

THE IMPACT OF CLEARANCE AND IRRIGATION ON THE ENVIRONMENT IN THE LAKE ERHAI CATCHMENT FROM THE NINTH TO THE NINETEENTH CENTURY

史 *Mark Elvin, Darren Crook, Shen Ji 沈吉, Richard Jones, and John Dearing*

Differences in microenvironments—defined by geology, geomorphology, and hydrology—led to major differences in the nature of the environmental problems created by economic development in different parts of the Erhai catchment in southwestern China during the premodern period. In particular we show that the second half of the eighteenth century was the critical period for the onset of rapid environmental degradation in the northern part of the catchment. From this it is established that premodern Chinese irrigated farming cannot be defined as indefinitely ‘sustainable’ without major qualifications.

Conceptual Background

Successful new techniques of exploiting the environment sooner or later create changes in the environment that make their continued use more difficult or more expensive, and usually both. Such changes may be primarily physical, as in cases of land degradation and erosion, the build-up of sediments in hydraulic systems, the contamination of air, water, or soil, and resource depletion. Alternatively, they may be primarily biological, as in cases of increased incidence of infectious disease due to the greater frequency of contacts between humans, or between animals or plants, or to the development of microbial resistance, or else the depletion of stocks, like those of trees and fish. Compensatory reactions include the development of new techniques, accessing new supplies of natural resources, and diverting additional labour, skills, and funds to maintenance and restoration. Or, occasionally, admitting defeat.

The speed with which such adverse changes in the environment occur, and the scale on which they occur, vary markedly from case to case. They range from the rapid and accelerating down to the barely perceptible, and from the widespread down to the marginal. If there is a general rule governing these events, we are still some way away from seeing the terms in which it should be framed. We cannot, for example, even safely assume that there was *ever* any initial resilient equilibrium state characterizing the relationship between human beings and their environment. Our present focus, though, is on the approximately two and a half millennia of *historical* time for which at least some documentation exists, and if this equilibrium did ever once exist it had certainly by this latter period long since disappeared. Our interest is thus essentially in examining the subset of ecosystem reactions vigorous enough for their onset to have left well-defined traces in the historical record, and analyzing their distinctive patterns and probable causes.

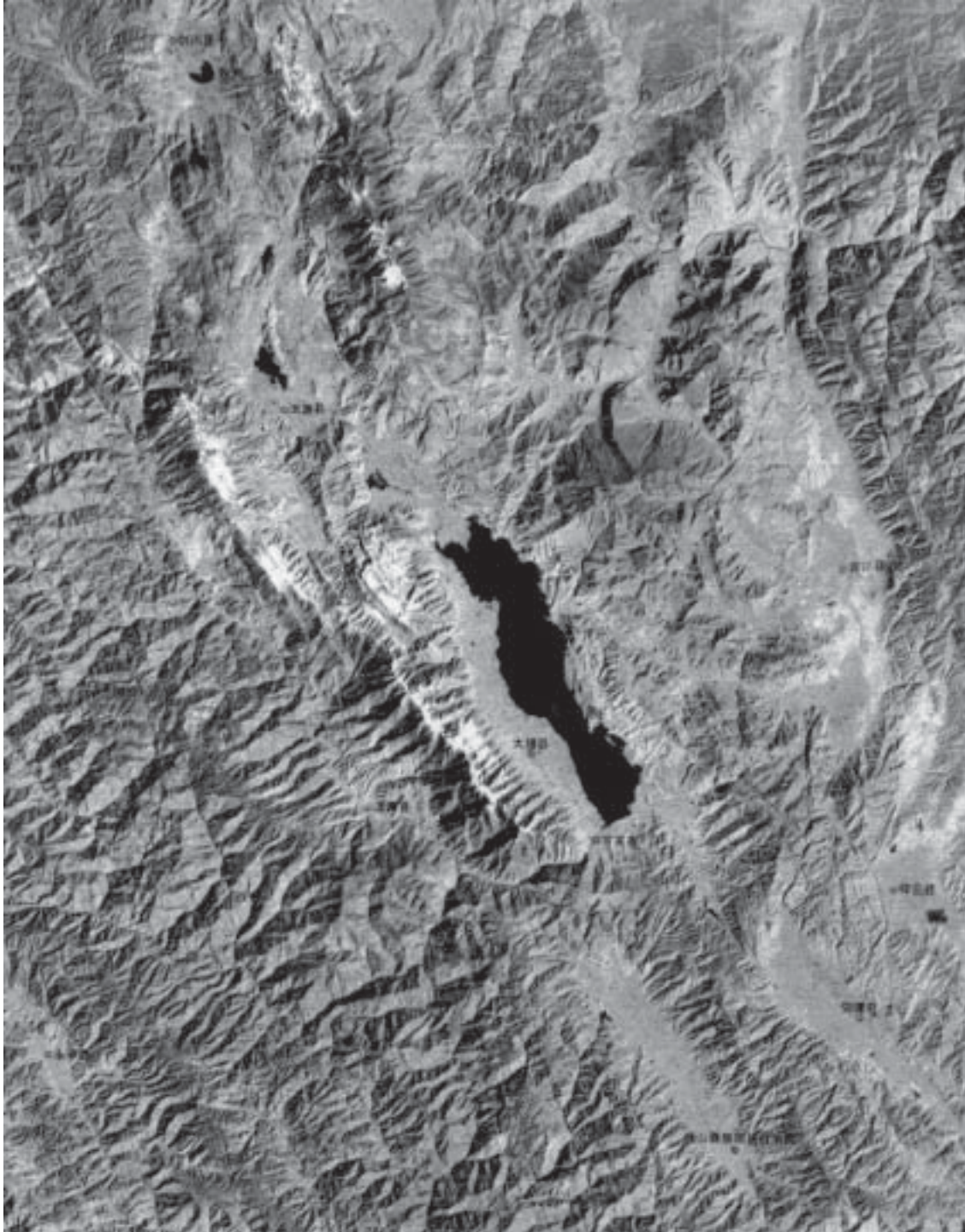
The major gap in the reconstruction of events offered here is climate change, in particular as regards the mean temperature and the seasonal pattern and quantity of precipitation. At the moment all that can be suggested is that both long-term and short-term changes in climate are likely to have had their most critical impact at the environmental margins. Hence, to the extent that systems of cultivation and water control were pushed toward their limits as the population that relied on them grew over time, these changes probably mattered more—other things being equal—in late-imperial times than earlier, whether in a favourable or an unfavourable direction. Because we do not yet have satisfactory historical climate data for this area at our disposal we have had to omit this important aspect, but anticipate being able to make good the omission in a later paper.

1. *Introduction*

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In what follows we demonstrate the markedly different levels of ‘sustainability’ determined by the interaction of varying microecological factors with a relatively standard repertoire of Chinese premodern irrigation technology. Seen in the perspective of long-run premodern Chinese developmental history, with timescales on the order of approximately centuries and millennia, all landscapes appear vulnerable, though to notably different degrees. *A fortiori*, with certain obvious qualifications, for the modern future.

The present paper is designed as a historically orientated contribution to this program of research, being a study in miniature of the catchment of the Erhai 洱海 lake in Yunnan 雲南 in southwestern China over a period of around fifteen hundred years before modern times.¹ Our documentary and epigraphic sources are, however, fragmented. The writing of a fully systematic, comprehensive, coherent, and above all balanced account of these two-and-a-half millennia is for the moment, and perhaps permanently, out of reach.

**Figure 1**

Lake Erhai catchment. This image from the Zhongguo ludi weixing jiachise yingxiang tuji (Atlas of False-Colour Satellite Photographs of the Land-Surface of China), 3 vols (Beijing: Kexue Chubanshe, 1983): 2, pp.141–2, shows the lake catchment in an approximately north-south orientation. The northwest to southeast line of the crests of the Diancang Range is highlighted by the snow cover. The lacustrine delta formed in relatively recent times by the Miju River is visible at the northern end of the lake. The small triangular lake northwest of the Erhai is Cibi, with the city of Eryuan lying at its southern end. The old city of Dali lies about two-thirds of the way down the alluvial plain on the west bank of Erhai, and Xiaguan at the southwest corner, where the outflow is located. Readers not used to satellite images may find the relief easier to visualize if they invert the orientation and look from the north to the south

The reconstruction that begins in section 1.2 and forms the main body of this study is our best effort to assemble these small islands of information into a meaningful archipelago. It could, of course, have been done somewhat differently.

The lack of redundancy in our sources reduces the certainty we can have that the information is reliable and correctly interpreted. Their paucity also means that a relatively large weight has often to be placed on items that are unique or very limited in number. These considerations frequently require that we quote longish passages virtually *in extenso*, and justify crucial translations. This does not make for clear and compact reading, but it does make evident the varying degree of confidence that it is reasonable to place in particular conclusions.

2.0 Erhai

² Liu Wenzheng 劉文征, ed., *Dianzhi* [Gazetteer of Yunnan] (between 1621 and 1627; reprint ed., Kunming: Yunnan Jiaoyu Chubanshe, 1991), map of Dali fu, separate from text.

The catchment is about 2565 square kilometres in extent, and the lake itself is somewhat over 1970 metres above sea level (as measured from Haiphong), varying through the year and over the years. Its approximate area is 249 square kilometres, likewise varying over time to some degree. The mean volume is on the order of 2950 m³. The main advantage in choosing this location is that the different sides of the lake vary in their environmental endowments. With qualifications arising from the multi-ethnic origins of the region, this diversity allows us to hold social and cultural variables relatively constant and so to isolate the interactions of technical and environmental factors. The modern remote-sensing image on p.3 gives a good initial physical overview of the area.

The administrative geography and nomenclature of the Erhai catchment changed frequently over the centuries. To give the reader a first approximation we have therefore reproduced a pictorial map of Dali prefecture (Dali fu 大理府) from the *Dianzhi* 滇志 (Gazetteer of Yunnan), published some time between 1621 and 1627 in the Ming dynasty, this being a convenient midpoint between earlier and later history (Map 1).² The most serious omission is the northward extension of the long Miju River (Miju jiang 彌苴河) subcatchment beyond the right-hand margin. Nor is the Boluo River (Boluo jiang 波羅江), which enters the Erhai from the south, shown. Likewise the long, but in fact fairly small, northward-flowing river that extends left-to-right across the bottom of the map from south to north does not have its source south of Yunnan xian 雲南縣 (modern Xiangyun 祥云) but north of it. In other words a watershed has been obliterated. The names of the main topographical features have been added in English. Correct cardinal points have been indicated in the margins, together with the Chinese orientations. An idea of the scale may be derived from the fact that the lake at this time was slightly under 50 kilometres long in a north-to-south direction, or right-to-left as the map has been drawn.

Map 1

Pictographic map of the Erhai in Ming times. This woodblock print from the Dianzhi of Liu Wenzheng shows, in highly schematic form, the lake and its environs in late Ming times. See the text for a discussion



³ The account of the geographical features of Erhai that follows is based on the chapters in the *Yunnan Erhai kexue lunwenji* [Collected scientific works on Erhai Lake in Yunnan {publisher's translation}], ed. Shen Renxiang (Kunming: Yunnan Minzu Chubanshe, 1989) (ISBN 7-5367-0234-5; rare), especially those by Cao Chengzeng, "Erhai liuyu shuiwen texing" [The hydrological characteristics of the Erhai catchment] and Duan Yanxue, "Erhai de yanbian" [The evolution of Lake Erhai], and on the *Zhongguo ziran ziyuan congshu* [Series on the natural resources of China], vol.35, *Yunnan juan* [Yunnan volume], ed. Zhongguo Ziran Ziyuan Congshu Bianzhuan Weiyuanhui (Huanjing Kexue Chubanshe, 1996).

⁴ Pronounced more like 'qing' locally.

