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## Land Use Dynamics and Policy Implications in the Jinghe Watershed of Western China: A Critical Assessment from Local Perspectives\*\*

### ABSTRACT

*This article provides insight into land use dynamics and policy implications from local perspectives in the Jinghe watershed of northwestern China. Spatial and temporal data were used to analyze the land use changes. A survey was conducted to investigate farmers' perceptions and the factors causing these*

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Due to the nature of this article, the *Natural Resources Journal* was not in a position to verify many of the sources cited. Nonetheless, it is thought that the information and perspectives presented will be of interest to the reader and of importance in the ongoing dialogue regarding land use issues. For questions regarding the article or the source materials, please contact the authors using the information provided in the authors' footnote.

*changes. A transition matrix and weighted index were used to make quantitative comparisons between land uses and farmers' perceptions from 1980 to 2003. The results show that land use changes occurred predominantly in forests and grasslands. Land use continues to shift between agricultural land, grasslands, and forests. Governmental policies, market demand, personal willingness, and a desire to conserve land resources are the primary driving forces behind changes in land use. From this research we conclude that a comprehensive resource conservation strategy should build resource conservation into policy making, institutional reforms, local participation, indigenous technology, population control, and ecological migration.*

## I. INTRODUCTION

Changes in land use play an important role in global environmental change because land use changes clearly affect sustainability, biodiversity, and interactions between the earth and atmosphere. Jinghe is a mountainous watershed located in northwestern China (covering 31 counties of the Ningxia Hui Autonomous Region, Gansu province and Shannxi province). Jinghe is strategic to the development of northwestern China, providing important water for irrigation of the Guanzhong Plain, the food bowl for the country downstream. The climate of the Guanzhong Plain varies from arid to semi-arid to humid areas. It links the marginal regions of the northwest with those of the middle part of the country. The watershed is a unique combination of mountainous land, deep soils, and an arid climate. It is ideally suited for grass and timber production and drought resistant crops such as winter wheat, millet, and herbs. The physical landscape of the watershed has undergone constant change. Of all these changes, changes in land usage have been the most ubiquitous.

In recent years, population growth has increased the impact on land resources. Impact due to increased demand for water and agricultural products has drawn increasing attention from Chinese academics, planners, and decision makers. During the decade from 1993 to 2002, China's population increased annually by about 11.2 million people.<sup>1</sup> During approximately the same interval, arable land area decreased dramatically. According to the Ministry of Land and Resources, in the years between 1987 and 2000, nearly 10 million hectares

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1. *Population and Its Composition, 2003*, CHINA STAT. Y.B. tbl.4-1, at 97, <http://www.stats.gov.cn/english/statisticaldata/yearlydata/> (search for "2003" at "Population" hyperlink).

(ha) (0.70 million ha per year) of cropland were converted to urban, forest/pastures, and horticultural lands or destroyed by disasters. Per capita arable land decreased by 23 percent from 1980 to 2000.<sup>2</sup> This swift loss of farmland is generally due to the combined effect of rapid economic development, population growth, urbanization,<sup>3</sup> agricultural restructuring, natural disasters, and land degradation.<sup>4</sup>

Population growth has also been observed in the Jinghe watershed. Population increased by 275 percent from 1949 to 2002, while per capita arable land decreased by 67 percent.<sup>5</sup> In the Guyuan district, in the upper reaches of the watershed, the population density was 29 people/km<sup>2</sup> in the early 1950s, already exceeding the threshold of 7 to 20 people/km<sup>2</sup> defined by the United Nations for arid and semi-arid regions.<sup>6</sup> Population density increased to 112 people/km<sup>2</sup> in 2003, putting even more pressure on limited land resources.<sup>7</sup> Farmers in the area have expanded their production activities to the mountainous slope land over the past decades to cope with the increased competition for land. Although this land could no longer be used for farming it was still possible to use this land to complement the food supply.

Intensive land use in such marginal areas has led to land degradation and vegetation destruction in many parts of the region and has also adversely impacted the environment. Many serious problems affect the region including soil erosion<sup>8</sup>, insufficient water supply,

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2. ADMIN. CENTRE FOR CHINA'S AGENDA 21, FA ZHAN DE JI CHU: ZHONGGUO KE CHI XU FA ZHAN DE ZI YUAN, SHENG TAI JI CHU PING JIA [THE BASE OF DEVELOPMENT: EVALUATION OF NATURAL RESOURCES AND ECOLOGICAL CONDITIONS IN CHINA] 108 (2004).

3. A study of 24 large cities indicated that urbanized areas grew at an annual rate of 3.4 percent, whereas the urban population grew at a rate of 2.6 percent between 1950 and 1980. This is compared to annual growth rates of 4.5 percent and 2.3 percent for urbanized areas and population since 1980.

4. Minghong Tan et al., *Urban Land Expansion and Arable Land Loss in China – A Case Study of Beijing-Tianjin-Hebei Region*, 22 LAND USE POL'Y 187, 187 (2005).

5. 2003 STAT. Y.B. OF GUYUAN 12 (Statistics Bureau of Guyuan District).

6. *Id.* at 12–18.

7. Lin Zhen et al., *Land Use Dynamics, Driving Forces and Policy Implications in Jinghe Watershed of Western China*, 27 RESOURCES SCI. 33, 33–37 (2005).

