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Population growth, management and environmental degradation in China

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Abstract — Environmental problems in China can be divided into two large classes: pollution and destruction of natural environment. Environmental degradation is particularly serious in areas with rapid population growth. In this paper, some of China's major environmental problems, particularly those concerned with land, forests, and continental waters are introduced in order to see how population growth and management have affected these resources over the past few decades. It is also explained how the Chinese plan to cope and eventually solve these problems.
Keywords: population; environment; degradation.

AN OVERVIEW OF POPULATION GROWTH IN CHINA DURING THE PAST 200 YEARS

China has been the world's most populous country for centuries. The nation's population has continued to expand repidly over the past two centuries. Between 1760 and 1900 China's population is estimated to have doubled. By 1969 it had doubled again. In the early years after the founding of the People's Republic in 1949, population growth was seen in the light of " more people greater strength ". Only in the 1970s, the idea that overpopulation could be harmful to economic growth was put forward.

POPULATION PRESSURE ON THE LAND

Population pressure on the land in China is on the increase. According to the United Nations report of 1977, the world average for arable land per person in 1975 was 0.31 hectares and by 2000 it is expected to be halved to 0.15 hectares per person (UNEP, 1977). In other words in the early 1970s, each hectare of arable fed 2.6 persons but by 2000 each arable hectare will have to feed four persons.

In China the population to arable land ratio is far below the world average and will more than likely worsen at a faster rate than the world average up to 2000 A.D.(Table 1). Deterioration is not only due to the growth of total population but also to a reduction in the amount of arable land. Much of the best quality land is being converted to housing and industrial land use. As indicated in Table 1, total arable land was reduced by 9,000,000 hectares between 1952 and 1981. In 1986 it was estimated that 37,000 hectares and in 1987 another 20,000 hectares of arable were transferred to non–agricultural uses. Crowding in the cities has reached the level of 5 square meters of housing space per person in Shanghai and 7.38 sq. m in Nanjing. Equivalent levels of crowding can be found in most Chinese cities over one million in population. New urban expansion will increasingly have to make use of surrounding arable land. The combined effect of population growth and reduction of arable land means that the average amount of arable land per person has been halved since the founding of the People's Republic in 1949.

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Table 1 The population to arable land and ratio in China

year	population, in millions	total arable, in millions hectares	average amount of arable per person, in hectares	no. of people per ha., arable
1952	570	108	0.18	5.3
1981	990	99	0.10	9.8
2000 est.	1200	96	0.08	12

Source: Qu Geping, Environmental Problems and Strategy of China, China Environmental Science Press, 1984

A more direct measure of population pressure on land resources can be seen from the increase in grain requirements. From 1952 to 1981 China's total grain production increased from 327,800,000,000 *jin* (163,900,000,000 kg) to 650,000,000,000 *jin* (325,000,000,000 kg). This increase represents almost a doubling of production in less than 30 years. However, production only increased 82 *jin* (41 kg) per person over the same period, roughly a per capita increase of only 14%. In order to achieve this per capita grain increase in a period of rapid population growth and declining arable area, the Chinese have opened up vast tracts of marginal lands and over-exploited the existing arable. Consequences of this over-exploitation include desertification and soil erosion.

DESERTIFICATION

Desertification can occur in semi-arid areas with strong winds and sandy soils if the ecological balance is broken. It is estimated that 35% of the earth's land surface is already desert or desertified. To this total of 45,608,000 sq km, another 60,000 sq km or 70,000 sq km are being added each year. Thus desertification now threatens 15% of the world's population in over 100 countries.

Dry lands in north China now occupy 334,000 sq km or 3.4% of the nation's territory. Areas which are deserts of long standing comprise 36.8%(123,000 sq km) of this total. Roughly another 15.9%(53,000 sq km) of China's arid and semi-arid lands have been desertified over the past 100 years, and 43.7%(158,000 sq km) is what can be termed latent desert land or marginal dry lands under the threat of desertification (Zhu, 1985). The desertification problem is found in at least 12 provinces and autonomous regions with nearly 35,000,000 people and 6,000,000 to 7,000,000 hectares of pasturage affected. The problem has intensified in the last 25 years with an estimated 1,560 sq km of desertified land being created each year.

Most desertification during the past 100 years has taken place along the semi-arid desert fringe in northern China where sedentary agriculture has been pushed into historically pastoral areas and where animal husbandry has been intensified. In general there are three desert zones in China all with annual precipitation below 55 mm and a humidity index of less than 0.3. On the western edges of the Dongbei plain and central parts of the North China plain, there are patches of desertified land which if properly managed will return to non-desert conditions. A second more arid zone is located just to the west of the above mentioned areas, largely in Inner Mongolia where desertification is much more serious but land can be reclaimed with considerable effort. The third zone comprises the deserts of northwestern China where conversion to grasslands is virtually impossible. Problems of desertification are most serious in the two eastern zones.

In the Kerqin grasslands of eastern Inner Mongolia various classes of desertified land occupied 20% of the land area in the late 1950s. By the end of the 1970s the proportion of desertified areas in these grasslands reached 53.8%. In the Barhu Left Banner on the Hulun Beier grasslands of eastern Inner Mongolia, desertified land rose from 9.2% in 1959 to 12% in 1984. East-central Inner Mongolia, in particular the southern portion of the Kerqin grassland including the area around the city of Chengde, has been the most seriously affected region in recent years.