2.1 *The Four Shores*³

The general climatic pattern is, as would be expected, broadly similar for all four sides of the lake. The most important common feature is the division of the year into a dry season from November to May and a rainy season from June to October, in which more than 80 per cent of the precipitation falls. The lake-level velocity of the wind reaches a maximum of 4 metres per second in February, with an annual mean of 2.5 m.sec⁻¹, and of course rises with altitude. Seismic activity is frequent, and the chapters on 'Auspicious and Uncanny Events' (*xiangyi* 祥異) in late-imperial local gazetteers, that for Jizu shan 雞足山 (Chicken's Foot Mountain) excepted, all contain references to the damage done by earthquakes. In most other respects the four shores of the Erhai—roughly speaking the west, north, east, and south—present different geomorphological, geographical, and hydrological features.

Rainfall is heavier on the west, rising from 1000 millimetres per year close by the shoreline to 1800 mm near the crests of the famous 'Nineteen Peaks' (Shijiu feng 十九峰) of the Diancang 點蒼 mountains, which rise above the lake to over 4000 metres. On the east the rainfall is mostly between 800 mm and 900 mm.year⁻¹, only a very small zone of high-altitude precipitation reaching a maximum of 1400 mm.year⁻¹. The west side is furrowed by numerous watercourses, notably the well-known 'Eighteen Streams' (Shiba qi 十八溪) which contribute 2.76 x 10⁸ m³ of water a year to the lake, and whose steep gradients give them the highest combined discharge to the lake at periods of peak flow. The Wanhua Stream (Wanhua qi 萬花溪) has, for example, been estimated to reach a once-in-fifty-years maximum of 158.4 m³ per second. The east side, in contrast, has only minor watercourses, mostly called 'ravine streams' (*qing* 箐⁴). The north side has the Miju River, which draws upon an extended northern subcatchment so that it empties 5.18 x 10⁸ m³.year⁻¹ into the lake. It is flanked by the smallish Luoshi River (Luoshi jiang 羅時江) draining the West Lake (Xihu 西湖) and the Yongan River (Yongan jiang 永安江) draining the East Lake (Donghu 東湖). At the present time these 'lakes' are not single sheets of water but inter-connected groups of small lakes and ponds. The south has the Boluo River, which contributes 1.14 x 10⁸ m³.year⁻¹ of water, and is the stablest of the major rivers. This contrast between the wet west and the drier east shifts slightly when we consider mean annual runoff. This is above 200 mm.year⁻¹ on the west and south sides, but under 100 mm.year⁻¹ on most of the east and north sides.

In late-imperial times the most rapid deposition of sediment into the lake came from the Miju, whose creation of a dramatic lacustrine delta is discussed in detail later. Its rate of vertical accumulation at its mouth during the later period from about 1950 to the middle 1980s has been estimated at somewhat under 5 cm. a year as compared to that of the Boluo which has been estimated for the same period as about 2 cm.year⁻¹. The rapid build-up of a foreshore extending into the lake by the Wanhua Stream is said to have started only in the 1970s, and the striking spit curved like a fishhook is visible on modern

maps and remote-sensing images about a third of the way down the west shore lakewards of the town of Xizhou 喜州 and the village of Shacun 沙村—‘sediments village’.

While our approach to the landscape is scientific, it should not be forgotten that it was imbued with stories and meanings in the minds of the local inhabitants, of whom the non-Chinese Bai 白 people were for a long time the most numerous.⁵ Here, for example, is the beginning of the foundation myth of the Bai kingdom of Dali that tells how Guanyin, the Goddess of Mercy, “covered the entire land of the Diancang Mountains and the Erhai” with her monk’s robe, while her white dog leapt from one end of it to the other in four bounds, so reclaiming it from a demon father and his son. It mentions the seventeenth of the Nineteenth Peaks, counting from the south:

At the end of the Sui 隋 dynasty and the start of the Tang 唐 [in the early seventh century CE] raksha demons [*luocha* 羅刹] had long occupied Dali. The people were afflicted by the harm they did. In 628⁶ they were favoured by the Goddess of Mercy [*Guanyin dashi* 觀音大士] coming from the Western Heaven and alighting on Wutai shan 五臺山 [Five Terraces Mountain] where she transformed herself into an old man, who made enquiries as to the facts concerning the raksha demons and their *xilao* 希老—[human associate?] Zhang Jing 張敬. All the people in the villages regarded the old man [the metamorphosed goddess] as if he was a father or mother, and none but respected and loved him. They recounted to him from beginning to end all the many kinds of harm that had been inflicted [by the demons], such as gouging out people’s eyes and eating human flesh ...⁷

The landscape was also filled with what were believed to be other relics of her visitation on this occasion, such as her stone table and stone writing brush. And likewise it was from the gorge of the upper Yang Stream (shang Yang qi 上陽溪), one of the Eighteen Streams, that she finally plucked the green jasper jar into which she first lured and then imprisoned the demons and their families in perpetuity. This was the imagined landscape in which the inhabitants of Dali lived emotionally, even as their practical existence was shaped by the more prosaic forces that are the subject of what follows.

2.2 *The West Side*

Human patterns of environmental exploitation have interacted with what can usually be shown to be variations in natural endowments, such as the elevated alluvial fans on the west at the foot of the Eighteen Streams, which were easy to clear and had a moderately reliable supply of water. Some of these apparent variations are still, however, to some degree problematic: differentiating presettlement vegetation cover across the catchment in particular awaits palynological and other detective work. In general, permanent settlement, with a component of farming, has existed longest on the south

⁵ This was the common component of the various names they gave themselves. Outsiders often called them *minjia* 民家. See Li Zhengqing, *Dali Xizhou wenhua shi kao* [History of the culture of Xizhou in Dali] (Kunming: Yunnan Minzu Chubanshe, 1998), pp.167–8.

⁶ The year of the sexagenary cycle given in the text in addition to the reign-period and year does not match this year.

⁷ See the anonymous work *Baiguo youyin* [Origins of the Bai kingdom] (1706), in Dali Baizu Zizhizhou Wenhuaaju (superv.), *Nanzhao Dali lishi wenhua congshu* [Anthology of literature on Nanzhao and Dali], 4 vols (Chengdu: Ba-Shu Shushe, 1999), 1: 2a, 6a, 7a–b.

⁸ Zhang Zengqi, *Zhongguo xi'nan minzu kaogu* [Archaeology of the peoples of southwest China], Yunnan Museum Research Series (Kunming: Yunnan Renmin Chubanshe, 1990), pp.180–200.

⁹ This we examined in the Dali Municipal Museum (Dali shi bowuguan 大理市博物馆) in Xiaguan. Mentioned in Yang Dewen, “Yunnan Dali shi Dazhantun erhao Hanmu” [The number 2 Han grave in Dazhantun in Dali Municipality], *Kaogu*, 1988.5: 449–56. Also noted briefly by Li Kunsheng, *Yunnan kaoguxue lunji* [Collected essays on the archaeology of Yunnan] (Kunming, Yunnan Renmin Chubanshe, 1998), p.25. The historical evidence for irrigated wet-rice farming during the Han dynasty in the area round what is today Kunming is summarized in *idem*, p.115. We would like to thank Professor Christian Daniels 唐立 of the Tokyo University of Foreign Studies for saving us from an error by pointing out that in our original draft we had misascribed the provenance of this piece.

¹⁰ C. Daniels and Watabe Takeshi, *Unnan no seikatsu to gijutsu* [Life and technology in Yunnan] (Tokyo: Keiyūsha, 1994), pp.127–8.

¹¹ Christian Daniels, letter to M.E. dated 23 August 2001.

¹² For passages that identify ‘dashi’ as a title for Guanyin see Duan Jinlu, *Dali lidai mingbei* [Famous steles of successive dynasties] (Kunming: Yunnan Minzu Chubanshe, 2000), pp.150, 447, 457, and 458. Guanyin had a central place in Bai mythology. See *Baiguo youyin*, in which the term ‘Guanyin dashi’ also appears: for example, vol.1, p.2a–b.

and west sides, going back at least three millennia.⁸ A pottery model, buried in a grave at Dazhantun 大展屯 village north of Xiaguan 下關, and showing an enclosed field, a pond, with a sluice-gate and channels, and domestic animals and fowl, suggests that some Chinese-style irrigated agriculture was present as early as the Han dynasty, approximately two thousand years ago (Figure 1).⁹ Watabe Takeshi 渡部武 has made a special study of this genre of grave goods, showing that they are found most densely in the upper reaches of the Han River (Han shui 漢水) and in the Sichuan basin as well as scattered locations in Yunnan and the far south.¹⁰ His colleague Christian

Figure 2

Pottery model of irrigated farming from a Han-dynasty grave in Dazhantun (southern end of the west side). On show in the Museum of the Bai Nationality in Xiaguan



Daniels has described them as “an expression of self-identity displaying the high level of agricultural technology held by ... migrants and their descendants who lived surrounded by the non-Chinese ethnic groups.”¹¹ It is reasonable to suppose, as he does, that most farming in the area at this time was still nonetheless either of a dry-field nature or much simpler.

If we look for the origins of farming on the lower part of the western shore, we can find traces of what was probably a folk-memory of a time when it was still not cleared. In the Ming-dynasty work *The Unofficial History of the Southern Kingdom* (Nanzhao yeshi 南詔野史) we read about the place Hetuo 鶴拓:

After the *dashi* 大士 [the Goddess of Mercy]¹² had drained [sc. ‘lowered’] the Er water, *the land was covered over with woods and thickets*, into which no human dared to penetrate. Two cranes came and went daily to the shore of the lake. People tracked them and made their way in. When they had spaded and ploughed the thorns and weeds, they obtained level land and

dwelt there. Today, south of Dali prefectural capital, there used to be a Two Cranes Bridge [Shuanghe qiao 雙鶴橋]. The purpose of this was to commemorate this strange event.¹³

The reference to Guanyin, a Buddhist deity, suggests that an older story was reworked after the entrance of Buddhism early in the first millennium CE. The date of the clearance is not recorded; it is reasonable to guess some time not later than the first millennium BCE. What is evident is that at least the lower western shore below the mountains, today virtually bare of any extensive stands of trees, was once completely covered with forest and dense undergrowth.

We say 'lower' as this information needs reconciling with the reported discovery of neolithic sites at the base of several of the Diancang mountains.¹⁴ Finds include farm tools such as stone axes and adzes, for clearing trees, and stone knives, as well as remains of rice. Extremely numerous pottery items include containers, bowls, plates, pots, and cups, plus spinning whorls and weights for nets. The houses were built with vertical posts and branches woven across the spaces between them, daubed with mud and straw for the walls. The depth of the accumulated materials points to long periods of fixed residence. The C14 dates of the first sites to be scientifically studied (in 1939) have a mean of 3770 years BP, and rather similar remains have since been found in a wide zone around the Erhai. Sedentary growers of rice, though with what precise techniques is not at present clear, have thus existed in this general region for a very long time indeed before the Han-dynasty date of the Dazhantun find. Since the sites are relatively high on the gentler slopes,¹⁵ at the base of four of the Nineteen Peaks, namely Foding 佛頂 ('top of Buddha's head'), Malong 馬龍 ('horse dragon'), Longquan 龍泉 ('dragon spring'), and Baiyun 白雲 ('white clouds'), respectively the third, fifth, seventh, and fifteenth peaks counting from the southern end of the chain, it seems probable that the heavily vegetated area recalled by folk memories, conceivably a swamp forest, was that on the poorly drained *lower* ground which emerged later after a fall in the level of the lake—the 'draining' by the mythical *dashi*.

Duan Yanxue 段彦学 has shown that after the Erhai developed in the late Pleistocene as the result of faulting in a pre-existing river valley, its water level was higher than it is today, and fell through the early and middle Holocene. Even around 5,000 to 4,000 BCE water still covered where Dali, Xiaguan, and Dengchuan 鄧川 stand today.¹⁶ The mixture of myth and legend preserved in *The Unofficial History* was probably picking up the last part of this decline in the level of the lake.