8. About 91 percent of the watershed is affected by soil erosion. About 0.26 billion tons of sand were carried annually from the Jinghe watershed to the Yellow River over the past 44 years. See generally Yellow River Conservancy Comm'n, Yellow River, [www.yellowriver.gov.cn/eng](http://www.yellowriver.gov.cn/eng) (follow "Thesis" hyperlink to index of technical papers) (last visited Jan. 31, 2007). This translates to a rate of 5,980 tons of sand per km<sup>2</sup> of the watershed. The Yellow River is therefore threatening to become clogged with silt more quickly than originally anticipated. Seasonal variation of sand erosion is observed. During December and January, sand concentrations in the Jinghe river are from 0.23 kg/m<sup>3</sup> to 0.37 kg/m<sup>3</sup>, but increase to 308–332 kg/m<sup>3</sup> during July and August. Shan (2005). Soil erosion mainly occurs on the slopes between July and September each year. Uneven distribution of rainfall, the

shrinking forests and grasslands, and a fragile eco-environment and natural resources. The sustainability of the entire ecosystem is affected by the degradation of natural and environmental resources and the reduced productivity and longevity of these resources. Moreover, local land use changes affect climate change and are significantly impacting biodiversity, water and radiation budgets, trace gas emissions, carbon cycling, and, ultimately, climate at all scales.<sup>9</sup>

Over the past decades, increases in agricultural productivity and soil fertility have been repeatedly studied.<sup>10</sup> These studies emphasize the input-output analysis for increasing agricultural production in the mountainous areas. Other research focuses on theoretical parts of an integrated system of agriculture and forest,<sup>11</sup> causes of deforestation,<sup>12</sup> and change of land use patterns.<sup>13</sup> Little attention has been given either to the recent land use transitions or socio-economic factors involved from the stakeholders' point of view. This is particularly appropriate upstream of the Jinghe watershed where a number of socioeconomic driving forces shape the land use patterns. Moreover, regional planners and resource managers have been slow to deal with land use dynamics because they are "inadequately equipped to analyze both rapid change and gradual evolution."<sup>14</sup>

Farmers' perceptions of land use changes are important since they can be used to guide behavior and decision making. Perception guides behavior and/or decision making because perception is based on goals already achieved and those yet to be achieved.<sup>15</sup> Studies have shown that people's perceptions, attitudes, and preferences explain

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loose structure of sand, segmental topography, wide distribution of slopes and valleys, and human interventions are major causes of soil erosion.

9. P.T. Zhang, *Ecological Reversion of Farmland and Its Influence on Grain Production in Western Region of China* 25 (2002) (unpublished Ph.D. dissertation, Chinese Academy of Sciences) (in Chinese).

10. S.W. NIU, *DESERTIFICATION AND ECOLOGICAL AGRICULTURAL ENVIRONMENTAL CONSTRUCTION IN WESTERN CHINA* 152 (2001) (in Chinese).

11. H. Breman & J.J. Kessler, *The Potential Benefits of Agroforestry in the Sahel and Other Semi-Arid Regions*, 7 EUR. J. AGRONOMY 25 (1997).

12. Keith Kloor, *Returning America's Forests to Their "Natural" Roots*, 287 SCIENCE 573 (2000).

13. Michael R. Muller & John Middleton, *A Markov Model of Land-Use Change Dynamics in the Niagara Region, Ontario, Canada*, 9 LANDSCAPE ECOLOGY 151, 151 (1994).

14. Daniel J. Marcucci, *Landscape History as a Planning Tool*, 49 LANDSCAPE & URB. PLAN. 67, 67 (2000).

15. Rajan Kantilal Gengaje, *Rural Development in Villagers' Perception: Analytical Approach to Strengthening the Interface Between People and Officials—The Case of a District in India* (1996) (unpublished Ph.D. dissertation, Asian Instit. of Tech.).

differences in farmers' land use activities.<sup>16</sup> Most importantly, farmers are the main actors in land management rather than planners, decision makers, and researchers. Recognition of such aspects will help to shed light on the relationship between land use changes and socio-economic factors.

The purpose of this study was to understand and quantify land use dynamics in three representative counties (Guyuan, Jingyuan, and Longde) from the early 1980s to 2003. The counties are located upstream of the watershed (Figure 1) and cover 348,900 ha, with a total population of 817, 863. Seventy percent of the counties are rural with an average landholding of 0.18 ha per capita.<sup>17</sup> We chose these areas because (1) they are dominated by mountainous agriculture; (2) they are similar in terms of geographic and socio-economic situation and land use patterns and could represent the general situation of the entire watershed; (3) the land use changes are mainly dominated by human activities, and severely affect ecological conditions downstream; and (4) while research has been done relevant to land uses and driving forces in the area, these results could be applied to the areas with similar environmental and socio-economic conditions. Within this context, the objectives of this study are to quantitatively document trends in land use structure. To further elucidate the links between human and ecological processes, the research also examines the interaction between human geography and land use. We will elicit a picture of socioeconomic drivers of land use change as perceived and graded by farmers. These drivers are an integral component to understanding why spatial patterns change and the resulting policy implications. We believe that a better understanding of rural land uses offers significant opportunities to improve land use planning and development within existing conservation practices and programs.

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16. SHARMISTHA SWAIN & JAYANT KUMAR ROURAY, *ASIAN INST. OF TECH., MICROWATERSHED LAND USE PLANNING AND MANAGEMENT IN INDIA: A GIS-BASED APPLICATION* 122-23 (Asian Inst. of Tech. 2002).