Due to the rapid rate of desertification, land productivity in semi-arid areas has dropped markedly. In desertified areas the annual grain productivity is in the 15–35 *jin per mu* (0.49–1.19 kg/hectare) range. In one part of Inner Mongolia where desertification has occurred recently yields have dropped from 150–200 jin per *mu* (1078–1500kg/hectare) in 1949 to 30–50 jin per mu (225–375 kg/hectare) in 1980 (Zhu, 1985). This can be coupled with an average rise in population density on the grasslands from 15 persons/sq km in 1949 to 60 persons/sq km in 1980. Likewise herd pressure on the range has increased from 50 *mu* of pasture per head in the 1950s to 15–20 *mu* per head in the late 1970s.

There are two main processes by which desertification occurs. The first process is the invasion of sand dunes from the periphery of deserts blown unto surrounding semi–arid marginal lands by high winds. Such invasion of marginal lands occurs along the fringe of the Taklamakan Desert in the center of the Tarim Basin in Xinjiang, in the Hexu Corridor of Gansu, in the Qaidam Basin of Qinghai, and in the eastern part of the Alxan region in Inner Mongolia. This type of desertification is largely a physical process. The other type is brought about by man's exploitation of the land excessive cultivation of an arid environment, overgrazing, excessive lumbering, improper use of water resources, and environmental damage caused by mining and railroad or road construction. These activities lead to a landscape which is quite similar to that found in the deserts formed largely by physical processes. This sort of human instigated desertification is widespread in eastern and central Inner Mongolia; in particular the Kerqin grassland, Qahar grassland, the southern portion of the Ulan Qab grassland and Ordos grassland. Desertification in these areas in clearly tied to human interference with the delicate ecology of these grasslands.

The causes of desertification in northern China are broken down more precisely in Table 2.

Table 2 The proportion of desertified areas in northern China by major causes

Cause	Area 1000 sq km	Per cent of desertified area in north China,%
Overcutting of forests	56.0	31.8
Overgrazing	49.9	28.3
Excessive agriculture	44.7	25.4
Improper use of water resources	14.7	8.3
Industrialization & urbanization	1.3	0.7
Wind blown sand dune encroachment	9.4	5.5

Source: Zhu Zhenda, Present status and Developmental tendency of Desertification of North China, Journal of China's Deserts, no. 3, 1985

It is quite obvious that the majority of desertification in north China is caused by human over–exploitation of fragile ecosystems. Figure 1 represents an attempt to graphically portray the desertification processes found in northern China.

Population growth in China is seen now as the primary cause for destruction of the ecological balance. Most of the economic activities in China which directly affect an ecosystem are the result of increasing population although introduction of new technologies and their mismanagement is also playing a part.

The 1977 U. N. Conference on Desertification established critical population pressure levels for arid lands. In arid lands with a humidity index of 0.2 to 0.3 the level of population pressure should be kept below 7 persons/sq km, whereas semi–arid lands with a humidity index of 0.3–0.5 should support up to 20 persons per square kilometer. However,in many arid parts of China,