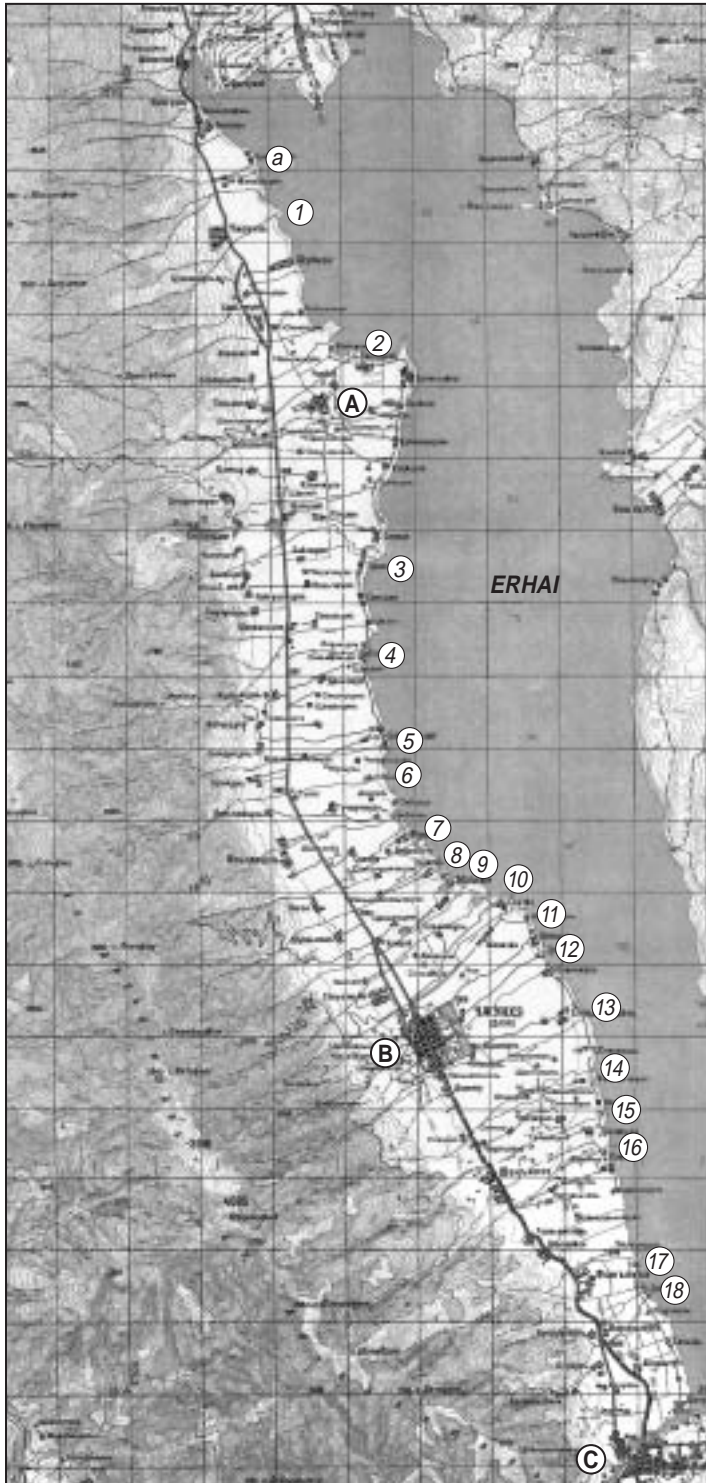
Once its lower shores were developed, the western side became the location of a number of political capitals. The first reason for this was that it now provided the conditions for a productive irrigated agriculture on a scale large enough to underpin a modest-sized polity. The second, more distinctive, was that by building fortresses to guard the entrances at the northern and southern ends it could be turned into a formidable defensive enclave

¹³ *Nanzhao Dali lishi wenhua congshu, Nanzhao yeshi, xia* 下, p.45a. Emphasis added.

¹⁴ Zhang Zengqi, *Zhongguo xi'nan minzu kaogu*, ch.12, pp.181–2. The original excavation report (not available to us) was Wu Jinding, Ceng Zhaoyu, and Wang Jiechen, *Yunnan Cang-Erjing kaogu baogao* [Report on the archaeology of the Diancang–Erhai region of Yunnan] (1942).

¹⁵ All above the more elevated of the two present-day N–S main roads. The Foding site lies W of Dajingpang 大井旁 village, which is modern Fengyangyi 凤阳邑 in Qiliqiao 七里桥 district, on the Mucan Stream 莫殘溪. The Malong site is also in Qiliqiao district, to the N of the Qingbi Stream 清碧溪, and 1.5 km from Shangmo 上摩[末] village. The Longquan site is north of the Lüyu Stream 綠玉溪, 1 km distant from Yitasi 一塔寺. The Baiyun site is 2 km from Chuanyi 鉤邑 in Wanqiao 灣桥 district. For details see Xue Lin, *Dali fengwu zhi* [Record of the scenery of Dali] (Kunming: Yunnan Renmin Chubanshe, 1999), pp.93–5.

¹⁶ Duan Yanxue, "Erhai de yanbian," pp.212–22.

Map 2*The Eighteen Streams in modern times**(a) (Butterfly Spring)*

- 1 Xiaqi
- 2 Wanhuaqi
- 3 Yangqi
- 4 Mangyongqi
- 5 Jinqi
- 6 Lingquanqi
- 7 Baishiqi
- 8 Yuanyangqi (Shuangyuanqi)
- 9 Yinxianqi
- 10 Meiqi
- 11 Taoqi
- 12 Zhongqi
- 13 Luyuqi
- 14 Longqi
- 15 Qingbiqi
- 16 Mucanqi
- 17 Tingmingqi
- 18 Nanyangqi (Yangnanqi)

A Xizhou

B Dali (old city)

C Xiaguan

Base map : Soviet 1:100,000 (1978), from the copy held in Cambridge University Library

Scale: grid square = 2 x 2 km

(Coombs Cartography Unit, Australian National University)

Source for stream names : Xue Lin, ed., *Dali fengwu zhi* [The Scenery of Dali] [Kunming: Yunnan Renmin Chubanshe, 1999], fold-out map

protected by the huge mountains at its back and the lake to its front. The strongholds were known respectively as the Shangguan 上關 and the Xiaguan, the upper and lower pass-barriers. In 738 CE the kingdom of Mengshe (Mengshe zhao 蒙舍詔) unified the Six Kingdoms (Liu zhao 六詔) of the Erhai area, and set up the Southern Kingdom (Nanzhao 南詔) under the suzerainty of the Tang dynasty. The capital was moved from Mengshechuan 蒙舍川 to Taihe City (Taihe cheng 太和城) near present-day Dali. Under Geluofeng 閣邏風 (712–78) relations with the Tang deteriorated into military confrontation. The Southern Kingdom was victorious, and then transferred its allegiance to the Tibetans, who were at this time a major military power. Around 766 a stele was set up by the officials of the Southern Kingdom to explain that their ruler had had no other option, and to praise his achievements.¹⁷

This stele gives us our first, rough, picture of the local economy. After the peaceful surrender of the city we read that “boys and girls, and jades and silks, clogged the roads for fifty kilometres. Cattle and sheep, and stores of grain, were lodged in the valleys for a month.” The royal relatives and officials led their subordinates “in cutting down trees to build through-roads, construct boats, and make beams for houses.” “Walled cities and settlements stretched out one after another,” while “villages were as dense as [the prongs on] a comb.” “His good faith reached [even] to swine and to fish. His favour enriched the vegetation and the trees. He blocked off the currents and floods, so that the upland plains became fields for rice and millet. He drained and breached the pools and ponds, so that the lowlying wetlands could be properties planted with gardens and groves. He changed the poor to being rich Each family had in addition five *mu* [0.27 hectares, using Tang measure] of mulberry trees [to feed silk worms], and the state had stores for nine years in its granaries.” In other words, there was a combination of pastoral and irrigated agricultural economy, urbanization, and the beginnings of systematic deforestation.

In the ninth century CE, when the story with which we are properly concerned commences, we find the first recorded irrigation system of any substantial size in the catchment (see Map 2):

In 845 [Feng You 豐佑 (817–59), the ruler of the Southern Kingdom] sent Army General Lord Sheng [Junjiang Shengjun 軍將晟君] to build the Transverse Channel [Hengqudao 橫渠道]. It ran from Moyong River [Moyong (‘mill-use’) jiang 磨用江] to Hetuo 鶴拓. This irrigated the fields of Donggao 東皋 and Chengyang 城陽. It then joined with the Longka River [Longka jiang 龍佉江] and flowed into the Erhai. *It was called the Brocaded Waves River* [Jinliang jiang 錦浪江].

He also stored up [water] south of the summit of Yuju Peak [Yuju (‘jade board’) feng 玉局峰] in the Diancang Range, making a reservoir. He called it the ‘Gaohe’ 高河 [‘high river’] or ‘Feng River’ [Feng he 馮河]. He further directed the mountain springs so that they drained off in the fashion of a river, irrigating several tens of thousands of *qing* 頃. The people obtained the profits of ploughing and planting.¹⁸

¹⁷ There are recent versions of the text in Fang Guoyu, *Yunnan shiliao congkan* [Collection of historical materials on Yunnan], 5 vols (Kunming: Yunnan Daxue Chubanshe, 1998): 2, pp.377–84, and Duan Jinlu, *Dali lidai mingbei*, pp.3–12.

¹⁸ *Nanzhao Dali lishi wenhua congshu*, *Nanzhao yeshi*, shang 上, p.23a. Emphasis added.

¹⁹ Gang Deng, *Development versus stagnation. Technological continuity and agricultural progress in pre-modern China* (Westport, Conn.: Greenwood Press, 1993), p.xxv.

²⁰ Quoted by Li Zhengqing, *Dali Xizhou wenhua shikao*, p.68, from the *Pogu tongji jianshu* 夔古通記淺述 [Genealogy of the Meng clan]. Emphasis added.

This requires some elucidation. The ‘Army Generals’ were twelve top-level officials who met with the ruler daily to discuss current concerns. The name of the Moyong River suggests that it was used to provide power for water mills, but this designation is not listed in other materials. It is, as we shall show below, another name for the Mangyong Stream (Mayong [‘lightbeams bubbling’] qi 芒湧溪), the fourth of the Eighteen Streams counting from the northern end. The Longka River is the present-day Long Stream (Long qi 龍溪), the fifth stream from the southern end. (See the list of streams in Table 5 [pp.57–8] and Map 2.) Thus eleven of the streams coming down the east-facing slopes of the Diancang Mountains were linked by a north–south channel that would have run for at least 16 kilometres, and presumably more, given that it would have had to have been curved to keep to the contours. If *qing* has its usual meaning of a hundred *mu*, then, using the Tang ratio of 0.054 *mu* per hectare¹⁹ the alleged irrigated area is a gross exaggeration. Since there are 100 hectares per square kilometre, a total cultivable area that is a low multiple of 54,000 hectares would not have fitted on a west bank where the relatively flat land is not much more than 150 km². What is evident, though, is a growing commitment of the state to hydraulic systems.

