false color images. At the same time, the original TM (ETM) images were enhanced processing, including linear stretch and color composite processing.

The author has carried out on-the-spot investigation on the wetland during August and September in 2010, combined with 3 periods in 1990, 2000 and 1990 TM (ETM) images, established 14 classes, 246 landmarks wetland remote sensing interpretation symbol library, and identified the remote sensing analysis program of 8 categories and 35 sub-categories in the grassland ecosystems as a core. Using ARCVIEW, ARC/INFO software system for digitizing graphics, interpreted and hook painted three Maqu alpine wetland maps. Using the ARC/INFO spatial analysis functions, calculated and analysed spatial data of the swamps. Then, using Excel completed data statistics.

RESEARCH METHODS

Usually, higher the spectral resolution, the recognition accuracy of the object is higher. The conventional method based on spectral characteristics of object recognition is mostly a simple combination of several bands as a classification index, there may be some ignored or overlapped phenomenon of certain information. In this paper, a stepwise discriminant analysis method for classification based on remote sensing spectral information and digital elevation as the characteristic variable, combining all the band spectral information of the image provided, according to the principle of stepwise discriminant analysis (He 2004), screening can effectively identify the variables of different types of surface features, building of discrimination indicators for surface classification. The method may avoid the loss of information and overlap, contribute to the rapid assessment of land classification. Specific process is as follows: 1) Determine the type of surface features in the study area; 2) Select the characteristic variables; 3) Build the discriminant equation of the surface types to classify.

Amended dryness formula of M. R. Chen was used to get the grass dry index:

$$G = \frac{C\sum T_{5-9}}{R} \quad ...(1)$$

Where G is the grass dry index, G greater the more dry, conversely G smaller the more humid; ΣT_{5-9} is accumulated temperature of more than 0°C in pasture growing season (May to September); C is the revised altitude factor, interannual variability when comparing only for convenience of calculation, take $C = 1$. $C\Sigma T_{5-9}$ is evaporation force. R is the same period of precipitation (Deng et al. 1993).

Determination of the type of surfaces in the study area: According to the present situation of national land use classification system (State Bureau 1997) and Maqu land use map, the land surface in the study area is divided into rivers, barren land, sand, residential areas, alpine meadows, subalpine meadow, shrub meadow, swamp meadow and shrub land 9 types. In accordance with the international conventions for the definition of wetlands (Crowe 2000), rivers and swamps in the area should belong to the wetland meadows. The present study is aimed at alpine wetland that has a role in regulating the flow of rivers. Therefore, only the swamp meadow limit as the category of wetland. According to the field investigation, some areas of marsh meadow have emerged the vegetation degradation of peat phenomenon completely (Fig. 1). As the classification method based on spectral characteristics of the image, in order to improve the classification accuracy, it is further subdivided into “peat swamp” and “swamp meadow” categories.

Selection of the characteristic variables: Analysed the spectral characteristics of surface features in the study area, surface classification of remote sensing images can be realized. Random sampling and statistical mean carried out on the 10 surfaces, and obtained spectrum information of all kinds of surfaces as shown in Table 2 and Fig. 2. Through a comparative analysis, these surfaces of six bands on TM showed different spectral characteristics. Although the spectral characteristics have little differences between the portions of the surface, but still be able to distinguish to some extent. Therefore, it is characteristic variables as building discriminated function.

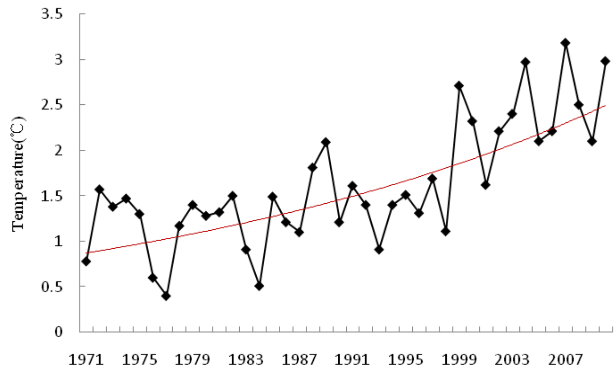

Fig. 2: The changes of annual temperature in Maqu from 1971 to 2010.