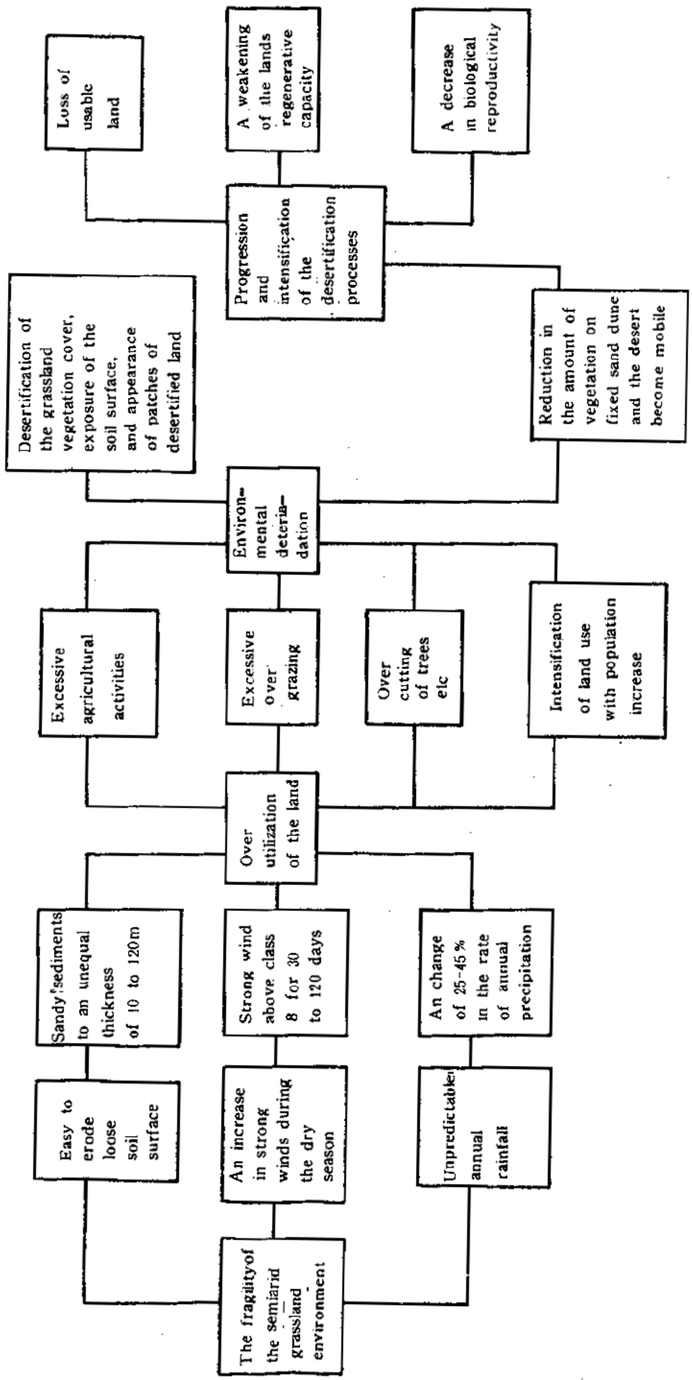

Fig. 1 A graphic representation of the desertification process in north China

the population pressure already exceeds these " safe " limits (Table 3). Population control in arid and semi-arid environments will be most essential if China is to control desertification. However, as many of these areas are settled by mongols who are exempt from China's one child policy, population control prove difficult.

Source: Zhu Zhenda & Liu Shu, Desertification — An Important Problem in Arid and Semiarid Zone of North China, Discussion on National Territory Realignment and Strategy of China, Science Press, 1983

Table 3 Population pressure levels in selected parts of Inner Mongolia with rapid desertification

Xian (county) or Qi (banner)	Humidity index	Population per square kilometer 1949	1957	1962	1966	1973
Shandu Xian	0.15	49.4	62.6	66.1	74.9	89.0
Siziwang Qi	0.12	3.0	4.7	5.9	6.1	7.3
Qahar Youyi Zhong Qi	0.19	23.7	35.4	39.2	44.5	51.6
Wuchuan Xian	0.15	15.0	23.2	27.7	29.3	35.4

Source: Zhu Zhenda & Liu Shu, 1982, Desertification Processes and Rehabilitation in Northern China. China Forestry Press.

One recent policy developed in part to control desertification is so called " Great Green Wall" or the " Three Northern Forest Belts " stretching from the oasis of Kashi in Xinjiang to the Great Hingan Mountains in northeast Inner Mongolia. This Great Green Wall is more a series of small belts of protective trees and grasses planted at intervals along the 7000 km semi-arid desert fringe than a Great Wall of forest as the English names implies. The first phase of this project began in 1978 and was completed in 1985 with 6,050,000 hectares planted. Initial reports are optimistic with hopes that a forest responsibility system (trees belonging to individuals-much like China's agricultural responsibility system introduced in the early 1980s) will lead to more care of seedlings than was the case in past Chinese afforestation efforts.

The second phase which began in 1986 and will last for ten years calls for planting another 6,320,000 hectares which hopefully will stabilize many sand dunes and increase the vegetation cover from 5.9% to 7.7% in these sensitive areas. Yet planting alone will not be enough as proper management of ecological activities and population control will also be necessary.

Since 1983 China has been trying to rejuvenate grasslands by airseeding. The Chinese are reporting success with this technique in areas with 150–200 mm of precipitation per annum. In many arid regions experiments are being conducted using hardy vegetation and inorganic materials to fix sand dunes.

SOIL EROSION PROBLEMS

Every year 3,000,000,000 tons of soil are eroded from the land surface of the United States of America. In the Soviet Union loses amount to 500,000,000 or 600,000,000 tons whereas China loses 5,000,000,000 tons of soil per annum. Clearly soil erosion is a major problem in China.

The middle section of the Yellow River is the world's most seriously eroded region. One tributary of the Yellow River, the Quye river had an average annual erosion rate of 1570 milligrams per square centimeter between 1957 and 1970. On the lower reaches of the Wuding River in the Tuanshangou valley, Zishou Xian, Shaanxi province the annual erosion rates can reach 3450 milligrams per square centimeter. This could well be the world's highest known annual erosion rate. The mud and sand flow in the Yellow River at its middle reaches in roughly 1,600,000,000 tons per annum. Erosion in this area is in part caused by physical factors. The soil surface here is composed of a loose thick layer of loess and loess-like materials. Loess com-