There is another account of the same event quoted by a modern historian from a local genealogy that we have not been able to see in the original and whose date is unclear:

In the sixth year of the Tianqi 天啟 reign-period [845] he [that is, Feng You] sent Army General Lord Sheng to open the Mangyong Stream and build the Transverse River [Hengjiang 橫江] to join together twelve of the streams. It went as far as Long Stream before stopping. Every Qingming Festival [when graves are visited by each family] in the third lunar month, *the nobility and bureaucrats all board boats to the sound of drums and music, and enjoy an excursion on the lake [hu 湖]*. This is called ‘Spring on the Brocaded River’ [Jinjiang chun 錦江春].²⁰

Passing over the slight discrepancy with the previous account as regards the number of streams said to have been joined, this conveys the impression that there was a much greater quantity of water in the streams then than there is now. The last sentence, taken together with the use of the name ‘Brocaded Waves River’ for the new channel in the preceding passage, suggests that interpreting *hu*, ‘lake’, here as the new transverse watercourse seems linguistically and logically hard to avoid. This latter feature has long since vanished on the ground, and would need archaeological exploration to rediscover. Clearly, in view of the constricted dimensions of present-day channels and their nearly total lack of water in the spring, it is natural to be sceptical about this interpretation and to wonder if it was not referring to the Erhai itself. On the other hand, the Erhai was rarely called a *hu*, but rather a *hai* 海, ‘sea’, in the sense of the German *See*, or, sometimes, a *he* 河 or a *shui* 水, both meaning ‘river’. If the Eighteen Streams in fact supplied enough water to support a flotilla of aristocratic pleasure vessels at this period of the year, this would imply that the local hydrological régime eleven hundred or so years

ago was different from what it is today. This is one of the issues that calls for the investigation of climatic change.

2.3 *The North Side*

The situation on the north shore was different. The land near the Erhai here was mostly a marshland thirteen hundred or twelve hundred years ago, and the first priority was drainage. The area where Dengchuan stands today was a Lilliputian ‘kingdom’ in the eighth century known as Dengtan 澄談, the second character of which means ‘state’. Its second ruler, Mieluopi 咩羅皮, was the nephew of Meng Guiyi 蒙歸義, who ruled part of the western shore, and, having been his ally in a campaign, for a time shared with his uncle the control of Dalí 大釐, which is approximately modern Xizhou 喜州. Since he was “weak and without strategic plans,” his uncle later drove him out and Mieluopi fell back to Dengtan. He then formed an alliance with two other statelets further north, Langqiong 浪穹 and Shiliang 施浪, to conduct a counterattack on Meng. Meng had in the meantime built a stronghold at Longkou 龍口, which was later to be known as the ‘Shang-guan’ to which we have already referred above, and was able to inflict a heavy defeat on his enemies. “He pursued them with great speed past Dengtan where the vanquished soldiers perished in large numbers by falling into the muds and sediments [*nisha zhi zhong* 泥沙之中].”²¹ This occurred some time after 737 CE.²²

The description of Dengchuan in the *Yunnan zhi* 雲南志 [Gazetteer of Yunnan] written by Fan Chuo 樊綽 in the Tang dynasty, hence nearly contemporaneously, confirms this impression of the geography:

The city rests up against the foot of the mountain, some distance from the Lu River 瀘水 to the east. *To its north are muds and sediments* [the area of the present Miju valley]. Since Geluofeng 閣邏風 and Yimouxin 異牟尋 (754–808) [rulers of the Southern Kingdom] both of them strengthened and extended it, it has been a very celebrated city.²³

The ‘Lu River’ is an older name for the contemporary Jinsha jiang 金沙江, or upper Yangzi, which lies to the northeast.

Draining the marshlands began with the cutting of the Luoshi River 羅時江 during the middle empire (approximately 581–1367 CE). Gao Shang-gui 高上桂, an eighteenth-century local scholar, left a brief account that puts the enterprise in hydrological context, especially its relationship with the Miju River 彌苴河, the central drainage channel for the entire northern subcatchment:

Mountains surround Deng[chuan] on all sides. In the centre runs the belt of the 60 *li* 里 [≈ 30 km] of the Miju River. At its head [this river] receives [water from] the Ning Lake [Ning hu 寧湖, the modern Lake Cibi (Cibi hu 茈碧湖)] some way to the north next to modern Eryuan 洱源]. Down below it empties into the Erhai. It is a divide between two waterways [*chuan*]||], one to the

²¹ Fan Chuo, ninth century, *Manshu* 蠻書 [Book of the barbarians], 10:10b–11a, in *Nanzhao Dali lishi wenhua congshu*.

²² Li Zhengqing, *Dali Xizhou wenhua shi*, p.64.

²³ Fang Guoyu, *Yunnan shiliao congkan*, vol.2, p.48. Emphasis added.

²⁴ Hou Yunqin, comp. and rev., *Dengchuan zhou zhi* [Dengchuan department gazetteer] (1854 [allegedly, but there is a preface dated 1855]; reprint ed., Taipei: Chengwen Chubanshe, 1968), 13: 15a /p.166.

²⁵ Zhou Kang, comp., Luo Yingmei, rev., *Langqiong xian zhi* [Langqiong (Eryuan) County Gazetteer] (1902; reprint ed., Taipei: Chengwen Chubanshe, 1975), 11: 60a–61b/pp.481–4.

²⁶ Xue Lin, *Dali fengwu zhi*, p.49.

east and one to the west. These two waterways are [each] shaped like half of a circular ritual jade [*bi* 璧]. Fields and cottages form an embroidery or ornamental inlay. The streams from the encircling mountains fly down and drain off through hundreds of courses, ponding on each side to form a lake. Both these lakes empty into the Miju.

In Tang times Luo Shi 羅時 ... and his younger brother cut through the mountain and led out the water of the western watercourse. For the first time the West Lake was led out in a different direction as the Luoshi River.²⁴

He goes on to discuss the problems of the eastern side of the Miju, but these belong to a later part of the story and will be examined in a subsequent section. There is a somewhat rhetorical account by Yin Ren 尹任 in the 1902 gazetteer for Langqiong County 浪穹縣 that gives further, and slightly different, details:

To the north of Dengchuan city was Zhong shan 鐘山 ['Bell Mountain']. Below the mountain there were streams that gathered into a pool some two to three *li* in circumference ... the Green Jade Pool [Lüyu chi 綠玉池] When it overflowed it became a [separate] lake [further south] more than ten *li* around ... called the 'West Lake' [Xi hu 西湖] Zhong shan acted as an overflowing goblet but there was no [natural] outflow to drain it. The fields around the banks suffered from being turned into marshes [*ju* 沮洳] and became impossible to cultivate. What came from the Zhong shan every rainy season in the autumn was merely rills [*juanjuan* 涓涓], but when these accumulated into a pond and then a lake they formed a great expanse whose waves reached all sides, and suddenly became a watery domain Luo Shi ... considered it his obligation to drain the water, and excavated his own fields to let it through, spending his own money to hire labourers It is reckoned he assembled several tens of thousands of men to cut more than ten *li* [> 5 km] of channel. The water that could not be contained in the pool and the lake all used this means to drain out through Zhao settlement [Zhao ba 兆邑], and, like the Mijuka River [Mijuka jiang 彌苴佉江, an older name for the Miju], emptied into the Erhai The fields beside the water suffered from neither drought nor flood, and could be cultivated. The people of the department greatly esteemed his having changed a watery domain into rich soil.²⁵

This is a retrospective and romantic account designed to praise Luo's public spirit; the laudatory and poetic decorations have been omitted here. More prosaically, the Bell Mountain, known today as the 'Buddha Bell Mountain' (Fozhong shan 佛鐘山), is 2811 metres above sea level and the plain in which the pool and the lake lie is at just under 2000, the horizontal distance from the summit to the nearest edge of the pool being fractionally over 2.5 km, or a slope of about 32 per cent. The mean depth of the lake at the present time is 1.8 metres.²⁶

2.4 *The East Side*

Information on the east shore before the middle of the Ming dynasty consists mostly of stone inscriptions. They are usually either funerary memorials of local notables or records of Buddhist temples. The texts are frequently only partly legible, and the language, often influenced by the local Bai tongue, is not always easy to understand. The impression that they convey is that there were local spots of intensive agricultural development from at least Sui and Tang times. The main foci were at Wase 挖色 and Haidong 海東 (sometimes called Xiangyangcun 向阳村 in recent times) by the lake shore, and Jizu shan some way inland to the northeast. There are ravine-rivers emptying out by Wase, notably the Fengweijing 風尾箐, and by Haidong, such as the Shibeijing 石碑箐,²⁷ but no major irrigation systems. Because the local units for measuring land seem, at least in this time and place, to have distinguished between an irrigated field, *tian* 田, in which rice was presumably grown, and for which the unit was a *jiao* 角, and ‘wheat land’, *maidì* 麥地, for which it was a *zha* 乍, it can be shown—if these assumptions are correct—that both were found. An inscription cut in 1432, recording the real estate belonging to the Wase temple known as the ‘Yingguo anbang shenmiao’ 應國安邦神廟, for example, mentions two holdings of one *jiao* each, and eight of one *zha* each.²⁸ This was an important temple, founded in the Southern Kingdom period, and the apparent four-to-one preponderance of the less productive (though not necessarily less stable) dry-field farming is worthy of note.

One of the earliest dates for development comes from a stele erected in 1689 to commemorate the restoration of the almost one-thousand-year-old Luoquan Temple 羅荃寺 in Haidong:

The ancient temple of Luoquan lies on the eastern lakeshore of the Yeyu 葉榆 [an old name for the Erhai]. It was founded under the Tang dynasty between 780 and 783. At that time a poisonous dragon was causing calamities, spitting forth waves and agitating the billows, so that the rowed boat-traffic almost came to a standstill. The monks used the action of the *dharma* to drive it away. Since the people had benefitted from this, everyone felt the impulse to make joyful donations. They therefore founded the temple building in order to perpetuate these achievements. They established farmland to feed its numerous members. The monks further built a sequence of pagodas along the mountain summits, and constructed a pavilion to Guanyin [Dashige 大士閣] on the brink of the cliff. Nothing was left undone to make it secure and well-endowed ...

As the years passed, it prospered and decayed in cycles ... In 1658 [when the region was conquered for the Manchus by Wu Sangui 吳三桂] the entire temple was burnt by the scattered [Ming] troops, leaving a pile of cold ashes buried under shattered tiles. The temple’s tenants [*sidian* 寺佃] then took advantage of this opportunity to appropriate [the land] and conceal [what they had done] by dropping the stone steles [inscribed with the locations of

²⁷ The second character of this name is doubtful, owing to the blurred reproduction of a photocopied map.

²⁸ Duan Jinlu, *Dali lidai mingbei*, pp.150–3.

²⁹ Ibid., pp.447–9.

³⁰ Ibid., pp.17–19. The braces ‘{...}’ indicate a character missing in the Chinese text. We have supplied a plausible replacement.

³¹ Christian Daniels, in a note on the meaning of *dian* 甸, stresses it has both a topographical and an administrative sense. ‘Domain’ captures something but not all of this. Personal letter to M.E. of 3 May 2001.

³² Duan Jinlu, *Dali lidai mingbei*, pp.198–9.

the fields owned by the temple] to the bottom of the lake, and abandoning the multitude of monks to [the mercies of] strangers.²⁹

A consortium of gentry and monks used old rent-books and trickery to wrest back seventy to eighty per cent of the land, and re-established the temple’s endowment. What is important, though, is that farming here could support what was evidently a substantial religious foundation from quite early times.