17. STAT. BUREAU OF GUYUAN CITY, *ECONOMIC COMPONENTS OF GUYUAN* 46-47 (2005).

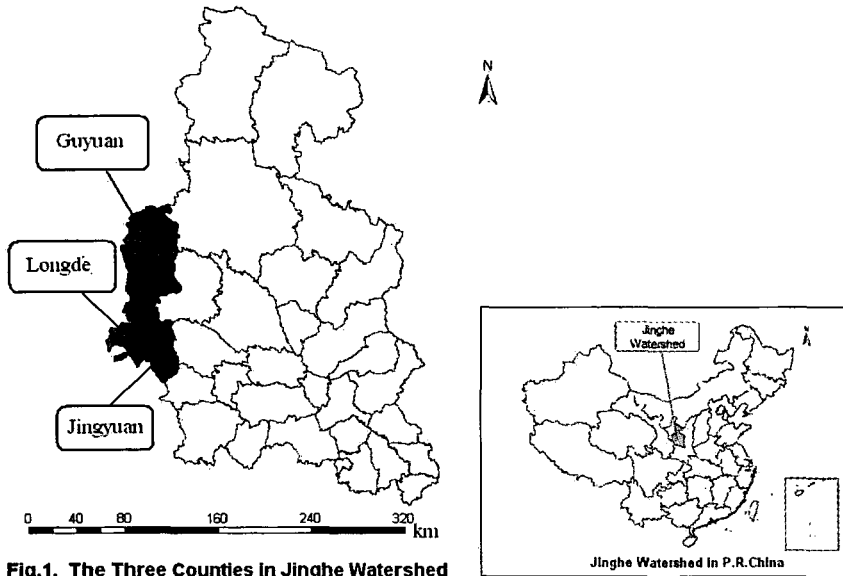


Fig.1. The Three Counties in Jinghe Watershed

## II. METHODS

A spatial database depicting the land use patterns of Guyuan, Jingyuan, and Longde counties for 1980, 1995, 2000, and 2003 was developed using a 1:100,000 scale land use map derived from Land Sat TM satellite imagery. Survey data<sup>18</sup> from the selected counties was used. The land use classification system that was developed by the Chinese Academy of Sciences<sup>19</sup> was adopted to represent the predominant land use patterns and six land use categories: (1) Arable land, (2) forest land (natural and planted forests were not distinguished), (3) grassland (natural grass ecosystems and managed pasture were also not distinguished), (4) water bodies, (5) urban and built up land, and (6) barren land (Table 1). Data was also gleaned from topographic maps, documents, and publications.

18. Survey Data were provided by the Resource and Environmental Data Center of the Chinese Academy of Sciences.

19. J.Y. Liu et al., *Recent Land Use Changes and Spatial Analysis*, 32 CHINA SCI. 1031, 1034 (2002).

**Table 1. Land Use Categories in China<sup>20</sup>**

Land Use Categories	Sub-Categories
1. Arable land	Cropland, orchards, etc.
2. Forest land	Deciduous, evergreen, and mixed
3. Grassland	Herbaceous and shrub-brush land
4. Water body	Stream, lakes, estuaries
5. Urban and built-up land	Residential, industrial, etc.
6. Barren land	Saline or acidic land, exposed rock, strip mines, etc.

Farmers were surveyed between September and October 2004 to gather information regarding farmers' perceptions and attitudes toward land use changes, their participation in the land management project, and especially factors affecting the changes. One village from each county surveyed was chosen to represent the general geographic and socio-economic situation in the county. Forty percent of all households in each of the three sample villages were surveyed.

In order to avoid leading statements and loaded responses, farmers were asked to give their opinions of five major predefined factors affecting land use. The factors were identified based on discussions with local agricultural extension agents and the Committee of Planning and Economy, the Committee of Science and Technology, and a preliminary review of additional materials such as documents, reports, and publications. Then farmers were asked their opinions of the factors and to weight them on a five-point scale. Zero points were given where there was a disagreement.<sup>21</sup> Both primary and secondary information were applied to support farmers' perceptions.

The transition between land uses was calculated using a transition matrix derived from ArcView's "Tabulate Areas" function. With three dominant land use changes, there are nine possible land use changes because the matrix represents all the multi-direction land use changes between all the mutually exclusive land use categories. The matrix cell values are derived directly from spatial data and are expressed as proportions. Assuming the sample is representative of the region, these proportional changes can be interpreted as the probability of land use change over the entire sample area, thus forming the transition matrices. Socio-economic data was analyzed using SPSS for Windows<sup>22</sup> software. Farmers' perceptions of factors affecting land use

20. *Id.*

21. See Sanzidur Rahman & Gopal B. Thapa, *Environmental Impacts of Technological Change in Bangladesh Agriculture: Farmers' Perceptions and Empirical Evidence*, 28 *OUTLOOK ON AGRIC.* 233, 233-35 (1999) (detailing a similar research method used in Bangladesh).

22. SPSS refers to Statistical Package for the Social Sciences.



changes were ranked by weighting responses to each factor. The composite perception was obtained by computing an index as explained below.

$$\text{Index} = (F1W1 + F2W2 + F3W3 + F4W4 + F5W5 + F6W6)/N$$

Where F1 = very high, F2 = high, F3 = medium, F4 = low, F5 = very low, and F6 = disagreement. W1 to W6 represent corresponding weights applied to different ranked classes as mentioned above. Specifically W1 = 1.0, W2 = 0.8, W3 = 0.6, W4 = 0.4, W5 = 0.2, and W6 = 0. N = sample size (90 households).