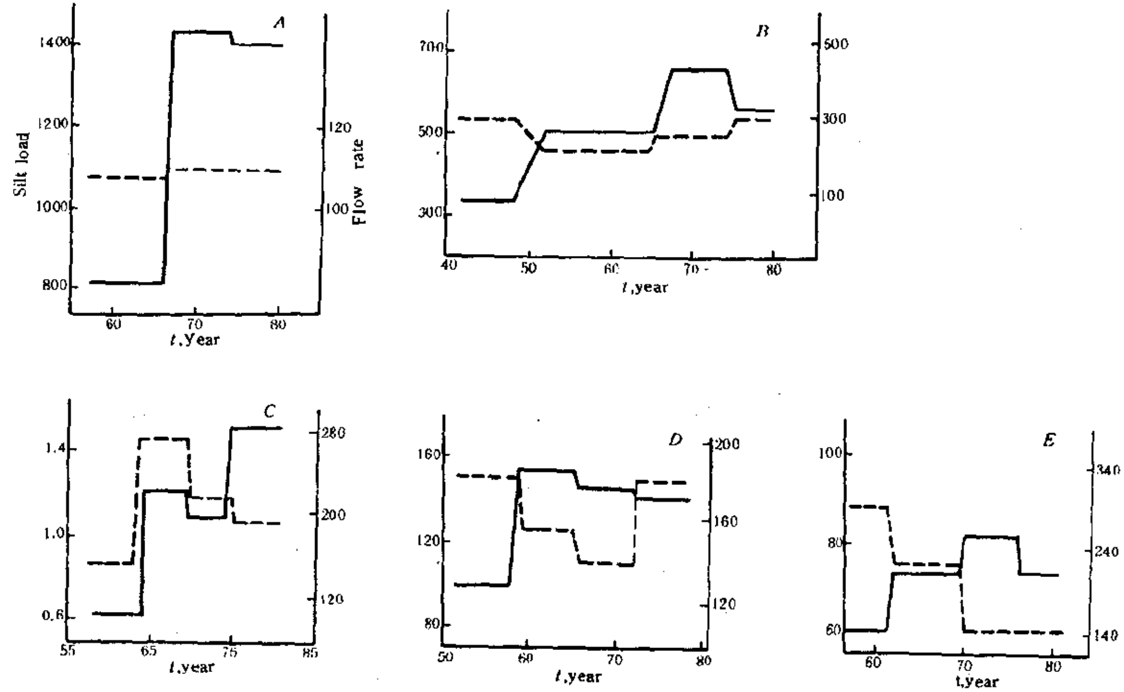

Fig.2 Changes in the rates of flow and silt loads in various Chinese rivers during the past thirty-fifty years

—Flow rate (g/m^3)
— Silt load (× 10m^3/a)
A Yachi He station on the Wu River
B Gongtan Station on the Wu River
C Lodu Xi Station on a tributary of the Jialing River
D Zhuqi Station on the Ming River
E Jingqiao Station on the Nan River

position is such that it can resist collapse and erosion, especially if the natural vegetation cover is undisturbed. However, centuries of human activity have caused a serious amount of erosion. The Yellow River basin is the heartland of Chinese civilization. During the past several thousand years, human activity in this cultural center has destroyed the region's fragile ecological balance. In particular in the last half century, population growth has accelerated this breakdown. According to data from the Yellow River Water Conservancy Commission (Huang He Shuili Weiyuanhui), from 1920 to 1949, the silt load of the Yellow River averaged 1,550,000,000 tons per annum. From 1950 to 1977 the average silt load increased to 1,800,000,000 tons (Zhu, 1984).

Moreover, during the past thirty years not only has the Yellow River silt load increased but also the Yangtze river in the east central China, the Songhua and the Liao River in the Northeast, and the Pearl and Min Rivers in southeastern China also have increased silt loads due to expanding cultivation and exploitation of the land. As of 1980 over 1,500,000 square kilometers of China's land surface (16% of the total) has suffered serious soil erosion.

The main impetus for erosion rates increasing in the past thirty–five years has been rapid population growth. In order to increase grain production, forests have been cut down, former marginal lands have been cultivated including grasslands, hilly lands and mountain slopes.

In order to comprehend the increase in soil erosion we can look at statistics for 48 representative hydrological stations. The earliest statistics date from 1819, with the latest coming from 1981. However, the majority of stations have data covering roughly 30 year periods. From these data we can select two indicators: flow rate and silt load. These two indicators are of course interrelated. In general as the flow rate increases, the water's ability to erode the soil increases and therefore the silt load also increases. Change in these two indicators reflect annual fluctuations in the erosion process due to physical factors. What we are concerned with is the tendency for the flow rates to remain unchanged while the silt loads are increasing over time. Because of the many fluctuations in the annual flow rates and silt loads it is difficult to discern the overall trend. As a consequence we have divided the data into five to eight year periods for which average figures have been calculated.

The statistics shown in Figura 2 reveal some of the major trends. The Gongtan station on the Wu River, one of the tributaries of the Yangtze River in Sichuan province has shown little change in its flow rate over the past forty years. However, the station's silt load records indicate a rise in loads over the same period (A). The silt load doubled between the 1940s and the early 1970s. The conditions at the Yachi He Station, also on the Wu river but in Guizhou province, are quite similar (B). The flow rate showed little change for over two decades. The silt load, however increased dramatically during the 1960s. The rise has been sustained and represents a 74–80% increase over the pre–1966 silt loads. The Lodu Xi Station (Sichuan province) on the Qu River, a tributary of the Jialing River in the upper reaches of the Yangtze River basin records a doubling of silt load in the post–1975 period when compared with 1950s silt data(C). Statistics from the Zhuqi Station on the Min River in Fujian province indicate that the flow rate dropped continuously from 1958 to 1973. The silt load, however, increased quite rapidly. The silt load of the 1960s increased 45% to 50% over the 1950s total (D). Jiangqiao Station (Heilongjiang province) on the Nonni river in the upper Songhua River basin also has a decreased water flow rate in 1955 whereas the silt load has generally increased (E). During the period 1970–76 the silt load increased by 50% over the 1961 rate.