The most extensive inventory of an endowment that we have for the Wase area comes from an 1198 inscription for the Gaoxing Lanruo 高興蘭若. This was evidently a full-scale monastery, though the Sanscrit *layana*, of which the second word is a transcription, just means a place for meditation or a hermit’s cell. “Two units of housing for the monks” (*sengfang er jian* 僧房二間) are mentioned. Gaoxing village lies about four kilometres inland from Wase itself. The legible parts of the text are too fragmentary for detailed analysis, but list gifts of numerous plots of farmland, as well as of another type of land whose nature is unclear, gardens, groves of trees, and even two head of cattle and two slaves or serfs (*nu* 奴). If the fifteenth-century convention of using *jiao* (here written 腳 rather than 角) as the unit for irrigated fields applied at this earlier date, then the Gaoxing Lanruo had an abundance of them, but there is no internal evidence to support this, except perhaps that the *he* 禾 in *hedi* 禾地 ‘grain land’ most commonly refers to rice. The technical terminology for units of land is hard to unravel. There is also no mention of water, unless we include the lines from the rhetorical introduction: “When the gorge [*jian* 澗] [runs with water] the colour of spring grows and fills [the world]; when the Liquidambar tree [*feng* 楓] loses its leaves, the autumn harvest first [begins to ripen].”³⁰

The comparatively slow pace of development outside Wase and Haidong is shown by an inscription from 1444 on the creation of an endowment of real estate for the Stone Bell Temple (Shizhong si 石鐘寺) on Mount Jizu:

Jizu, ... having an altitude that nothing transcends, the birds cannot fly over it, and human beings cannot climb it. People of an earlier time established a temple in a hollow in the mountain, calling it ‘Stone Bell’, to offer a reception to those who came and went. Since it has not had a permanent endowment [*changzhu* 常住] for a long time, if the monks depart it will not be able to endure. Recently, in 1411, the local pious donors [*tanxin* 檀信] Wang Song, Li Nu, Dong Jun, and Wang Qing, collectively put forth their strengths [*chuli* 出力, possibly ‘their money’] to clear the Liandong dian [a level area surrounded by mountains]³¹ for farming. They obtained a section of fields [*tian* 田] amounting to several *mu*. They joyously gave this to be the permanent endowment of this temple.³²

Stone Bell Temple lies to the southeast of the summit, about 5 kilometres away near the head of a small river valley, above Shazhi 沙址, just outside the Erhai catchment. We have not been able to locate Liandong dian, but it is likely to have lain in this direction. The point is that the donors did not give land already being farmed, presumably because there was none available, but had to open it up themselves.

For the period after the middle Ming we know from travelogues and poems that the east side was mostly still a world of old-growth pine trees, swift but exiguous brooks and waterfalls, and temples perched on vertiginous summits. Also of stupendous views across the lake to the snow-clad Diancang mountains, and miraculous transfigurations of sunlight and mist that became, in the minds of the Buddhist faithful, apparitions of the Buddha.

A passage from the “Record of Mount Jizu” (Jizu shan ji 雞足山記) by Feng Shike 馮時可 on the start of the ascent of this mountain conveys the general tone of the Ming tourist literature and the incidental information embedded in it on topics like the uses of water and the survival of the original vegetation cover:

We went from Binchuan 賓川 to Liandong 煉洞, first passing through Monk’s Village [Heshang zhuang 和尚庄]. People’s homes here rest against the trees and are flanked by streams so that all the village consists of level bridges and cool ripples. Fragrant plants shine at each other and intertwine their charms, resembling in this the scenery of the lower Yangzi valley. When we had travelled on for about ten kilometres, and followed the mountain track, we entered a wooded valley where the rocks were richly coloured and the streams ran burbling by. The shade cast by the trees was like that within a tent.

After a very long time we came to the Celestial Raiment Bridge [Tianyi qiao 天衣橋], where the trees were still huger and more ancient, and the leaping springs even fiercer. When we reached the Jiedai Temple [Jiedai si 接待寺] we could see the Pavilion of the Goddess of Mercy (Dashige) rising on high in the distance, a signpost pointing to heaven [*tianbiao* 天表]. The tattered cloud wrack and broken mists blazed above the many-tiered precipices.

After taking three or four turnings through the woods and then making our way forward, there was another small pavilion, encircled by mountains to its front as they rose around it, one level following another. After this the mountains became more profound and the trees more closely set, hiding and overshadowing one another. The flows from the springs responded to each other as they drummed and rang like bells and chiming stones. On the facing slopes of the mountains a tea-house ... half emerged above the tree-top twigs. At its side a stream broke into a suspended waterfall, the lights in its mists reflecting down a thousand fathoms. After a long while we came to Stone Bell Temple where the ridges joined together and the eminences were piled up, continuously enfolding each other, while the pale green of aged trees³³ reached to the skies and the angled hills were clad with thick vegetation that grew in profusion without ever coming to an end.³⁴

A somewhat different picture emerges from a description of much the same route by Wang Shixing 王士性, a late-Ming statesman and traveller:

There are numerous bare ridges on all sides, and small summits on which nothing grows. It is only on this mountain [Jizu] that conifers [*song shan* 松杉³⁵] are dense and intertwined, a place where the clouds linger I came in from the southeast [that is, Binchuan] and first of all there was Stone Bell Temple. Several hundreds of paces to its east was the Black Dragon Pool [Heilong tan 黑龍潭] whose bubbling water flowed out through the floating fields [*fengtian* 葑田].³⁶

³³ Since a well-established hard-wood canopy may have had only limited regenerative undercanopy, it is possible the later conifers on this mountain were a successional species brought about by an earlier clearance.

³⁴ Qian Bang (Ming dynasty), comp., Fan Chengxun (Qing dynasty), rev., *Jizu shan zhi* [Gazetteer for Jizu Mountain] (printed 1692), pp.503–4.

³⁵ *Shan* can cover many genera. Thus at the present day *Yun shan shu* 云杉屬 is used for *Picea*, and *Leng shan shu* 菱杉屬 for *Abies*, while *Shanmu* 杉木, *Cunninghamia lanceolata*, is the only species given as specifically ‘shan’ in Xue Jiru et al., *Yunnan senlin* [The forests of Yunnan] (Kunming and Beijing: Yunnan Keji and Zhongguo Linye, 1986), and identified only by this name (pp.543, 547, and 548).

³⁶ Qian Bang/Fan Chengxun, *Jizu shan zhi*, p.500. Emphasis added. Another possible but much less likely reading of *fengtian* is ‘fields of rape [-turnip]’. *Brassica rapa* L. (Rapa Group), classically most commonly *wujing* 蕪菁, was anciently known as *feng* 葑 in parts of the region between the Yellow River and the Huai River. See Chen Guiting, ed., *Bencao gangmu tongshi* [General explanation of the *Materia Medica* (of Li Shizhen 李時珍, 1596)], 2 vols (Beijing: Xueyuan Chubanshe, 1992): 2, p.1331.

³⁷ Ibid., p.238. See the text reproduced in Figure 4.

³⁸ Ibid., p.239.

³⁹ Visit by M.E. and D.C., March 2001. See also Li Kunsheng, *Yunnan kaoguxue lunji*, p.30, on a ceramic 'water dripper' (*dishui* 滴水) found in the excavations of a Southern Kingdom building.

Floating fields were wooden frames filled with earth and vegetable matter that were tethered to the bottom of a pool, so they could rise and fall with the level of the water. No watering was needed, and they were an ingenious way of growing cereals with a minimum of labour. We have, however, found only one reference to irrigation proper. This is for the Cloud-Stopping Spring [Tingyun quan 停雲泉].³⁷ Sophisticated hydraulic skills existed, but we only hear about them from the sources when they were used for purposes more newsworthy than farming:

The Bathing Tower Spring [Yuta quan 浴塔泉] comes out from the eastern peak of Mount Xigu [Xigu shan 西顧山]. Its leaping currents set the mists dripping and its waves splash the snows as they pour forth. The monk Tiji 體極 from the monastery of the Zunsheng Tower [Zunsheng ta 尊勝塔] made some tiles into piping, and drew the water from the southern foot of Mount Xigu across to the northern ridge of Mount Wenbi [Wenbi shan 文筆山]. These two mountains confront one another, each of them being an elevated location. He made a conduit between the two sides that rose up [again] from the bottom, in such a way that the water flowed down into it [at one end] and leapt up out of it [at the other], a reverse current that never stopped. He collected [the water] to make a pool where fish were reared, and it could be drawn upon for drinking. The ingenuity in this embodied supernatural craft ... His disciple Miaoji 妙濟 replaced the ceramics with copper [pipes] and drew [the water] into the monastery itself. He excavated a separate rectangular pool in the centre of which he built a small pavilion. The water flowed around it on the level so that it seemed like a landscape from the isles of Fairyland [Pengdao 蓬島]. Visiting travellers and the scions of official families all stop there for a couple of nights and together take delight in it.³⁸

In other words he installed a siphon. It is likely that this drew upon an earlier local Bai tradition of piped water. There is a piece of cylindrical ceramic pipe in the Dali Municipal Museum (Dali shi bowuguan) that comes from the Dengchuan area and dates to the late Nanzhao or early Dali period³⁹ (Figure

3). The later shift to copper piping suggests access to a high level of metallurgical skill.

This mixture of simplicity and sophistication suggests that the Jizu mountain economy was to a considerable degree dependent on an inflow of outside income, whether the donations of the pious or the contributions of tourists. It does not seem to have had an adequate local economic base in intensive agriculture, and probably—although we cannot be certain about this—imported some of its supplies from areas lower down.



Figure 3

Ceramic piping from the Dengchuan area (north side)—(on show in the Museum of the Bai Nationality in Xiaguan)



2.5 The South Side

During late-imperial times, the administrative unit on the south side was a 'department', Zhaozhou 趙州. Only that portion of it northwest of the Dingxi Range (Dingxi ling 定西嶺), which rises to over 3000 metres and was called the 'Kunmi shan' 昆彌山 before the Ming dynasty, falls in the Erhai catchment. The name of its capital today has been changed to Fengyi 鳳儀 and the area under its jurisdiction is much smaller than it used to be. The part that concerns us here is mainly the valley of the Boluo River, with its eight or so short tributaries and its divided double mouth emptying into the Erhai.

Once Zhaozhou had recovered from a period of decline between the Han and the Tang dynasties, approximately from the third century to the end of the sixth, it seems to have become a prosperous area based on irrigated farming.⁴⁰ It was on the edge of a more economically sophisticated world that was linked with Kunming to the southeast. The following passage from *The Book of Barbarians* written by Fan Chuo about this world in the ninth century is therefore useful as background, though Zhaozhou's relative marginality needs to be remembered:

South of the prefectures of Qu 曲 and Jing 靖⁴¹ and west of the Dianchi 滇池,⁴² local customs emphasize irrigated fields [*shuitian* 水田]. They do plant hemp, beans, and millets, but only in the spare land beside their houses. There is only one harvest of these a year.

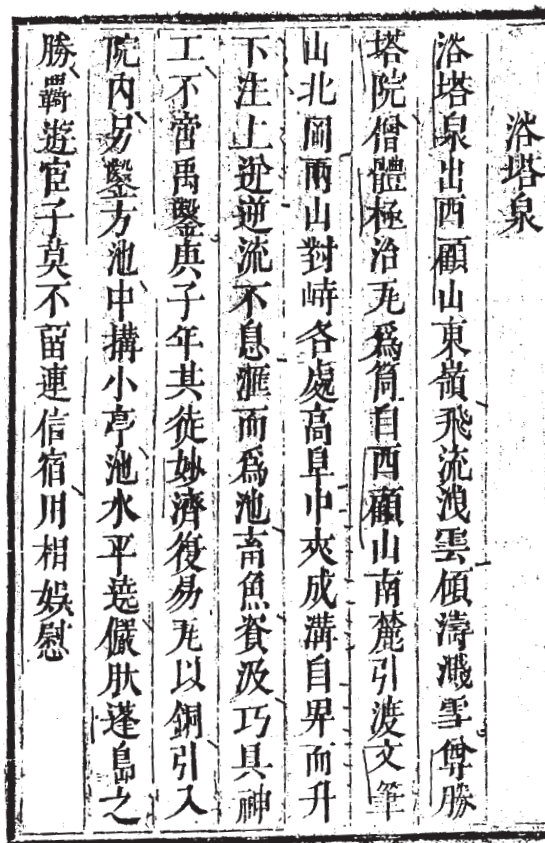
Between reaping the rice in the eighth lunar month to the transition from the eleventh to the twelfth lunar month they plant barley in the rice fields, to be harvested in the third and fourth months. After they have harvested the barley they once again plant rice. Wheat is planted on ridges. In the last ten days of the twelfth month, [the stalks] are already pulling away from their nodes. In the third month the wheat and barley are reaped at the same time. The wheat flour is soft and pasty, with but little flavour. Most of the barley is used for grilled grain, and has no other uses. For fermenting wine they use rice for the yeast [the literal translation], but the taste is acidic and unpleasant.