### III. RESULTS

#### A. Land Use Proportions and Transitions

Changes in coverage by land use categories are shown in Table 2 for 1980, 1995, 2000, and 2003. Between 1980 and 1995, arable land increased by 2.2 percent, forest land increased by 0.54 percent and grassland decreased 2.68 percent. Other studies have credited this increase in arable land primarily to farming in areas not suited for agriculture or pasture.<sup>23</sup> The increase in arable land is also the result of the conversion of grassland (6.07 percent) and forest (0.61 percent) to agricultural uses (Table 3). This reflects the implementation of household responsibility systems in the early 1980s, which encouraged farmers to expand their farming activities to all possible arable lands. Grasslands were the target of farmland expansion because grasslands are near farmland and are easier to convert to farmland than is forest land.

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23. P.T. Zhang, *Ecological Reversion of Farmland and Its Influence on Grain Production in Western Region of China* (2002) (unpublished Ph.D. dissertation, Chinese Academy of Sciences) (in Chinese).

**Table 2. Proportional Area in Each of the Land Use Categories for the Study Counties<sup>24</sup>**

	1980	1995	2000	2003
Arable	41.51	43.71	43.90	31.71
Grass	45.61	42.93	42.66	46.11
Forest	9.94	10.48	10.40	19.14
Water body, urban and built up, barren land	2.94	2.88	3.05	3.04
Totals	100.00	100.00	100.00	100.00

Between 1995 and 2000, land use distributions remained nearly constant, with a very slight increase in arable land (0.19 percent) (Table 2) and small decreases in grassland (0.50 percent) and forestland (1.65 percent) (Table 3). Arable land and grassland uses changed the most in the study counties, mirroring the trend seen across China. Arable land increased  $17.67 \times 10^5$  while grassland and forestland decreased by  $2.66 \times 10^6$  ha across the country. Regionally, arable land increased  $4.36 \times 10^5$  in northwestern China's arid and semi-arid region. Grassland decreased  $9.28 \times 10^5$  ha with half of the grasslands converted to arable land while the other half was reduced to desert.<sup>25</sup>

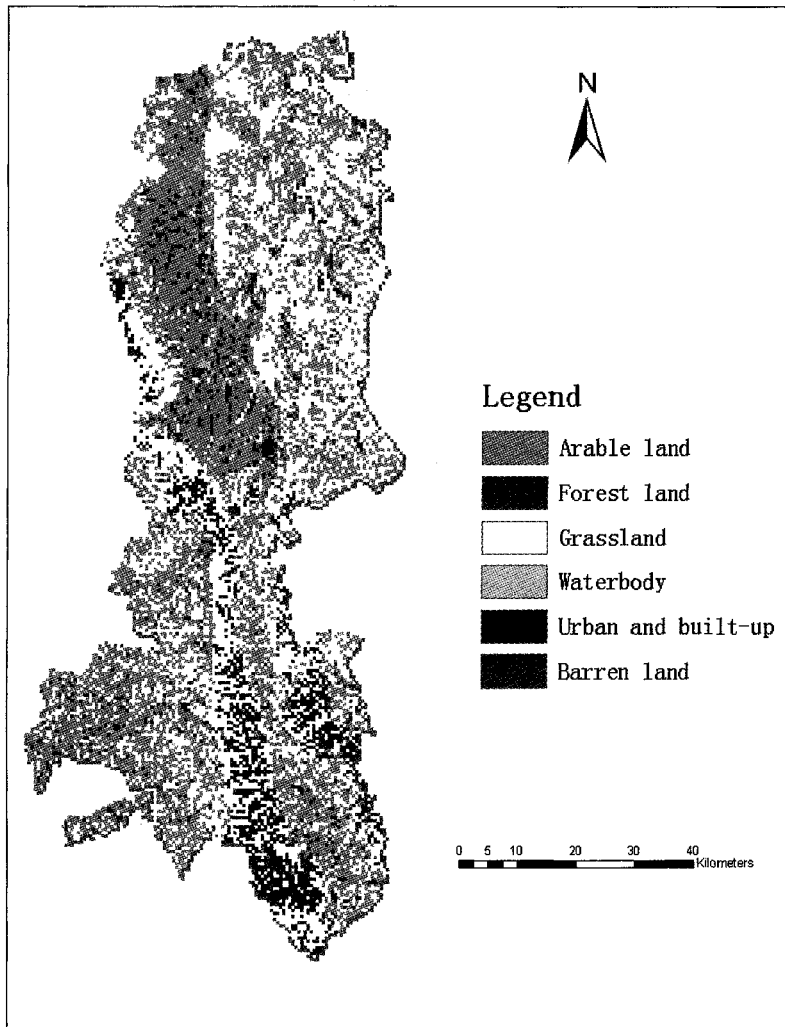
**Table 3. Totals for Each Type of Land Use Transition for Each Time Period**

	1980-1995	1995-2000
Arable-Arable	98.41	99.86
Arable-Grass	0.66	0.06
Arable-Forest	0.93	0.08
Grass-Grass	93.21	99.23
Grass-Arable	6.07	0.50
Grass-Forest	0.72	0.27
Forest-Forest	98.73	97.98
Forest-Arable	0.61	1.65
Forest-Grass	0.66	0.37

Calculated using ArcView function of Tabulate Areas.

24. WORLD DATA CTR. FOR RENEWABLE RES. & ENV'T, CHINESE ACADEMY OF SCI. (2004); see <http://www.wdc.cn/wdcdrre>.

25. Liu et al., *supra* note 19, at 1034.



**Figure 2. Land Use of the Study Counties**

In 2003, the major land use categories remained arable land, grassland, and forestland (Figure 2). However, the proportion of these land use categories had changed. Arable land area decreased by 12 percent (down to 32 percent of total land use) between 2000 and 2003. Grassland increased by 3.5 percent (to 46 percent) and forestland increased by 8.7 percent (to 19 percent) during the same three-year period. Forest land increased from 0.09 ha per capita in 2000 to 0.28 ha in 2002, and grassland increased from 0.14 ha per capita to 0.31 ha. These

changes reveal a consistent increase in grassland and forestland at the expense of arable land since 2000.