The above examples are all cases where the flow rates have increased only slightly or have been decreasing over decades while the silt loads have been increasing. Therefore we would expect that under conditions where the flow rate is increasing or there are heavy increases in rainfall, the silt load (and hence the rate of soil erosion) would increase even more dramatically.

Soil erosion brings about several serious problems. First of all, soil erosion destroys the remaining soil, breaking up the land surface. Second, erosion destroys soil fertility.

From historical records we know that the surface area of Dongzhi Yuan (Dongzhi Mesa) on the Lõess plateau in Gansu province was 42 km from north to south and 32 km from east to west. Today, however, although the north–south length shows little change, from east to west Dongzhi Mesa is only 18 kilometer at its widest and less than half a kilometer at its most narrow point. The two valleys on either side have virtually eroded the whole mesa landform. It is estimated that Dongzhi Yuan's surface area has decreased from 1,344 sq km to 756 sq km. In other words from 1300 down to today, Dongzhi Yuan has lost 588 sq km or nearly 44% of its surface area. Slope erosion and down cutting are the primary agents in this particular example. Based on an analysis of 1967 and 1979 areal photographs of 17 valley ridges in Guyüan Xian, Gansu, the ridges eroded inward an average of 5.32 meters per annum. The result of this valley erosion has been extreme destruction of the surface. Another example is the Suidejiuyüan Mao(Suidejiuyüan Eroded Mesa) district in northeast Shaanxi province where there are 3.47 km of valley length per square kilometer. In the Xingzi River valley of northern Shaanxi province, the valley length density reaches 7.39 kilometers per square kilometer.

As soil erosion increases, soil fertility decreases and the surface area of ruined land increases. Taking the lõess plateau of north central China as an example; of the 1,600,000,000 tons of mud and sand transported by the Yellow River annually, half is relatively fertile surface soil washed off of slopes. Under such conditions the amount of arable land and the per unit area of harvest deceases. As productivity deceases more marginal land is brought into cultivation. The process of opening marginal land has been further increased by the rapid house building boom in the countryside since 1978. As more marginal hilly land is cultivated, soil erosion becomes more serious. This is a vicious downward spiral which has been noted by many geographers. In the marginal hilly areas of China, family planning must be strictly enforced (Huang, 1983). In these areas a slight population increase has serious consequences for the total population. The fact that many of the hilly areas are occupied by minority peoples who are exempt from China's one child population policy means that population control in these regions is not liked to quickly reduce population levels.

FORESTS

The impact of population pressure on forests is well known. United Nations estimates state that the world's forests once covered an area of 7,600,000,000 hectares. By 1862 the total area was reduced to 5,500,000,000 hectares. By 1975 the world total was reduced to 2,600,000,000 hectares. Recent estimates suggest that the world's forested areas will continue to be spared because they are largely inaccessible to man.

China's forest resource have long been exploited and her rate of forest coverage is low. China's forest cover is now estimated to be 120,000,000 hectares or 12.7% of the country's surface area, giving a total timber capacity of 216,000,000 cubic meters. Compared with the world average forest coverage of 22%, China's figure is quite low. In terms of population, China only has 0.13 hectares of forest per person with a timber capacity of 10 cubic meters per person. These figures are again quite low when compared with world averages of 1.46 hectares of forest or 65 cubic meters of timber capacity per person. China's per capita forested area is only 1/11 of the world average and her per capita timber capacity 1/6.

There are several general reasons why China's forested area is being reduced. The primary reason is overcutting. Trees have been cut at a faster rate than they have been planted. Only 20% of china's forests are artifical. In recent years cutting has been taking place at a 10% faster rate than her forest growth and exceeds the rate at which China should cut by 40% to 43%. Based on these figures, China's forest resources are dwindling annually by 2% to 3%. Many areas of the country are showing faster reductions than these average forest cover reductions. For example the upper portions of the Min River valley in northern Sichuan had a forest cover of 30% in the early 1950s. Today the coverage is roughly 18. 8% of the valley's total area—- a 1/3 reduction in total forest cover in 35 years. In the same period the forest cover of Yunnan province has been reduced from 60% to 30% and Fujian province has dropped from 65% to roughly 20%.

Much of this overcutting can be related to the attempts to open up new areas for cultivation. For instance after the Sanjing plain in northeastern China was first settled in large numbers in 1968. Within ten years several forests were reduced in area by 1/4 to 2/3. Hainan Island has had its forested area reduced by 1,110,000 hectares in order to make room for rubber plantations. In the Ziwu mountain region of Gansu provice over the last 30 years more than 40% of the forested area has been destroyed and there are more than ten large farms within the formerly forested area.

Slash and burn techniques are still used by some minority peoples in mountainous tropical and semi–tropical southwestern China. On Hainan Island anywhere from several ten thousand *mu* up to over 200,000 *mu* are cultivated by swidden (slash and burn) methods annually. It is estimated that slash and burn cultivation annually destroys 210,000 cubic meters of timber. Often the timber is left to rot on the hillsides as there is no way to economically remove it.

China also uses a lot of timber as fuel. In Xinjiang Saxiul (huyang) forests, Euphrates poplar (suosuo) forests, and all sorts of shrub have been destroyed. In some places, even roots and bark have been picked up as well. Forest fires, especially the major fires in western Heilongjiang and eastern Inner Mongolia during the summer of 1987 have further reduced China's forest cover in one of the country's most important timber region. China has indicated that some of these fires were started by forestry workers who were not following proper safety precautions.