When they plough the fields they use the three-foot-long plough with a yoke-frame [*ge* 格] more than 10 feet long, and two oxen some seven or eight feet apart from each other. One tenant-farmer [*dian* 佃] in front leads the oxen. One manages the shaft of the plough while a third controls the plough[share?].

The barbarians are extremely expert in dealing with mountain fields. All of them are subject to the inspections and urgings of the barbarian officials

Figure 4

Description of the construction of a siphon by the monk Tiji from the *Jizushan zhi* 雞足山志 (*Gazetteer for Jizu Mountain*). The siphon was originally made of ceramic piping (see Figure 3), but later replaced by copper (discussed on p.18)



⁴⁰ Revd Chen Zhaotang, *Zhaozhou zhi* [Zhaozhou gazetteer] (1838; 1914 [prepared for publication by Li Qixing]; reprint ed., Taipei: Chengwen Chubanshe, 1975), pp.6-7.

⁴¹ In later times joined into one as 'Qijing', which was located at about 25° 30' N and 104° E.

⁴² Kunming lake, at about 24° 50' N and 103° E.

⁴³ Fan Chuo, *Manshu*, 10: 30a–31a.

⁴⁴ Reading *nue* 虐 as *nue* 瘧.

sent out by the barbarian generals in the walled cities and towns. Any such supervising barbarian who is observed soliciting wine or food [from the farmers] is beaten to death under the blows of a heavy bamboo

For watering their fields they all use springs, and are unharmed by either floods or droughts.

When the harvest is completed the barbarians holding official positions allocate the rice according to the number of people in each tenant's family. The remainder goes into the official [granary].⁴³

The economic and military social systems were thus tightly organized by the state at this period.

When, close to four centuries after Fan Chuo, Guo Songnian 郭松年 made the journey he described in his *Record of a Trip to Dali* [Dali xing ji 大理行記] some time between 1280 and 1283, and about thirty years after the Mongol conquest of the area, he came along much the same line, travelling from Kunming in a northwesterly direction. We take up the account where he came into the prefecture of Dali though not quite yet into the catchment. It is clear that there was still a southeast to northwest gradient in the quality of farming practice:

After one has voyaged for fifteen kilometres [from the circuit frontier] there is a farmland domain [*dian* 甸], a sort of agricultural 'oasis' surrounded by mountains]. Its streams and plains are gentle and level, the topography of its mountains encircling and enclosed. Its circumference is over a hundred kilometres [hence about 33 km across]. This is the department of Yunnan

Travelling on west again for more than fifteen kilometres one reaches the farmland domain of Pin [Pin dian 品甸]. Its rivers and wetlands are no less good than those of Yunnan [department], but the people do not reach the latter's level in their farming. There is a pool called the 'Blue Lake' [Qinghu 青湖] in this farmland domain, and the benefits from its irrigation reach as far as the cleared lands of Yunnan [department]

Travelling through the mountains for a further fifteen kilometres one comes to the White Cliff farmland domain [Baiyan dian 白岳甸]. Its topography is aligned from north to south, and its scale is about the same as that of the Pin farmland domain in Yunnan [department]. The inhabitants are densely concentrated. Grain and hemp completely fill the cleared land

Travelling on through the mountains for another twenty kilometres one comes to the Zhaozhou farmland domain [Zhaozhou dian 趙州甸], otherwise known as the 'Zhaotan' 趙澗. The formation of the mountains embraces it on all four sides. The position-power of its site is one that gives shelter from the winds and concealment from the [harsh] aethers. Its rivers and wetlands are level and spread widely about. There still remain some tall and stately trees around the homesteads of ancient families. The Shenzhuang River (Shenzhuang jiang 神莊江) threads its way through the middle, irrigating a hundred thousand *mu* of land [7000 ha, presumably an exaggeration]. For this reason the common people are rich and numerous, and there are few disasters due to drought or [malarial] fevers⁴⁴

Seven and a half kilometres after leaving the capital of this department the road winds back and forth, and the mountains encircle one. There are dense

woods and tall bamboos, luxuriant, deep-set and fine to behold. Among them arise peaks on which are holy temples. Whenever there are floods, droughts, or epidemics, prayers offered here are fulfilled, and the people of the department depend on them.⁴⁵

The Shenzuang is presumably the Boluo under another name, but we have not been able to confirm this.

Irrigating from springs gave a welcome stability when faced with the uncertainties of variable weather. The mid-sixteenth-century gazetteer for Dali observes of Zhaozhou on the south side of the Erhai:

There is a spring below Wufo shan 五佛山 [Five Buddhas Mountain] *that never dries up and never overflows*. It is called the ‘Spring of the Sages’ [Shengquan 聖泉] To the east of the department capital [of Zhaozhou] are Mount Longbo [Longbo shan 龍伯山] and Mount Fengyi [Fengyi shan 鳳儀山]. In this range is the Dragon Spring [Longquan]⁴⁶ that is capable of irrigating over ten thousand *mu* of land.⁴⁷

The disadvantages of stability of this sort were a limit on easy further growth once the water was being fully shared out, and little challenge to innovate as compared with intensifying the competition for increasingly scarce resources.

An illustration of this environmentally driven tendency to conflict is provided by the Dongjin Lake 東晉湖 which lay some way to the northeast of the department capital.⁴⁸ The immediate cause of the antagonism between what were apparently two different ways of using the lake is not clear. Perhaps the best suggestion is that made by Christian Daniels that the clash may have been between an older style of irrigation that relied on the natural rise and fall of the water following the seasonal variation in rainfall, and the later, more tightly disciplined, style with retention basins, sluices and channels. The first was probably mainly used for grains that were coarser but more resistant both to flood and drought than rice (mostly *Echinochloa* spp, that is ‘barnyard millets’). The crop was grown on the intermittently flooded areas, known as *shuijiaodi* 水澆地, or ‘water-sprinkled land’.⁴⁹ The second system was used for rice.⁵⁰

A general background description was written by Han Qi 韓槩 ... , applying to a date that is not at present clear but may be early to middle Ming:

The water enters gradually and never stops, ... but it is not deep at the moment. The lake is rather more than five kilometres around, and it is traditionally said that there are nine dragons in it. Thus it springs from more than one source There are several hundred *qing*⁵¹ of fields inside and outside the lake, all of which depend on it for irrigation. It never runs dry in winter, and never overflows in summer. It does not dry up during droughts, and does not burst its dykes when there are floods. The advantages it confers are on a par with those from the Luo River [Luo jiang 羅江]. A lock [*zha* 閘] has been installed at the mouth⁵² of the lake. After the grain [*gu* 穀] has ripened, it is closed in order to store up the water. After the wheat [or ‘barley’] has been reaped [in the spring, and presumably in the fields below it], it is opened to drain out the water [to provide the right depth of a few inches for the transplanted

⁴⁵ I have used the text and commentary in Fang Guoyu, *Yunnan shiliao congkan*, vol.3, pp.133–7.

⁴⁶ The term ‘dragon spring’ seems also to have been a generic designation in Zhaozhou, that is, it was a *type* of spring.

⁴⁷ Li Zhiyang, ed., [*Jiajing*] *Dali fuzhi* [Jiajing reign-period Dali prefectural gazetteer], 1563 (incomplete). Microfilm from “Rare Books, National Library, Peiping” in the Menzies Library, Australian National University, roll 487, microfilm #1055), 2:11a. Emphasis added.

⁴⁸ The account that follows is based mainly on Han Chen 韓辰, “A record of the establishment of the lock on the embankment for Dongjin Lake,” in Chen Zhaotang/Li Qixing, *Zhaozhou zhi*, pp.489–92, and Han Qi, “A record of Dongjin Lake,” in *idem*, pp.584–6.

⁴⁹ This system would also have worked well on the west shore of the Erhai, given the annual rise and fall of the water level, but we have no evidence that this occurred.

⁵⁰ See C. Daniels, “Roko-ko ni okeru hie saibai no rekishiteki ichi” [The historical position of the cultivation of barnyard millets at Lake Lugu], in *Shisen no kōko to minzoku* [The rivers, lakes and peoples of Sichuan], ed. C. Daniels and Watabe Takeshi (Tokyo: Keiyūsha, 1999), for a description and photographs of a lake at 2685 m. above sea level where this old practice still, possibly uniquely, has survived. The suggestion that this might be relevant to Lake Dongjin was made in a letter to M.E. of 23 August 2001.

⁵¹ 100 *qing* = 104 *mu* = 700 hectares.

⁵² Presumably the outflow.

⁵³ *Dalbergia* spp, a hardwood used to make furniture. Species in Yunnan include *assamica*, *latifolia*, *stipulacea*, *szemaoensis*, and *tamarindifolia*.

⁵⁴ Chen Zhaotang/Li Qixing, *Zhaozhou zhi*, pp.584–5.

⁵⁵ *Gu weizhushui zhi hu* 古為瀨水之湖. Emphasis added.

⁵⁶ Chen Zhaotang/Li Qixing, *Zhaozhou zhi*, p.160.

⁵⁷ Literally, ‘a bridge’ (*qiao* 橋).

⁵⁸ Duan Jinlu, *Dali lidai mingbei*, pp.296–7.

⁵⁹ The double contrast with ‘officials’ and ‘soldiers’ is needed in this context.

⁶⁰ Duan Jinlu, *Dali lidai mingbei*, pp.296–7.

⁶¹ This last phrase is our best guess for a Chinese character that appears in none of the common dictionaries. It is contrasted later with ‘irrigation’.

⁶² When what was happening would not be too apparent.

⁶³ Chen Zhaotang/Li Qixing, *Zhaozhou zhi*, p.490.

rice seedlings both inside and outside the boundaries]. The authorities make sacrifices of animals at the proper dates to return thanks for the services it provides. There are numerous *tan* 檀 trees⁵³ and peaches along the dykes and the edge of the fields. They shine in the warmth of the springtime, the red of their blossoms running between the slopes and the sunlit surging of the countless acres, now disappearing now reappearing among the blue-green mountains and the verdant trees.⁵⁴

Another account in the late-Qing-dynasty local gazetteer repeats much of this but also reveals the human conflict beneath the surface idyll and hints at past changes in its structure: “There are nine springs that never run dry either in winter or summer. *In the past* they formed a lake in which water was stored.⁵⁵ During the winter it accumulated, and in the summer it drained out to irrigate and care for [crops].” It was used, or meant to be used, both by the soldiers from the local military guard station and by civilians in seven of the villages nearby.⁵⁶ “If one looks to the south of the lake today, there is a dyke that is solid and broad. The far-seeing intentions of the men of past times are imposingly evident. A gap has been cut away that would [once] have served as a point of passage⁵⁷ that could control [the water] by opening and closing [a gate]. One can believe without hesitation that it was [once] a retaining embankment.” In 1490⁵⁸ the General Circuit Supervisor Lin Jun 林俊 was trying to raise the funds for building a wall round the capital, and “found by examination that the lake-fields had been self-servingly concealed by powerful people who paid no taxes on them. He sold these off to the commoner-civilians [*min* 民],⁵⁹ lightening their taxes but taking the price.”⁶⁰ This was a squeeze-play as the commoner-civilians needed irrigation water and felt obliged to produce the funds.