Deterioration of grasslands in dry land systems is a serious problem in China. Climate change and human activities have changed ecological landscape patterns, which has contributed to the degradation of grasslands in the arid regions of western China.<sup>26</sup> Between 1986 and 1996, 1,074,000 ha of grassland were converted for agricultural production in northern and western China as a result of economic development policies and the unavailability of proper management plans in the country.

Empirical case studies reveal similar changes in land use in other countries. Research on deforestation and reforestation finds that sometimes forests get "worse" before they get better.<sup>27</sup> However, the overall conclusion is optimistic. It is possible for forest areas to increase while the population and economy grow. As evidenced in France, continuing deforestation is not an inevitable consequence of population growth and economic development.<sup>28</sup>

### B. Factors Affecting Land Use: Assessment from the Farmers' Perceptions

The primary factor affecting land use changes was "government policy at all levels," followed by "market demand," "personal willingness," and "conserving land resources" (Table 4). Farmers' perceptions are supported by primary and secondary sources.

**Table 4. Factors Affecting Land Use Changes<sup>29</sup>**

Factors	Percentage of Total Household (%)	Index value
Governmental policy at all levels	67.5	0.74
Market demand	32.5	0.61
Personal willingness	30.0	0.40
Conserving land resources	15.0	0.38
Others	8.0	0.19

Note: The higher the index, the stronger the perception.

26. Y. Ma et al., *Analysis of the Dynamic Trends of Landscape Patterns in the Arid Regions of West China*, 27 GANHANQU DILI [ARID LAND GEOGRAPHY] 516, 516 (2004).

27. See A.S. Mather & C.L. Needle, *The Forest Transition: A Theoretical Basis*, 30 AREA 117 (1998).

28. See A.S. Mather et al., *The Course and Drivers of the Forest Transition: The Case of France*, 15 J. RURAL STUD. 65 (1999).

29. Field Survey (2003).

Governmental changes in land use policy at national, provincial, and county levels play an important role in China's land use change. Rapid economic development since the economic reforms of 1978 has also changed land use patterns. Beginning in the early 1980s, globalization and economic reforms have caused rapid and dramatic economic growth followed by structural and social changes. In response to the rapid depletion of farmland, the state council passed the "Basic Farmland Protection Regulations" in 1994.<sup>30</sup> These regulations prohibited the conversion of basic farmland to non-agricultural activities. Counties and townships were also required to designate basic farmland protection districts in accordance with provincial farmland preservation plans.<sup>31</sup>

In addition to changes to national economic policies, the household responsibility system of the early 1980s permitted the allocation of public land to individual farm households. By transferring farmland use and management responsibilities to farmers, they were able to derive the full benefit of their efforts. This radical change in the property rights regime stimulated farmers' enthusiasm and production efficiency as they worked to increase their production and income. Often farming was attempted in grass and forestland and dried water bodies, on steep slopes not suitable for cultivation, and in other areas not allocated as basic farmland by the government. This system increased agricultural land while grasslands declined between 1980 and 1995. This shift from grassland to agricultural land did not occur in other provinces of the country. For example, in Shandong, Shaanxi, and Hunan provinces, more land was converted to non-agricultural land use. The most severe declines in agricultural land occurred in more developed areas where economies were growing faster than in the study area. While non-agricultural land use also increased, some of this increase was the direct result of the conversion of agricultural land to non-agricultural use.<sup>32</sup>

Between 1995 and 2000, the number of hectares of grassland and forestland declined while the number of hectares of agricultural land increased slightly due to the higher demand for cultivation and construction.<sup>33</sup> Concern about soil erosion, desertification, flooding, and

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30. Basic farmland consists of: farms for base agricultural products (such as crops, cotton, edible oils, and other high quality products) approved by the government, exploited farmland with high productivity and good irrigation, base vegetable products for large and middle cities, and experimental fields for scientific and educational purposes.

31. STATE DEV. PLAN. COMM'N, THE OVERALL PLAN OF WESTERN REGION DEVELOPMENT AND RELATED POLICY MEASURES 79, 86 (2002) (P.R.C.).

32. George C.S. Lin & Samuel P.S. Hob, *China's Land Resources and Land-Use Change: Insights from the 1996 Land Survey*, 20 LAND USE POL'Y 87, 98 (2003).

33. Zhen et al., *supra* note 7, at 33.

water shortages caused by intensive cultivation on slopes led the State Council to issue the *Circular for Conservation of Forest Resources and Prohibition of Deforestation and Occupation of Forest Land* in 1998.<sup>34</sup> In 1999, the central government updated the *Law of Land Management*, stressing the importance of returning cropland on slopes to pasture (*tuigenghuanmu*) to stop soil erosion. This law has slowed the conversion of forestland and grassland to farmland.

Significant changes in land use were observed between 2000 and 2003. Chinese leaders learned that marginal gains in food production through over-cultivation of slope land in western China were not worth the severe soil erosion and devastating flooding it caused in central and eastern China. In response, the government launched the Sloping Land Conversion Program (*tuigenghuanlinhuancao*), which converted arable slope land to forest and grassland in order to protect ecologically fragile regions.<sup>35</sup> The *Circular of the State Council on Further Carrying out Pilot Projects to Convert Cultivated Land Back into Forestry and Pasture*<sup>36</sup> was another major policy strategy in the development of western regions.<sup>37</sup> The circular stressed converting cultivated land back to forest, designating mountains for reforestation, contracting with individuals to carry out reforestation, and providing grain as a form of relief. In arid and semi-arid areas, the cultivation of drought resistant shrubs and the recovery of native vegetation is most important to prevent erosion. The conversion of cultivated hillsides with severe soil erosion and farmland with desertification is of the highest priority. About four million ha or ten percent of the total cultivated land should be converted based on these regulations and laws. Thirty-eight percent of this land is located in the northwest region and 62 percent is in the southwest region.