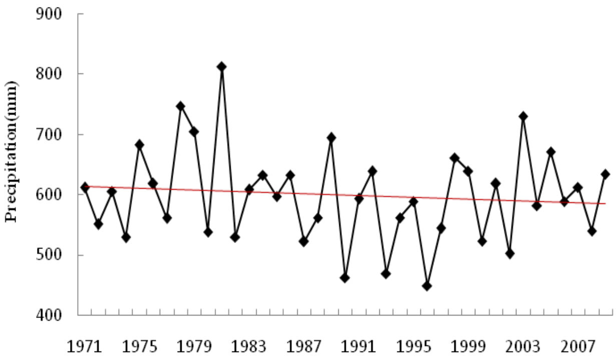

Fig. 3: The changes of annual precipitation in Maqu from 1971 to 2010.

It was found that the distribution position of different surfaces in the study area has a certain definition, which can be used to distinguish between similar spectral characteristics of ground objects. Such as the spectral characteristics similar to barren lands and sand, the former located at the top of the hill, above alpine meadows and below the snow line, the relatively high altitude, with an average altitude of 4200m or more, and the latter located on both sides of the Yellow River, river island, its terrain is relatively low, with an average elevation within 3300 - 3600m. Wetland located on flat terrain, near the banks of the river to be poor water vent, smaller slope, with an average altitude within 3450 - 3500m. Alpine meadow located beneath barren lands, above subalpine meadows, with an altitude within 3700 - 4200m. Therefore, increasing the height of the terrain as the feature variable, build a discriminant function to improve the classification accuracy.

Table 2: The gray-level mean values of samples taken from various surfaces.

Surfaces	TM_1	TM_2	TM_3	TM_4	TM_5	TM_7	Number of samples
River	29.23	21.47	27.44	16.38	10.68	3.34	418
Peat bog	22.88	16.93	20.37	66.74	73.64	31.41	3262
Marsh meadow	16.48	15.22	13.21	99.93	70.38	24.08	811
Sandy	59.66	42.14	57.63	83.82	130.16	89.42	766
Barren land	62.98	40.19	54.99	86.51	143.78	87.87	1851
Residential Area	45.63	31.97	45.06	90.42	129.84	82.64	262
Shrub land	18.95	16.24	13.29	116.11	74.33	25.61	266
Alpine meadow	35.78	25.66	32.09	86.38	113.17	54.86	8042
Subalpine meadow	21.25	19.29	17.00	125.70	85.14	29.28	1249
Shrub meadow	26.31	21.50	21.73	115.21	100.78	38.87	1457

Table 3: Comparison of the results obtained from discriminant analysis classification and visual interpretation.

1990 a	Area (km^2)	Raster	The number of points on the grid	Category fine Degrees (%)
Discriminant analysis classification	1151.70	1842720	1382479	83.92
Visual interpretation method	1029.42	1647378		

Table 4: The wetland area of different districts in Maqu in 1990, 2000 and 2010.

Districts	Wetland area (km^2)				Area change (km^2)		
	1990a	2000a	2010a	Average	1990-2000a	2000-2010a	Total
Awancang	86.69	92.56	86.18	88.48	5.87	-6.38	-0.51
Cairima	264.71	260.83	247.99	257.84	-3.88	-12.84	-16.72
Manrima	463.45	434.91	414.62	437.66	-28.54	-20.29	-48.83
Muxihe	6.76	4.78	6.46	6.00	-1.98	1.68	-0.30
Nima	122.84	109.33	89.51	107.23	-13.51	-19.82	-33.33
Oula	41.73	36.44	32.69	36.95	-5.29	-3.75	-9.04
Oulaxiuma	4.56	2.18	4.03	3.59	-2.38	1.85	-0.53
Qihama	142.12	139.61	146.67	142.80	-2.51	7.06	4.55
Livestock Ground	18.84	22.61	21.17	20.87	3.77	-1.44	2.33
Total	1151.7	1103.25	1049.32	1101.42	-48.45	-53.93	-102.38
Change rate					-4.21	-4.89	-8.89
Annual change rate					-0.84	-0.61	-0.74