“The topography of the lake was such that it was deep on the west side and shallow on the east.” This implies that it lay on the eastern side of the Boluo river, presumably where there is a wide and for some distance a very gently sloping side-valley. Its dimensions were given as roughly those of a rectangle, twice as long in a north-to-south direction as in the east-to-west one, but it has proved impossible to determine its precise location on the modern map, in part because the distances given in the gazetteer seem too large. This spatial structure was at the root of the corruption of another sort that now ensued: “When the [level of the] water fell, so covering the land to a moderate depth [?],⁶¹ it was possible to sow crops [*boyi* 播藝]. The commoner-civilians of the village of Hanyi [Hanyi cun 漢邑村] to the east of the lake profited from this, and made a corrupt deal with those who managed the outflow of the lake: [the lock] would be closed in the evenings⁶² and opened during the day time. Thus the water was retained [*chu* 畜], and those [villagers] who had not had enough of it [now] had good harvests. In 1553 the soldiers in the military colonies laid a plaint about this with the authorities, asking for a sharing out of the water [so they could use it] for [proper] irrigation. [The authorities] sent the magistrate of Zhaozhou department, H. E. Pan 潘, to deliberate on this problem.”⁶³ Pan discovered that the malpractice had been going on for a long time, and he asked

rhetorically which had more wide-spreading advantages, ‘covering the land to a moderate depth’ or irrigation, the answer obviously being the latter, at least in his eyes. He berated the commoner-civilians for their unprincipled selfishness, which was likely to bring down supernatural displeasure, and put the power of hydraulic management into the hands of the soldiers led by Battalion Commander Zong.

Mr Zong thereupon engaged craftsmen from the neighbouring counties, bought materials from the mountain valleys, and they hollowed out the rock to make basins that resembled the structure of the storeys of a building [*ru lou zhi zhi* 如樓之制]. In the stones that formed the edge of each storey [*lou zhi fanshi* 樓之坂石] they made three apertures. In each of these they placed posts to serve as locks [*suoyao* 鎖鑰] in the fashion of door-bars [*jiong* 扃]. As a consequence of this the water did not leak away, and the proper seasons were observed for opening and shutting them.⁶⁴

⁶⁴ *Ibid.*, pp.491–2.

⁶⁵ *Ibid.*, pp.492–5.

It would seem that the old lake thus disappeared as such and was replaced by basins arranged like shallow steps.

It has not proved possible so far to put the chronology of all the episodes in this story on a sound foundation, and some of the details remain conjectural. What is clear is the particular characteristics of southside spring-fed farming: the combination of the stability of the supply of water, irrespective of weather, with the creation of social and economic tensions deriving from the limited quantity available, and maybe also from a clash of technologies. We should modify this picture by adding that both the reality and the fear of drought were strong in Zhaozhou even so. During the great drought of 1547, for example, Magistrate Pan induced a dragon associated with a local spring to manifest himself (or possibly herself in this case) and produce a downpour by promising to construct a handsome shrine as a reward. This was done and he declared, “My people need no more be afflicted by drought.”⁶⁵

The environmental history of the Erhai catchment has thus to be approached with a constant awareness of the differences between the four sides of the lake. Similar circumambient conditions, notably those relating to the climate, could have a markedly different effect on each of them, depending on topography, drainage, and soils; and, it is reasonable to conjecture, also prompted differences in what was thought important to record.

3.0 *The Ming Prelude to Environmental Crisis*

The events at Dongjin Lake reconstructed in the last section lead into the theme of the present section, namely the intensifying of pressure on resources during Ming times (1368–1644), without this as yet leading to serious environmental, as opposed to human, consequences.

We begin with a prelude, picking up Guo Songnian’s *Record of a Trip to Dali* in the Yuan where it broke off in the preceding section:

⁶⁶ *Xuanliu* 懸流, literally 'hanging currents'.

⁶⁷ *Wang zhi weiran qianchenzhe, nai Diancangshan zhi benchongye* 望之蔚然前陳者，點蒼山之奔沖也—perhaps a poetic intuition of the huge alluvial fans?

⁶⁸ *Xianjie bu rong* 纖芥不容

⁶⁹ Reading *xue* 雪 'snow' as *lei* 雷 'thunder'.

⁷⁰ I have used the text and commentary in Fang Guoyu, *Yunnan shiliao congkan*, vol.3, pp.133–7.

⁷¹ Li Zhengqing, *Dali Xizhou wenhua shikao*, p.77.

⁷² Duan Jinlu, *Dali lidai mingbei*, pp.112–15.

One goes by river for fifteen kilometres until one reaches Rivertail Pass [Hewei guan 河尾關, the present-day Xiaguan, 'Lower Pass' or 'frontier barrier']. This is where the Er Water [Er shui 洱水] flows out. They have built a framework of wood to form a bridge whose length is more than 150 feet. It drinks the water through its arches [*qiongxing yinshui* 穹形飲水] ... About half a kilometre or so downstream there is a stone gate made of huge rocks in a transverse structure [*henggu* 橫柵] and known as the 'Stone Horse Bridge' [Shima qiao 石馬橋]. This is where the multitudinous waves fight for a passage, and the cascading currents⁶⁶ pour down with a rush ... Their sound can be heard a kilometre or more away ...

Seven and a half kilometres after entering through the Pass, [going north up the west shore of the lake] the mountains and valleys are abundant and attractive. When looked at from a distance they are a densely luxuriant front line of battle, or in other words the swift onrush of the Diancang mountains.⁶⁷ The peaks are arrayed in lines, in irregular sequences. The walled city [of Dali] lies below them ...

As for the Diancang mountains, that ridge that runs in a strip from south to north for more than fifty kilometres, with their peaks and precipices, their clouds that coil about them and their cover of snow that never melts throughout the four seasons of the year, their high streams drain down from above into the lake, and their springs spurt forth their bubbling waters. The mirror of the Water [the Erhai] is pure and clear and does not contain any minute plants in it,⁶⁸ while the reflections of fine trees and rare herbs shine inverted in it, being the dwelling of holy dragons who magically bestow their

epiphany when prayed to in years of drought. [The ridge] spreads out into eighteen streams that flow in cascades and fly out in waterfalls, draining in the spaces between the multitudinous peaks so that, when the thunderstorms⁶⁹ rumble and roar, and mists obscure the heavens, the advantages [from these phenomena] are distributed around, since all of them can be used for irrigation.⁷⁰

Like many tourist accounts this may have been written in ignorance of the social tensions beneath the surface beauties. We don't know what these may or may not have been, in part because the Ming conquest involved the destruction of the Dali archives,⁷¹ as well as of monasteries that had libraries.⁷² This has left a black

Figure 5

Diancang sunset, Dali. The city of Dali lies up close against the eastern side of the vertiginous wall of the Diancang Range. 'Sunset' thus comes here several hours before it does to the mountains above the eastern shore of the lake (photo: M.E.)



hole in our knowledge of Erhai history. For this reason, many phenomena that seem to appear in the Ming may well have predated this dynasty. In the case of the hydraulic administration of the Eighteen Streams, however, it is likely that the forcible settling of Ming military colonists side by side with the civilian population did lead to new problems.

Pressures on the supply of water can be shown most clearly for Binchuan, which was in the original Dali prefecture but just outside the catchment to the east. A stele on the rules governing the allocation of water, dating from 1692, records an attempt to settle a quarrel that had run through the greater part of the preceding Ming dynasty. It was about what it described as “tiger-like gangs [*huohu* 伙虎] throwing the system into disorder, and using their position of power to dominate unlawfully the regulations for water.”⁷³ Fourteen soldiers, from three military villages (*junwu* 軍伍) in Daluo Guard (Daluo *wei* 大羅衛), had submitted a complaint to the authorities. They made the following points: In 1398 they had been allocated military colony land (*tuntian* 屯田) in Zhang, Bu, and Xiamei 張，卜，下梅, an area already held by the Lijiao Battalion (Lijiao *ying* 利交營). It had originally paid over seven hundred piculs of grain as land tax, but had “only the water from one ravine [*jing* 箐], that of the Dragon King Temple on the Eastern Mountain, with which to irrigate.” In 1494 the soldiers had come under the administration of the new civilian Department (*zhou* 州), on the same terms as before as regards taxes and water, but,

The Luoluo 猓獠 [tribesmen led by] Zhou Neng 周能 unexpectedly dug open the uncultivated mountains and occupied them. In no time at all they had sent a report of this to the Mu [Family] Mansion [Mu (shi) fu 沐(氏)府]⁷⁴ and paid in grain as tax. As a result the Mu Family Mansion sent an official to investigate this village that had reported for payment, and he found that Zhou Neng’s village was waterless [*ganzhuang* 乾庄]. He thereupon requested water from the official soldiers of the three villages of Zhang, Bu, and Xiamei. The soldiers at that time [that is, the Ming dynasty] were infantrymen under an Imperial Duke [*Guogong* 國公], so how could they dare to disobey? They thereupon transferred 8 inches of drinking water [*song shishui bacun* 送食水八寸] [a deliberately misleading humanitarian categorization?]. This at once became an established rule.

How could the soldiers have foreseen that with the passing of time the power of the position held [by the others] would have increased to the point that they would actually have [the access to their water] unlawfully blocked off? This caused the wet and dry fields of the three villages to be left uncultivated.⁷⁵

During the sixteenth century the military authorities intervened to remedy this problem—an instance of the commonly-found dominance of those upstream over those downstream in an irrigation system. They reaffirmed the quotas, and set up “channel apertures with sluice boards [*shuiban qukou* 水板鉅口]⁷⁶ for the equitable release [of water].” In 1659, however, the villages under the Mu Family Mansion rallied to ‘Prince Wu’ 吳王 [presumably

⁷³ *Ibid.*, pp.451–3.

⁷⁴ The form with *shi* 氏 appears later in the inscription. Presumably this refers to a local indigenous ruling family.

⁷⁵ Duan Jinlu, *Dali lidai mingbei*, p.451.

⁷⁶ Reading 鉅 *ju* = ‘hard’ as *qu* = 渠 ‘channel’. The unvoiced initial is a possible variant. See H. Giles, *A Chinese-English dictionary* (Shanghai, 1912; reprint ed., Taiwan: Jingwen Shuju, 1964), #3112.

⁷⁷ Hence 'Prince Wu' seems a better translation than 'Prince of Wu', which he was not. See A. Hummel, ed., *Eminent Chinese of the Ch'ing period*, 2 vols (Washington, DC: US Government Printing Office, 1943–44): 2, pp.877–80.

⁷⁸ Reading *gui* 究 as *gui* 軌 in the phrase *bugui* 不究

⁷⁹ Duan Jinlu, *Dali lidai mingbei*, pp.451–2.