In response to aforementioned policies, farmland has been and continues to be converted. By the end of 2000, 14,000 ha of farmland were converted into forest and pasture in eight southern counties of Ningxia Hui Autonomous Region.<sup>38</sup> Virtually all sloped farmland would need to be designated as wooded or pasture in order to meet the conversion target subscribed to by the central government.

Governments around the world frequently regulate land use practices in order to conserve resources and the environment. For example, government action has had a large effect on farmers' land use

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34. STATE COUNCIL, CIRCULAR FOR CONSERVATION OF FOREST RESOURCES AND PROHIBITION OF DEFORESTATION AND OCCUPATION OF FOREST LAND (1998) (P.R.C.).

35. STATE DEV. PLAN. COMM'N, *supra* note 31, at 202.

36. *Id.* at 196.

37. *Id.*

38. GUANGMIN DAILY, 2001.

in Vietnam. A study there investigated the possibilities and the processes of a forest transition and showed a halt to net deforestation and even a slight increase in forest cover over the last ten years.<sup>39</sup> Several state programs promote reforestation, the most recent and ambitious being the "5 Million Hectares Program," aimed at returning forest cover to the 1945 levels. Household Forestry policies also promote transferring the responsibility for forests to local communities and households for better management. In Thailand, the government imposed a logging ban in 1989 in response to floods and mudslides perceived to be linked to deforestation.<sup>40</sup> A study of land use changes in the Middle East finds that government policies rather than local land use practices affect land use and can either increase or decrease degradation.<sup>41</sup>

In addition to government policy, market demand was the second major factor affecting farmers' land use. After the economic reforms of 1978, China's development policy shifted from self-reliance to opening up to the outside world. The central government stressed the importance of developing agro-markets because they ensure financially beneficial demand for products. Farmers are well aware of the market economy and have wide discretion when choosing their production activities. First, market demand is higher for value-added products. For example, based on the market survey done in 2005, forest and animal products such as fruits and meat sell for five to twenty times more than cereal crops such as wheat and millet. Instead of cultivating cereal crops, which have lower economic returns, farmers are switching to more lucrative purposes. Second, higher timber prices have accelerated rainforest exploitation and also encouraged investment in forest plantations.

The third factor affecting land use change is personal willingness to change. Field survey results show that farmers are most interested in the economic benefit of land use changes. Cereal crops such as millet and wheat are resource intensive and not economically rewarding. Farmers are encouraged to convert farmland into forest and grassland by state cash subsidies. The government will also provide farmers with 300 Yuan (1 Yuan=.12 US\$) for medical and educational expenses and 225 kg of cereal crops per year for food consumption for every hectare of farmland

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39. The study was conducted as part of the Economic and Social Research Council's Global Environmental Change Programme, managed by the Department of Geography, University of Aberdeen. See <http://www.sussex.ac.uk/Units/gec/>.

40. P. Hirsch & L. Lohmann, *Contemporary Politics of Environment in Thailand*, 29 *ASIAN SURV.* 439, 439 (1989).

41. See T.T. Nielsen & H.K. Adriansen, *Government Policies and Land Degradation in the Middle East*, 16 *LAND DEGRADATION & DEV.* 151, 151 (2005).

they retire.<sup>42</sup> This subsidy is similar to the income earned by farming and is welcomed by most farmers. Additionally, the field survey showed that farmers are compensated with 1500 kg of grain per year for every hectare of farmland that is returned to forest or pasture. The policy discourages farmers from recultivating retired farmland in the future. So far, the conversion rate from farmland to forests and grasslands has been higher than expected.<sup>43</sup> Conversion of farm land also allows former farm laborers to work in the city and send wages home. According to the survey results from this study, about one third of the labor force from the survey area worked in urban areas, sending home \$120 U.S. per person. Many farm laborers are now working in cities across China. About 150 million rural people migrated to urban areas as migrant workers in 2002.<sup>44</sup> Of these, 9.4 million were rural farm laborers.<sup>45</sup>

The concern for conservation is the fourth most important factor affecting land use changes in the study area. The conversion of agricultural land was one of the primary land use changes. Transitions from arable land to grass and forest were the most frequent changes because farmland was becoming so degraded. Farming on steep slopes leads to serious declines in soil fertility and causes salinization, land degradation, vegetation destruction, and soil erosion. About 96 percent of the total land area of the watershed is affected by soil erosion, and 75 percent out of it is experiencing severe erosion.<sup>46</sup>

Local farmers also thought that land usage changed due to urbanization and the land becoming barren. Although population growth and industry are increasing in many parts of the country, urbanization was not a serious problem in our study area due to geographic location and the lack of natural resources needed for industry.

Farmers' perceptions are important because sustainable land management is based largely on the actions of farmers rather than policy makers, researchers, and extension agents. About eight percent of farmers considered the land use changes to be very good while 73 percent found the changes to be good because the changes can reduce both their workload and the rate of soil erosion while increasing income. About 15 percent of those surveyed had a moderate opinion of the land

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42. STATE DEV. PLANNING COMM'N, *supra* note 31, at 80.