Building discriminated equation of surface classification: First of all, under the ArcView software, adopt the method of visual interpretation to extracting a representative area of the 10 farming surfaces from the image. In order to match with the image, converted the 25m × 25m grid to ESRI GRID format, used it as a template. Under the ArcGIS software, TM_1, TM_2, TM_3, TM_4, TM_5, TM_7 and altitude (DEM) 7 variables were randomly sampled. Then, the random sample was loaded into the SPSS software, used the stepwise discriminant analysis method. According to probability test requirements set F of 0.05 and λ value of the minimum, screened variables which can effectively distinguish between the surfaces, built discriminant equation using the characteristic variables (He 2004, Dong 2001). Finally, using the ArcGIS map algebra calculation function, the characteristic variables were screened into 10 discriminant equations, conducted grid computing, compared the size by value, put it into value represented by the largest object type, completed classification of the study area.

In the classification results, river, sandy and barren lands were the best classification, followed by peat bog and marsh meadow, and the worst classification was shrub land. Because the shrub land was mainly distributed in the coastal area of Yellow River, the soil was moisture large, and the spectral characteristic was near meadow. The research object of this study was wetlands, so the only classification results extracted from peat swamp and marsh meadow were analysed. Because of absence of the same phase higher resolution images, visual interpretation at present was considered to be the highest precision, but the labour intensity of

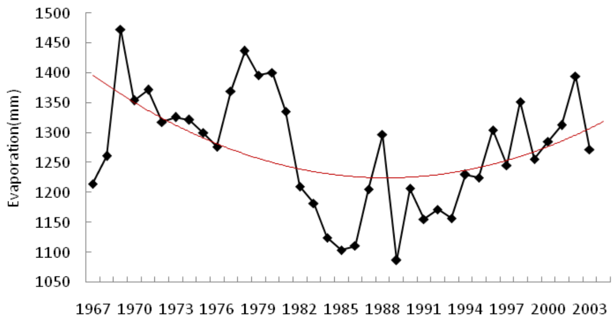

Fig. 4: The changes of annual evaporation in Maqu from 1967 to 2004.

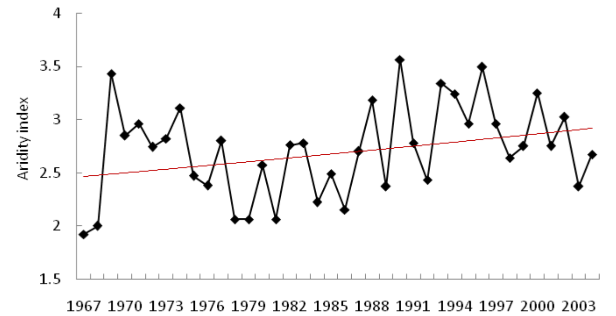

Fig. 5: The changes of annual aridity index in Maqu from 1967 to 2004.

the classified method was larger. So, in order to achieve accuracy assessment of the classification methods, the wetland area of discriminant analysis and the results of visual interpretation were compared (Table 3), its accuracy is 83.92%, relatively high. Therefore, the surface classification applied the discriminant analysis method.

REMOTE SENSING MONITORING RESULTS

According to the classification method, get the 1990, 2000 and 2010 statistical results of wetland areas and changes in different districts of Maqu. To gain a more accurate understanding of the wetland distribution, take an average of 3a to analyse the distribution of wetland (Table 4).

Wetland distribution: Table 4 shows that the area of Maqu wetland is 1101.42km^2, which accounts for 10.0% of the total land area of Maqu County. The districts were distributed wetlands, but mainly concentrated in Marima, Cairima, Qihama, Nima and Awancang, five townships in the south-eastern, accounting for 93.9% of the total area of wetlands in Maqu. The wetland area of Manrima, the largest was 437.66 km^2, accounting for 39.7% of the total area of the wetland; Cairima followed, accounting for 23.4% of the total area of wetlands; Qihama, Nima and Awancang accounted for 13.0%, 9.7% and 8.0% respectively, of the total area of wetland.