The above–mentioned reasons for the depletion of China's forests are all interrelated— China is overpopulated, her forests are too few and unevenly distributed, and management has at times been lax on safety regulations. As it is, China's problem is exasperated by low levels of timber per capita. The world annual per capita consumption of timber is 0.65 cubic meters whereas China's annual consumption is only 0.05 cubic meters per person (the Chinese figure does not include firewood). As the construction boom continues, the Chinese people's standard of living increases and her population continues to grow, shortages of timber will become even more acute.

A country's forests are different from its land resources. Land is a fixed resource for which it is difficult to find a substitute. On the other hand, forests are renewable and substitutes can be found for various uses of timber. If China were to follow policies of frugality combined with reforestation than she could slow the pace of forest depletion. However, this is a difficult pill for the Chinese peasant to swallow, and consequently a difficult policy for the Chinese government to enforce. Eventually the price structure must be adjusted to raise to the value of timber to levels which will reduce consumption.

Forests have multiple positive effects on the environment : they help the soil to retain moisture, help reduce soil erosion, reduce the possibility of landslides, have a positive effect on air quality, and provide a refuge for birds and other wild animals. The loss of these positive effects can produce serious environmental consequences.

We have already noted the effects of soil erosion on the environment. However, it should also be noted that the felling of trees in the upper reaches of river catchments can have serious consequences downstream. This problem has become extremely serious along the Yellow River. The provinces along the Yellow River have only 0.3% to 10.9% forest cover and the lower Yellow River bed is now rising approximately 10 centimeters annually (Li, 1986). In places the river bed is already 10 meters above the surrounding flood plain and only kept from overflowing by the maintenance of dykes. In the past 35 years overcutting of trees along the upper Yangtze River has also increased rapidly. The river bed along the Hequ section of the Jing River which flows into the Yangtze river in Hubei province has also risen rapidly due to siltation reducing that river's capacity to take up Yangtze River flood waters. Even more obvious have been changes that have occurred in Dongting Lake along the Yangtze River between Hunan and

Hubei provinces. More than 1,400 hectares of new sand banks appear along the lake's surface annually as it silts up. Dongting Lake's surface is already 3 meters above the land beyond its dykes. Moreover, the surface area of the lake has shrunk from 3915 sq km in 1954 to 2740 sq km in 1978. Originally Dongting Lake was China's largest freshwater lake. Now it is the country's second largest freshwater lake.

Loss of forest coverage has also affected China's climate. For example Jilin province had 643 mm annual precipitation averages in the 1950s. By the 1970s the average had dropped to 575 mm per annum. In neighboring Liaoning province where forest cover did not change that greatly between 1950 and 1970, precipitation levels did not show such drastic changes (Li, 1986). Although it is possible that factors may be causing these discrepancies, change in forest cover is the most likely reason.

As forests are felled, many species of rare animals become rarer and many become extinct. As natural forest are destroyed on Hainan Island, the number of many species of trees and tropical forest fauna rapidly are being depleted. The natural forest cover of Hainan Island has dropped from 25.7% in 1955 to 11.9% in 1979—an annual decrease of 2.6% for the whole period.

The forest cover of Xishuangbanna in southern Yunnan has declined from 55% in the early 1950s to below 30% by 1987. The number of wild animals in Xishuangbanna have declined at an equally rapid pace. Taking deer horns as an example, the rate of sales has dropped by 82% from the 1960s to 1970s which suggests that deer herds have decreased dramatically. Based on data from Xishuangbanna it appears that every year natural forest cover is reduced by 10,000 mu. Every year a biological species disappears and another species comes under threat of extinction in Xishuangbanna. It is estimated that Xishuangbanna has lost 500-800 of its biological species since 1957.

The above represents only a partial and unsystematic discussion of the problem. It is clear, however, that over the past 35 years as population has increased there has not been enough awareness of the complexity of environmental problems nor an appropriate policy to stem the pressure put on vegetation and fauna. Moreover, the extinction of species is a phenomenon which is irreversible.

INLAND WATER RESOURCES

Water, like a forest, is a renewable resource. Many Chinese, like the British, believe that " water is an inexhaustible resource, which can be used wthout running out. " Such a concept, however, is far from the truth. Although there is a huge supply of water on the earth's surface (1,400,000,000 cubic kilometers) most of it is seawater with fresh water occupying 2.7% of the total. Moreover, much of this fresh water is locked up in the polar ice caps and mountain glaciers. The water found in rivers, fresh water lakes, the soils, and in underground aquifers accounts for only 0.5% of the world's water.

As population increases while urbanisation and industrial growth continues apace, mankind is becoming more and more aware of an impending water crisis. Water distribution on the earth's surface is far from even with over half of the land surface now lacking water resources. Many of those areas most seriously lacking water are in developing countries. The countries of the Sahel and the Horn of Africa are already experiencing serious drought. Egypt and parts of South Asia and North America may experience serious shortages in the near future. It is expected that between 1975 and 2000 world water needs will increase by 200% to 300%. The greatest proportion of this water will be needed for agricultural irrigation. Rapid population growth and deforestation will only add to this water shortage problem. China's total river flow is estimated to be 2,600,000,000,000 cubic meters annually. An additional 771,800,000 cubic meters are available from ground water sources. This gives China close to 2,700,000,000,000 cubic meters of total water capacity.