43. J.T. Xu & Y.Y. Cao, *Sustainable development issues in converting cultivated land to forests and grassland*, 2 INT'L ECON. REV. (Chinese) 56, 59 (2002).

44. Ministry of Agric., Survey (2003) (P.R.C.).

45. *Id.*

46. MGMT. COMM'N OF THE YELLOW RIVER, DEVELOPMENT PLAN OF JINGHE WATERSHED 18 (2004).



use changes. They were concerned with the impact on grain production and the sufficiency of food production after the conversion of farmland into forest and grassland. Instability of the market for agricultural, forestry, and livestock products was also cause for concern. Additionally, there was concern about their limited skills and knowledge of the proper management of forests and grasslands. Field surveys conducted in Gansu province showed that the public is very interested in participating in decision making concerning the ecological reversion of farmland.<sup>47</sup> They are also anxious about the impact that the ecological reversion of farmland will have on their lives. Thus, it is important for the government to address public interest in the relationship between the ecological reversion of farmland and its impact on farmers' standard of living.

### C. Farmers' Preference on Land Use

The farmers surveyed were primarily concerned with the need to feed a growing population on limited arable land. Per capita arable land is shrinking. In Guyuan, Longde and Jingyuan counties, the populations have respectively increased 40 percent, 20 percent, and 60 percent between 1980 and 2004 while per capita arable land has decreased by 31 percent, 39 percent, and 48 percent respectively over the same period.

Consequently, the majority of those surveyed wanted the land to be dominated by food crops to ensure food security. The remaining land should be reserved for forest and grassland. Ninety-four percent of respondents preferred the plains to be primarily farmed for grains with the remainder of the plains cultivated for cash crops such as mulberry (used in the silk worm industry) and vegetables.

To prevent soil erosion on steep slopes, survey participants also wished that 50 percent of mountainous areas be forested and 38 percent be grasslands. Survey participants approved of crop cultivation using existing terracing on the remaining mountainous 12 percent.

## IV. CONCLUSIONS AND POLICY IMPLICATIONS

### A. Conclusions

This study considered local perspectives on land use changes in remote, mountainous, and marginalized regions of western China. Land use changes and local perspectives were driven by the integration of

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47. Zhang, *supra* note 23, at 44.

land use dynamics and socio economic factors. Study results show that socio-economic factors were very important in determining land use activities. The primary concern between 1980 and 1995 was the expansion of arable land due to the increase in farming activities. Because the conversion of farmland to forest or grasslands was the dominant land use change from 1995 to 2003 and in particular between 2000 and 2003, it has been suggested that land use in areas of marginal agricultural potential will become less intensive than in areas intensely cultivated for food crops. The conversion of farmland to forest and grassland indicates that arable lands in these areas are becoming more enclosed and will appear more forested and grassy. This conversion will have a positive effect on ecological conditions in the area. The recent "shrinkage of China's farmland...[may reflect] an irreversible trend of growing marketization, urbanization, and globalization that should be accepted rather than deterred."<sup>48</sup>

Farmers perceive government policies, market demand, personal willingness, and a land conservation ethic as the most important factors affecting changes to land usage in the study areas. Most farmers had positive opinions of the current land use changes. However, they would still prefer that land be cultivated for grains and other food crops instead of being returned to forest or grassland. Although this preference is reasonable as there is a traditional concern about food security, recent research has shown that the conversion of farmland to forest or grassland may not have a major impact on China's future grain supply or the world grain market.<sup>49</sup> Impacts on the local food supply may still be significant. Households may face food shortages if government subsidies for land conversion are insufficient or if forest and grass products do not provide enough economic support.

## B. Implications

The results of the study have management and planning implications for future land use decisions. First, resource conservation must be built into policy making. Improvement of the ecological environment must be given priority over a desire to increase local income.<sup>50</sup> Also, cooperation and coordination between governmental institutions

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48. Lin & Hob, *supra* note 32, at 106.

49. Zhiming Feng et al., *Grain-for-Green Policy and Its Impacts on Grain Supply in West China*, 22 LAND USE POL'Y 301, 301 (2005).

50. H.J. Wang & R.R. Ren, *Conversion of Agricultural Land into Forest and Grassland and Ecological Environmental Construction in Arid and Semi-Arid Areas of China*, J. DEV. FOREST SCI. & TECH. 7, 7 (2001) (in Chinese).

involved in land use management must be increased. Policy decisions should be made based on comparisons between costs and benefits. Local farmers also need to be informed of the purposes and reasoning behind the policy decisions that impact them. Land use decisions should be made jointly by the agencies<sup>51</sup> that collectively own the land and are involved in land management in order to make scientifically and environmentally sound decisions.<sup>52</sup> Additionally, land use planning must be scientifically sound and should be paired with other strategies in order to preserve vital agricultural lands and benefit farmers.<sup>53</sup> Land allocation in the study area must consider food security, economic benefits, and environmental conservation as well.

Second, agro-environmental programs must be more concretely and specifically implemented. For example, programs to convert farmland into forest and pasture should require the planting of seedlings and grasses suited for both local conditions and erosion control. Additionally farmers should be provided with the corresponding skills and techniques needed to create and tend to their forests and pastures. Subsidies for converted farmland must continue until farmers can subsist on converted farmland. Farmers also must be kept informed about the status of land use and crop production and future plans.