Wetland area changes: The statistical results in Table 4 show that the wetland area of Maqu was overall a trend of shrinking between 1990 and 2010. In 20 years, the wetland area was decreased by 102.38 km^2, i.e. by 8.89%, and an average annual loss of 0.37%. Reduced area of wetland mainly concentrated in the Manrima, Nima and Cairima, the reduced area of the three townships occupies 96.6% of the total reduction of wetland area. Manrima wetland area reduced maximum for 48.83km^2, accounting for 47.7% of the total reduction of wetland area. The area of wetland showed a slight increase in Qihama and livestock proving ground, accounting for 6.7% of wetland area.

Comparative analysis of the change of wetlands in two periods i.e. 1990-2000 and 2000-2010, we can see that the changing trend of the townships wetland is not the same. Wetland area change trend of Cairima, Manrima, Nima and Oula was consistent with the overall trend of the wetland, within two periods, which showed a downward trend. While the wetland area of the remaining townships was fluctuating changes, it expressed as a time to increase (or decrease), another time to decrease (or increase). In the previous 10 years, the wetland area decreased 48.45km^2, annual reduction rate of 0.43%, and the wetland of Manrima reduced the largest, the wetland of Awancang and animal testing ground slightly increased (respectively increased 5.87 and 3.77km^2). The back 10 years, the wetland area decreased 53.93km^2, annual reduction rate of 0.31%, and the wetland area of Manrima and Nima decreased the most, the wetland area of Muxihe and Qihama slightly increased. It is not difficult to find, wetland area reducing rate of 1990-2000 is significantly faster than the 2000-2010.

Maqu alpine wetland is mainly concentrated in the south-eastern part of the county, 1990-2010 wetlands area showed the overall tendency to shrink. This was consistent with the existing research results (Zhang et al. 2000, Liu et al. 2002). Wetland area of different townships is not in the same change trend, and wetland area of some individual townships appeared a slight increase, but relative to the wetland shrinking of other districts, both in quantity and magnitude were smaller.

DRIVING FORCES OF WETLAND CHANGES

Maqu wetland degradation was the result of the combination of natural factors and human factors. In order to find the shrinking reasons of Maqu alpine marsh wetland in the 20a, the paper combined the features of climate change and human activity conditions in the analysis.

Climatic factors: Affected by the global warming, climate drying trend of Maqu is obvious. From the annual average temperature curve in Maqu (Fig. 2) we can see, the annual temperature from 1971 to 1976 was mainly fluctuating balance, fluctuating upward trend after 1976, more pronounced warming since 1993, 10 years increased up to 1.0°C. Judging from changes of annual precipitation in Maqu (Fig. 3), less annual precipitation from 1971 to 1974, the annual average changes of 548.7 mm; from 1975 to 1981 the annual precipitation was above normal, the annual average changes of 665.4 mm; after 1982 the annual precipitation presented the fluctuation of the decreasing trend, then the annual precipitation increased since 2000. From 1985 to 2010, the annual evaporation and precipitation showed the opposite trend (Fig. 4). The annual evaporation rose from 1145.5 mm in the early 1980s to 1308.5 mm in the current. From 1967 to 2004, the annual aridity index change and temperature change trend is the same, in contrast to the annual precipitation change trend (Fig. 5). The late 1960s to the late 1970s were the relatively dry stage. From the late 1970s to 1980s experienced relatively humid period, and from the late 1980s to 2004 obviously becoming dry, the drying degree rose significantly.

In short, climate change was the root cause of reduction of precipitation. The reduction of precipitation directly led to reduction of surface runoff and decline of groundwater level in Maqu wetland. The temperature rise caused evaporation to increase, and the surface became dry, alpine meadow marsh evolved into alpine meadow, which caused vegetation coverage to reduce, bare land continues to expand, so lot of lands had serious desertification. In addition, the region belongs to the Qinghai-Tibet plateau alpine area, so the underground has perennial permafrost. Rising temperatures and melting permafrost, the ability to isolate surface water has reduced, and plenty of surface water has infiltrated, that led to wetlands dried up and shrinking, groundwater level falling, soil moisture content reducing, plant growth restricted, causing the degeneration of wetland. Thus, climate warming lowered the fragile ecosystem stability, reduced resilience weakened, becoming the main driver of wetland degradation.