Despite this large volume of water, China's total water capacity per cultivated area is only 1/2 the world average. Because China's water resources are unevenly distributed both areally and temporally, water shortage problems are all the more important. The levels of precipitation over much of China are influenced by monsoonal winds with significant seasonal and annual variations. Over 60% of the precipitation comes in 3 or 4 months of the year and much of this comes in rapid bursts of heavy rainfall. Great annual variation means that some years China is faced with excessive eroding and in other years, drought. Even more significant is the fact that China's rivers go through several years of high water followed by several years of low water levels. This problem is particularly serious in north China. Drought and flooding have made agricultural production in China unpredictable.

As previously mentioned, water resources in China are not evenly distributed areally. Roughly 1/2 the country gets under 400 mm of precipitation per annum. The Yangtze River catchment and areas to its south have 82% of China's total volume of water flow but only contain 36% of the cultivated area. In contrast, the Yellow River, Huai River and Haihe River catchment areas in north China proper have only 8.4% of the total national volume of flow, and each *mu* of farmland in this northern area has only 16% of the national average of water. Underground water resources are also unevenly distributed. Where there is a lot of surface water there is also a lot of groundwater and vice versa. For example, the drier northern provinces of Shanxi, Hebei, Shandong and Henan have 1/4 of China's arable land but only 1/10 of the nation's groundwater.

China's flood and drought problem have forced the country's leaders for centuries to stress construction of public hydraulic works in order to maintain peace and stability. Since 1949 the government has also invested a tremendous amount of capital in such projects. For example an estimated 165,000 kilometers of river embankments and 86,000 reservoirs have been constructed. In addition river courses have been straightened and irrigation projects completed so that China's basic water problems are under control.

China's population, however, has grown rapidly since 1949 and there has been an increase in the urban population as well as the amount of water used for irrigation. This has meant a shortage of water, especially in north China.

China's per capita annual water resources are equivalent to 2,700 cubic meters which is only approximately 1/4 of the world's average (approx. 10,900 cu m). In the Hai He and Luan He Rivers catchments which include the cities of Beijing and Tianjin, the per capita figure is only 298 cubic meters, only 1/9 of the national average. The arable land of these catchments is 11% of China's total, whereas its water resources are 1.5% of the national total. There are only 172 cubic meters of water for each arable *mu*; 1/10 of the national average. Hence Beijing and Tianjin face potential water crises in the near future.

In order to increase agricultural production, China's irrigated area has almost trebled from 240,000,000 *mu* (16,000,000 hectares) in the early 1950s to roughly 700,000,000 *mu* (47,000,000 hectares). Irrigation water now accounts for 84% of the total water used.

The tremendous increase in water use has led to overexploitation. For example the overexploitation of surface water has caused a few rivers and lakes to dry up whereas overpumping of groundwater has caused aquifers to dry up.

The Tarim River in Xinjiang is China's largest inland draining river. At the end of the 19th century it was possible to navigate the river in a small wooden boat between Markit (Maigaiti) and Tikanlik (Qikelike) over 800 kilometers downstream. By 1958 the river flowed into the Taitema Lake to the north of Qarkilik (Ruoqiang), which represents a shrinkage of length. From the 1960s water form the Tarim River has been used for irrigation on a large scale, and water in the lower reaches was reduced. Aral (Alaer) Station in the upper reaches has an annual flow rate of 4,980,000,000 cubic meters whereas Kala Station in the lower reaches only has 950,000,000 cubic meters per annum. From Kala the river flows into the Daxihai Reservoir. Below Daxihai there sometimes is outflow as far as Yengisu (Yingsu). Below Yengisu there is no flow at all. From Alakan it is now difficult to even find the Tarim River bed as it is buried in sand. Lop Nor used to be Xijiang's most famous lake. In 1934 the lake's surface area was estimated at 1,900 sq km. By 1962, however, the surface was reduced to only 530 sq km. Today since the Tarim River no longer flows into Lop Nor it is completely dry. Manasi Lake had a surface area of 550 sq km in 1958 with a water depth of 5 to 6 meters. Today, Manasi Lake is completely dry. Aibi Lake has shrunk from 1070 sq km in 1958 to 570 sq km. Other lakes such as Aiding Lake and Buluntuohai have also shrunk as a result of irrigation. Numerous similar examples can be found, especially in northwest China.

North China's cities rely heavily on groundwater. As these cities grow and industrialize, agricultural water needs also increase. The strain on underground water is now greater than the replenishment rate. Prior to 1970 the ground water supply in the western suburbs of Beijing was plentiful. Since 1970 the water table has been dropping at a rate of 0.5–1.5 meters per annum. This has produced a regional funnel in the water table. Comparing levels from the same seasons during the years 1970 and 1980, we find that in the most concentrated region of extraction, the water table has dropped by 10 to 15 meters and in the surrounding area by 5 to 10 meters. The water levels have become so low in the eastern Beijing area that wells have to be dug 20–120 meters before pumpable water is reached. Since 1959 the pressurized water depth has been lowered by one to two meters a year. In general wells now must be dug to a depth of 20 to 30 meters and at the funnel head 40 meters.