Institutional reforms are necessary to implement these programs. In 2000, the Chinese government formulated and implemented a land conversion policy. This policy did not mobilize active participation due to inefficiencies in the forest administration and a lack of motivation by farmers. The land conversion policy is jointly implemented by the State Forest Bureau and its local branches at the provincial, district, county, and township levels. The policy was not successfully implemented due to ambiguities, vagueness, and contradictions in the policy and also due to the overlapping responsibilities of different agencies. While local government officials are focused on meeting quotas for the amount of cropland that must be retired, they are not concerned with which tracts of land should be converted or what species they should be converted to. Natural resources agencies use the administrative rulemaking process across the country and in the study area to address controversial public land

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51. People's Republic of China: Bureau of Land Resources, the Bureau of Agriculture and Animal Husbandry, and the Bureau of Environmental Protection.

52. The following agencies are involved in land management in the People's Republic of China: the Bureau of Land Resources, the Bureau of Agriculture and Animal Husbandry, and the Bureau of Environmental Protection.

53. Elisa Paster, Comment, *Preservation of Agricultural Lands Through Land Use Planning Tools and Techniques*, 44 NAT. RESOURCES J. 283, 318 (2004).

management and policy decisions.<sup>54</sup> The management of forests and grasslands should be quickly transferred to grassroots community user groups and the community should be encouraged to participate in planning and management practices. This will require user group training in forest, grassland, and financial management as well as an awareness of the economic and environmental benefits of sustainable resource management.

Farmers are dissatisfied with policies because some highly visible land conversions have not been successful when the species planted were not suitable for the local environment. Additionally, cash and food subsidies for farmland conversion are not adequate. Although the policies are scientifically based and environmentally sound, they have not been successfully implemented because farmers' concerns were not taken into consideration and farmers did not participate actively in implementation activities.

Although local farmers did not participate in project design or implementation, they must plant trees and grasses according to the guidance of local officials in order to meet area quotas for land conversion. Survey results indicate that farmers were not informed of the reasons for the land conversion project nor did they participate in determining which location should be converted into forest and grass land or which forest and grass species would be most suitable for local conditions. Additionally, full consideration was not given for farmers' demands for compensation. In order to increase participation, information must be disseminated and people must be involved and consulted in project design and implementation. Management authority must be delegated to the local people. Farmer groups and land based projects such as community forestry, agro forestry, and pasture development should be encouraged in order to help the region. In-depth research is necessary to identify areas with specific agricultural land use priorities.<sup>55</sup> Also, appropriate decision support systems (which include data collection and analysis and the design and selection of the best alternatives for resource management) would be a very effective method for the efficient and sustainable use of productive resources.

It is also necessary to promote locally suitable and environmentally sound farming techniques such as multiple and mixed cropping, terracing, mulching, and fertilizing and zero-tillage techniques

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54. Martin Nie, *Administrative Rulemaking and Public Lands Conflict: The Forest Service's Roadless Rule*, 44 NAT. RESOURCES J. 687 (2004) (discussing the use of rulemaking by U.S. agencies to address controversial issues).

55. See, e.g., U.B. Nidumolu et al., *Enhancement of Area-Specific Land-Use Objectives for Land Development*, 15 LAND DEGRADATION & DEV. 513, 513 (2004).

in hilly areas. While these practices were used in the past they are now being abandoned due to overuse of the region. Also, organic fertilizers are scarce and are being replaced with chemical fertilizers, which have adverse economic and environmental implications. Fertilizers such as dung and crop residues are now being utilized for fuel.

Indigenous resource management systems must be revitalized and strengthened through research, dissemination of information, and the provision of agricultural extension services (including training and visits). Many ideas such as legume cultivation and agro forestry must be promoted. They exact minimal financial and social costs to individual households while contributing substantially to resource conservation.

Population control is also a priority because of its great effect on development and the environment. Although local governments acknowledge the importance of population control, China's special population policy for the Hui ethnic group plays a large role in the study region as Hui is a major ethnic group in the region. Seventy-two percent of the population of Jingyuan, 45 percent of Guyan, and ten percent of Longde are Hui. The family-planning policy for the Ningxia Hui Autonomous Region allows Hui farmers in rural areas of the counties in the study area to have three children instead of two as in other areas. Traditional norms linking the number of children to one's wealth, the preference to male children, and low education levels have hindered Hui from following the policy. Instead, Hui families have an average of four to five children. Local officials suggest that the three-child policy for Hui be strictly enforced or even eliminated. Also, increased education for women allows them to earn an income and participate fully in decision making. Better equipped and financed family planning programs would allow women to determine their own reproductive behavior.

A long-term resource conservation strategy must also be developed. The idea of ecological or green migration is a good but not yet successful option for local governments and should be strengthened. By 2010, the government hopes to relocate farmers from the hilly regions of the study counties to the irrigated northeastern part of the province.<sup>56</sup> Insufficient infrastructure, lack of employment opportunities, and strong social and emotional links with relatives cause many to return to their original locations. Because it is very important to relocate these farmers, the migrants' needs must be addressed in order to make relocation more successful. Additionally, relocation may be more successful if the entire village migrates (which is called *Diao Zhuang Yi Min* in Chinese).

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56. The government hopes to relocate 26,800 farmers from Guyuan, 51,400 from Jingyuan, and 26,000 from Longde.

Training and education of migrants on agricultural production skills and technologies and off-farm income generating techniques are also necessary.

In summary, for the sustainable management of land resources in the watershed, it is necessary to integrate resource conservation and policy making and planning with full participation of the stakeholders. It is especially important to include the institutions and local farmers to ensure the successful implementation of the policies and plans. In this regard, training programs are necessary to increase the awareness and technological understanding of local farmers in order to develop integrated natural resource management. Additionally, population control should be stressed in order to mitigate the intensive use of the resources. And finally, long-term resource conservation with an emphasis on ecological migration would be a good option for the area.