Soil and geological factors: The soil of Maqu wetland is mainly alpine marsh soil and swamp soil, has higher organic matter content. Affected by the late quaternary glacial activity, diversion of the Yellow River had occurred many times. Old riverbed constantly abandoned, deposited a large amount of sediment. The left bank has formed two broad riverside terraces. One terrace located in the Yellow River, and the soil is sandy soil and sandy loamy soil. The second terrace is alluvial plain and alluvial torrents overlap that staggered distribution, and vertical distribution of soil was surface soil, black soil, loess and sandy soil. Because, these two terraces were rich sediment deposited, the surface soil was very thin, only 30-40cm. If the surface soil and ecological vegetation once damaged, then sand exposed at the surface. Even with ecological restoration and revegetation measures, it was hard to recover, and was likely to become a plateau desert. Desertification of grassland was mainly distributed in the areas along the Yellow River.

Rodents and insects cause serious harm: The degradation and desertification of grassland have broken the original relative balance of the food chain in the wetland, which results in, *Canislupus campestris*, *Vulpes vulpes*, *Aquilaspp* and other predators of rodent lose their living conditions, then the number has fallen dramatically. Maqu wetland has emerged rodent and pest, the number of *Ochotona curzoniae*, *Myospalas baileyi*, *Microtus oeconomus*, *Marmota himalayana*, *Lepus oiostolus*, and others increase rapidly. Among them, *Ochotona curzoniae* was the largest, the most widespread, and *Myospalas baileyi* followed. Rodents and insects were predators of the grassland. Their influence on the grassland vegetation was varied: Chewed plant stems and leaves to reduce the grassland resources (such as *Ochotona curzoniae* and *Microtus oeconomus* in a variety of fine forage grass stems, leaves, flowers and feed the fruit as the main target feed), dug the hole to damage the grassland (such as *Myospalas baileyi* living in underground, had a strong mining capabilities, chewed on plant roots to cut off the roots, put a lot of subsoil to the ground, forming dense mound; these mounds buried a mound of vegetation). Rodents and insects caused the natural grassland coverage to decrease, the good forage to reduce, the poisonous weeds to increase, and the productivity of the grassland to decline. Some of the original lush pastures had become barren "Black Beach" and secondary bare. The area of rodents and insects increased at an annual rate of 14.2% in Maqu wetland, such as the area of rodents in 1993 was 7.0×10^4hm^2, 1995 year was 12.3×10^4hm^2, 2001 amounted to 16.7×10^4hm^2. Currently, rodents and insects occurrence area had more than 50% of the total wetland area (Wang et al. 2006).

Overgrazing: Overgrazing was the main human factor, driving the wetland degradation. Maqu county is livestock-based economy, the swamp and marsh meadow pasture area about 8.93×10^4hm^2. It provided a good foundation for the development of animal husbandry substance. In recent 40 years, the animal husbandry of Maqu has rapidly developed, the number of livestock increased year by year (Li 2005). In the mid-1980s and the late-1990s, there were two surges. In the early 1950s, actual carrying capacity of Maqu wetland was less than half of the theoretical carrying capacity; in the late 1960s, the actual carrying capacity was more than theoretical carrying capacity, and to maintain the momentum of the increase; in 1998, reached a maximum of 2.482 million sheep units; then slowed down. It was only 0.43 sheep units/hm^2 pasture in 1949, and was 1.19 sheep units in 1969, reached a maximum of 2.54 sheep unit/hm^2 in 1998, and remained as 2.31 sheep unit/hm^2 in 2005. With the increase of actual carrying capacity, pasture overload rate also showed a clear upward trend, reached a maximum of 106.25 percent in 2000, pressure on wetlands was increasing. Overgrazing led to the grass growth stunting, the grass production declining, the grass quality lowing, the grass variety degrading. This accelerated the speed of wetlands degrading, further exacerbated more wetland drying up and shrinking.