Huhehaote and Baotou in Inner Mongolia also have shrinking water tables. The tables have dropped over 20 meters in the last 30 years. Wulumuqi in Xinjiang has had its water table drop by up to 13.4 meters.

In many places where water is used extensively for irrigation, the water tables have also dropped. It is estimated there are 2,000,000 wells on the North China plain alone. Well–fed irrigation occupies roughly 60% of the plain's irrigated area and is eating into the ground water supply at an alarming rate. There are now more than 30 funnels in the North China plain water table. In these funnel areas it has become increasingly difficult to drill wells and this has resulted in financial loss. The Turfan Basin of Xinjiang also has Qanat (kanr) well irrigation systems. However, as the water table has dropped over the last 10 to 20 years, approximately 1/3 of these Qanat wells have dried up.

Besides the above–mentioned overexploitation of water resources, filling in of lakes to increase arable acreage has led a reduction of China's surface water. In the 1960s and early 1970s a lot of China's smaller lakes were filled in. Taking the Jianghan plain on the Shaanxi–Hubei border as an example, there were 1,066 lakes on the plain in the early 1950s. Today, however, there are only 326 with the total water surface reduced from 8,330 sq km to 2,379 sq km.

Of China's major lakes, Dongting Lake's surface has shrunk by 2,357,000 *mu*; Boyang Lake by 1,190,000 *mu*; and Tai Lake had 230,000 *mu* filled in between 1969 and 1974. Hong Lake in northern Hubei province has shrunk by 370,000 *mu*. Since 1956 Damai Lake in Inner Mongolia shrunk by 1,600,000 *mu*. These reductions have resulted in reduced inland fish catches and have reduced the flood controlling capacity of those lakes attached to river systems.

COUNTERACTIVE POLICY

Above we have introduced various forms of environmental degradation which have occured over the past 35–odd years. Face with these problems, China is now formulating policies to combat them. There are three foci to environmental policy in China: (1) to improve environmental education, (2) to improve environmental management, and (3) to actively reduce population growth. As the third foci is part of larger economic policy our efforts here shall concentrate on the first two foci.

As secondary and tertiary education is not as widespread in China as in most developed countries many Chinese do not understand how they personally can reduce pollution and environmental degradation. Many have little idea how their actives affect the environment around them. Especially in the post–1978 period with emphasis on economic growth, the basic attitude of many people can be described as exploitative. Some policies in the past were put forward without careful analysis of the consequences. Often quick returns on agricultural production were all that was emphasized.

The approach now planned is to promote grass roots environmental education. Besides stressing the importance of environmental protection itself, workers in this field must convince people that environmental protection is in their own economic interest. An enviromental newspaper–*zhongguo Huanjingbo*, was started in the mid–1980s and subscription is compulsory for schools and government organizations. Environmental and subsription is compulsory for schools and government organizations. Environmental and birth control propaganda can be seen all over China.

In China science, technology, and management are now regarded as the " three great factors" in the modernization drive. Although all three overlap to some degree, science and technology can be seen as one and the same. In this sense management is just that more important. It is seen as essntial for proper utilization of technology. In particular management is seen as important in environmental protection. The Chinese are aware that environmental problems in countries such as Britain have been reduced, only after environmental protection laws and environmental ministries were established.

China's environmental problems have been exasperated by a lack of management rigour. Environmental protection units did not appear in any significant numbers until the 1970s and it was during the 1970s environmental laws first appeared. These early laws included the Erosion Protection Act, the Forest Protection Act, and the Forest Law of the People's Republic. Although these represented a beginning, they were far from adequate both in content and the government's ability to enforce. In the 1980s a spate of laws were created to fill that gap and better attempts were made to enforce them. There are, however, still problems with the government's inability to enforce these laws, particularly in peripheral regions with fragile environments.

In terms of land use, recent polity stresses using land in the most quickly profitable and unfortunately to a lesser extent, environmental manner. Agricultural land policy now does stress use based on soil type and ease of plowing the land. Some land is to be taken out of cultivation, in particular sloping hillsides and land easily desertified. However, this will only be possible if these agriculturalists can be found some other employment. Any of this marginal land freed up is to be turned into forest or pasture. Opening to cultivation or pasturage of marginal lands, especially in arid or semi-arid regions should be prohibited.

In forestry, emphasis will be put on increasing the number of trees planted and on insuring that the saplings live. The current natural forestry bases, the Daxinganling Mountains in Heilongjiang and the forests of Sichuan must be preserved as forestry bases. They are needed not only for their economic benefit but also for the positive effect they have on the natural environment. It now remains to be seen what will be the impact of the Daxinganling forest fires of 1987. In the warm moist south of China it will be necessary to create artificial forests. These will be necessary to meet the ever growing demands for household fuel. In the north, as previously mentioned, the so–called " Great Green Wall " is being created to reduce the negative environmental impacts caused by a lack of vegetation. Reports indicate that forest cover levels have improved in the northwest, northeast and north China from a low of 4% to 5.9% (Li, 1986).

In terms of water resources the government is now trying to establish and enforce water quality standards. New methods of saving water in urban areas, industry and agriculture are being introduced. Here most effort concentrates on water saving in newly established plant with older industries and water networks modified where funds are available. At the same time some effort is being devoted to creating new hydrological projects which hopefully will reduce drought, flooding and salinization–alkalinization.

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