Excessive digging and picking: The unique natural environment of Maqu wetland, not only has a variety of wild herbs, but also is rich in peat resources. In Maqu wetland, there are a lot of wild expensive medicinal materials, such as *Saussurea medusa*, *Rheum tanguticum*, *Rhododendron anthopogonoides*, *R. przewalskii*, *Gentiana macrophylla*, *Fritillaria przewalskii*, *Cordyceps sinensis*, *Morchella esculenta*, *Lamiophlomis rotata*, *Plantago asiatica*, etc. In recent years, under the drive of economic benefits, people dug wild herbs in the range of large area, so the wetland grassland had digging holes, native soil was badly damaged, and vegetation exposed alopecia areata disease. Wetland ecological environment suffered severe damage. In addition, Maqu wetland contained a large number of peat layers. In recent years, local residents in order to obtain economic benefits for large-scale exploitation of peat, largely destroyed wetland ecological vegetation. The vandalism has changed the type of land cover, made the sand layer under the wetland surface baring, caused soil erosion aggravating, and accelerated grassland degradation and desertification.

Other factors: With the local economic development, mining, urban construction, herdsmen settlement construction, tourism developments and others, damaged the eco-environment. Within 3.7km^2 range of Geer Ke gold mining areas, due to large-scale development in the past 10 years, the vegetation coverage from the original 75% to 90% downed to less than 50%. The road as an important form of human disturbance had an important influence on the occurrence and restoration of wetland. Most grazing activities conducted along the road, the negative impact of unplanned grazing on wetland was no doubt. Wetland closer the road was more likely to be disturbed. Road limited the movement of animals, it was a kind of potential interference and harm for some animals. The road divided biological activity territory, affected the biological environment for survival, made the species degradation, and had no conducive to biodiversity conservation.

In short, due to overgrazing, excessive digging and picking, mining and other human unreasonably utilization of wetland resources, severely damaged the original ecological vegetation, so accelerated the progress of wetland degradation and desertification in the region. According to Maqu County Historical survey data, in the 1950s, there was no desertification phenomenon; in the 1960s, there were sporadic desert land and small dunes; in the 1980s, the total area of desertification was 1440hm^2; in 2000, the area of desertification was 6080hm, accounting for 0.63% of the total land area of the county; in 2010, area of desertification was 5.34×10^4hm^2, accounted for 5.53% of the total land area. In desert grassland, the area of salinization and desertification was 3.5×10^4hm^2, mainly distributed in Manrima village, Hequ racecourse, Cairima village, Awancang village, Nima village and Oula village, etc. According to the speed, Maqu wetland ecological environment was worrying.

DISCUSSION AND CONCLUSIONS

Based on remote sensing spectral information and terrain height of characteristic variable, used the stepwise discriminant analysis method. In the study area, obtained higher classification accuracy, more accurately and objectively reflected the spatial distribution and change of Maqu alpine wetland.

The wetland area of Maqu is about 1101.42km^2, accounting for 10.0% of the total land area of the county. All the villages have wetland distribution, but mainly concentrated in Manrima, Cairima, Qihama, Nima and Awancang, five townships in the southeastern region.

In the past 20 years, the Maqu wetland overall showed declining trend, the wetland area was reduced by 102.38 km^2, i.e., decreased by 8.89%. However, the wetland changes in different villages were not the same, wetland changes in parts of the villages had significant stages in time, showing an increase in the period, reducing another time. Wetlands shrinking rate was different in the past 20 years, and the later 10 years were slower than the first 10 years.

Maqu wetland degradation was the outcome of the combined action of natural factors and human factors. Natural factors such as warming and drying climate, rodents and insects were the main factors of the wetlands shrinking; human activities such as overgrazing, excessive digging and plucking exacerbated the wetlands shrink.

Because of the lack of relative quantitative analysis, the discussion about the wetland changes of Maqu is limited to the qualitative level. The combination of quantitative analysis, the deeper investigation on the cause of the wetland shrinkage, will be the main content of further research in future.

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