Wu Sangui, the semi-independent Chinese general who had allied himself with the Manchus, destroyed the remnants of Ming power in the southwest, but later rebelled against the Qing⁷⁷. The officials whom he deputed relied on the power of their position to act tyrannically. "They took all the water in the ravine and held it forcibly. They unfeelingly compelled the lands of the three villages to be left unfarmed, taxes to be entirely unforthcoming, and the soldiers all to flee." This monopoly lasted for twenty-five years, but after repeated complaints had been lodged the situation was remedied. "It is fortunate," says the stele, still citing the points made by the complainants, "that today the village(s) of the Mansion have returned to the [jurisdiction of the] Department." Some of the "tiger-like rogues" had, however, continued "treacherously to plot improper actions,"⁷⁸ They had refused to draw up the bonds they had been told to provide, and "went from household to household apportioning silver, bribing and giving orders, relying both on wickedness and on money, inciting the former magistrate H. E. Zhou 周 with their falsehoods, and wanting to use the lands of the Mansion that paid exactly 3 piculs [of tax] unlawfully to swallow the water of the soldiers from the military and other villages that paid hundreds [of piculs] [*yu yi sanshiyouling fuliang zhi tian, batun junyu wu bailiangtian zhi junshui* 欲以三石有零府糧之田，霸吞軍餘伍百糧田之軍水]."⁷⁹

The response of the authorities was to have a former Company Commander and gentry from the Rural Compact system examine the old registers, and carve the quotas on stone to ensure "the equitable assignment of benefits from the water." Neither soldiers nor civilians were to resist or contravene these allocations. The amounts were defined in Chinese feet and decimal inches for each of six channel apertures as shown in the Table below:

Table 1

Water Quotas for Dragon King Temple Ravine in Binchuan, Dali Prefecture, 1692

Channel aperture	Recipient	Chinese feet	Centimetres
1	Zhou Neng's Village	0.8	25.6
2	Bu village soldiers' water	2.8	89.6
	(Each of 2 branch channels [<i>zhequ</i> 折鉅])	(1.4)	(44.8)
	Office water [<i>zhishui</i> 職水]	0.4	12.8
	(Each of 2 branch channels)	(0.2)	(6.4)
	Transfer [<i>song</i> 送] to Jijia Village	0.2	6.4
3	Zhang village South Ditch soldiers' water	1.7	54.4
	(Each of 2 branch channels)	(0.85)	(27.2)
	Rent rice water [<i>zumishui</i> 租米水]	0.4	12.8
	(Each of 2 branch channels)	(0.2)	(6.4)
	Transfer to Yuanjue Temple	0.2	6.4
4	Sanbolang [<i>san bolang</i> 散波浪] water	1.2	38.4

	(Each of 2 branch channels)	(0.6)	(19.2)
	Transfer drinking water [<i>shishui</i> 食水]	0.2	6.4
5	Zhang village North Ditch soldiers' water	1.7	54.4
	(Each of 2 branch channels)	(0.85)	(27.2)
	Office water	1.0	32.0
	(Each of 2 branch channels)	(0.5)	(16.0)
	Huangpu water	0.8	25.6
	(Each of 2 branch channels)	(0.4)	(12.8)
	Guangbiao excavated ditch water	1.0	32.0
6	Water for Gangbai on Laoren Ditch	0.8	25.6
	(Each of 2 branch channels)	(0.4)	(12.8)
	Transfer drinking water	0.2	6.4
Total for 6 apertures, and 15 recipients, excluding bracketed items:		13.4	428.8

Source: Duan Jinlu, *Dali lidai mingbei*, p.452.

Note: The metric conversion uses the Qing-dynasty *yingzao* foot (*yingzao chi* 营造尺) of 32 cm. See Qiu Guangming, *Zhongguo lidai du-liang-heng kao* [A study of Chinese measures of length, capacity, and weight over successive dynasties] (Beijing: Kexue Chubanshe, 1992) pp.117–18.

If these data have been interpreted correctly, then Zhou Neng's village, which was entitled to about 6% of the total, could find a use for all of it, and thought it worth a prolonged struggle to get and keep possession of it. There was evidently already a strategic shortage of water in the easternmost part of Dali prefecture by Ming times. By 'shortage' we do not mean a situation that can be defined in any absolute way, but a persisting general strongly felt perception of unmet requirements. This would have been the result of a relationship between the number of would-be users, in other words population pressure, the need for water per unit of farmed area, and the efficiency in its use determined by contemporary farming technology in an economically competitive context. The accessibility of local water resources would likewise have been determined by that technology, in conjunction with the available financial means, organizational abilities, and other necessary inputs. It is usually easier, however, to see the symptoms of this condition than to analyze its precise causes. Since in rice farming the period when water is critically needed is when the seedlings are being transplanted, usually the very late spring or early summer, at the end of the third or in the fourth lunar month in this area, hence late April and May in the Western calendar, it might also be appropriate to sharpen this formulation to 'a strategic seasonal shortage'.

What did the feet and inches mean? Since the weather and hence the amount of water available varied from year to year, it is reasonable to guess that these measures determined the horizontal dimension of the inflow apertures, which were presumably of a standard shape.

⁸⁰ Ibid., p.129. A photograph of the rubbing and a transcription into simplified characters is on pp.126–9. We are grateful to Professor Daniels for drawing this inscription to our attention, and to him and the staff of the National Library of Australia for providing us photocopies of this transcription in unsimplified characters from the *Dali congshu* 大理叢書 [Collected documents from Dali] which is for the moment not available to us.

⁸¹ Christian Daniels, fax to M.E. of 3 May 2001.

This stele from Binchuan provides a background against which to understand another stele inscription that provides a somewhat similar set of quotas for the use of water for the Eighteen Streams area on the lower slopes of the Diancang Range in the economic heartland of the old Dali kingdom. This second stele was cut some time in the Xuande 宣德 reign-period (1426–35), and survived until some time after 1944, when a rubbing was made from it in the Dali Library. After this it was destroyed or disappeared.⁸⁰ The rubbing is not easy to read in some places, and it is reasonable to suspect that the numerals for the allocation of ‘shares’ (*fen* 分), which more often than not add up to a total of 10 for a given location (*chu* 畝), may have been mis-transcribed in all or most cases where they do not. This may possibly also be the case for other characters but there is no way of telling. Lexically, *fen*, commonly, though not always, carries the sense of ‘a tenth’ or ‘a hundredth’ (or, exceptionally, ‘a sixtieth’ in the case of clock time).

The heading of the inscription speaks of “the water regulations for the determination of shares between the soldiers and commoner-civilians in a total of 35 locations on the Eighteen Streams within the passes [*guanli* 關裡—that is, between Shangguan and Xiaguan] in the Prefecture and Guard of Dali [*Dali fu wei*],” whereas only 32 locations are separately listed. Two of the missing places can be accounted for by the subdivision of location 26, “water from the White Rock Gorge [Baishi jian 白石澗]” into 3 components, one of whose ‘shares’ sums to 10 and the others, as transcribed, to 9 and 7. It seems likely that the ‘shares’ referred to the time that a sluice gate could be open, this being another way in which a proportional distribution can be put into effect in spite of variations in the volume of the downflow from year to year. Except in specially noted cases, the ‘share’ was probably equivalent to ‘the right to draw off water during the hours of daylight’. The chief reason for saying this is the wording of the exceptions: the entry for location 1, “the West Mountain Gorge at the outflow [*hewei* Xishan jian 河尾西山澗],” does not use shares but says “the soldiers of the Left Subguard shall have 3 days and 3 nights, and the commoner-civilians 2 days and 2 nights;” while the entry for location 3, “the West Gorge of Yangpi Village [Yangpicun xijian 楊皮村西澗],” which does use shares, specifies that the water “is to be released throughout the daylight and night time.” Against this we have to put that the work of Tateishi Kenji 立石謙次 of Tōkai University 東海大学 on Menghua Prefecture (Menghua fu 蒙化府) (Wei shan 巍山) shows that in the early seventeenth century “10 days and nights was considered the old standard for water allocation.”⁸¹ It is necessary to be aware of the possible effect of local variations in hydraulic conditions: in the case of Dongjin Lake in Zhaozhou described in the preceding section, the villainy of the commoners of Hanyi Village was said to have had the sluice shut at night, so that water on their side could accumulate. Dali, likewise, was not necessarily in the same situation as Menghua.

Christian Daniels has speculated that the cases that at this time lacked the full 10 shares might reflect a reduction in the relative quota originally assigned

to a collective group of recipients.⁸² This relates to a point that emerges from the Binchuan case: once institutionalized, a fixed water-quota system tends to act as a disincentive to the further expansion of irrigated farming, unless the increase in cultivated land can be matched by a corresponding increase in available water. However easy in the early days of a system, this is likely, under conditions of fixed technology and climate, to become increasingly hard to achieve over time. (Once again, limits on our knowledge prevent us controlling properly at present for changes in the local climate during the last several hundred years of premodern times.) Fixed quotas are also an incentive to quarreling and water-theft, because the increases in farmed acreage that nonetheless occur exert an increased pressure to obtain extra water. There seems to be no direct evidence as to how any *de jure* adjustments were made, if they were.

The preamble to the Dali inscription runs as follows:

The Guard Commander of Dali Guard has to hand a submission from Company Commander Yan Bin, the director of the military colony fields of the Left and other Battalions, and others, regarding the soldiers of the military colonies, in which they state:

We have made an official inspection of each of the outlet locations of the rivers, ditches, ravines, and pools [*tang* 塘] originally belonging to the military colonies, for all of which there are regulations from the Hongwu 洪武 reign-period [1368–98] relating to the shares determined for the release of water by soldiers and civilian-commoners respectively. We would petition the branch [military] authorities [*xingsi* 行司] and the Prefecture of Dali they adhere to the periods and share quantities in these water regulations for the original allocations between soldiers and civilians, and, in accordance with what these rules prescribe, rotate the benefits of irrigating the fields and transplanting, *so that we avoid struggles to get possession [of water]* as the date for this approaches.

Seeing that the busy season for farming will soon be upon us, let each [of the petitioners] write out clearly item by item on a stele⁸³ the original regulations for the allocation of water that they have submitted. When the season comes for transplanting, they are to share out the water in the old way and irrigate the fields. *Struggling for its possession is not to be tolerated.*

The authorities went on to describe how they were sending out officials to ensure compliance, adding that “in each military colony, the soldiers and the civilians are to consult together about the fields and the locations, and without interruption check off the lock-gates [*changchuan dianzha* 常川點閘] [as they fulfil their times].” Finally, “If any persons have the audacity to struggle among themselves or to break the water regulations, it will then be appropriate to have an inspection and enquiry on the ground to clarify the facts, and put the offenders without fail in wooden neck-collars as a painful punishment.” The use of permanent and public records of reference for the sharing of water may be an indirect symptom of growing pressure of population on a limited resource.

⁸² Ibid.

⁸³ In Duan Jinlu, *Dali lidai mingbei*, p.127, *bei* is stated to stand for *pai* 牌 ‘warrant’ or ‘tally’. This does not seem to make such good sense in the present context, but it would be unwise to overlook Duan’s opinion. Emphasis added.

Table 2 presents the bare bones of the allocation scheme. The type of the source of the water is identified where stated, distinguishing between a 'gorge', a 'ditch', a 'pool', a 'spring'. Where the source-type is not identified, we have left a blank.

Table 2

Allocation of Water Shares in the Eighteen Springs Area, 1426-35
(in fen except where noted)

Number	Source Type	Soldiers' Water Shares	Civilian Water Shares	Total	
1	Gorge	3 days + 3 nights	2 days + 2 nights	10	*
2	Ditch	2 + 5	3	10	
3	Gorge	2 + 1	7	10	†
4	Gorge	3 + 2 + 2	3	10	
5	Pool	1 + 1 + 1	1	4	
6	Gorge	3 + 1	3	7	
7	Pool	1	1	2	
8	Gorge + Ditch	3 + 1	6	10	
9	Gorge	2	8	10	
10	Gorge	4 + 2	4	10	
11	Gorge	4 + 3 + 1 + 2	1	11	
12	Gorge	5	5	10	
13	Gorge	5	5	10	
14	Gorge	3 + 1 + 1	5	10	
15	Gorge	4	2	6	
16	Gorge	3 + 1	4	8	
17	Gorge	5	5	10	
18	Gorge	4	6	10	
19	Spring	3 + 2	5	10	
20	Gorge	3	7	10	
21	Spring	5	5	10	
22	-	5	5	10	
23	Gorge	4	6	10	
24	Gorge	5	5	10	
25	Gorge	3	7	10	
26a	Gorge	2	7	9	§
26b	Gorge	0	7	7	
26c	Gorge	3	7	10	
27	Gorge	4 + 2	4	10	
28	Spring	4	6	10	
29	Gorge	4	6	10	
30	Gorge	3 + 2 + 1	4	10	
31	Spring	4 + 2	4	10	
32	Spring	6	4	10	
34		152	162	314	

* Counting a day or a night as equivalent to one ‘share’ (*fen*).

† This entry, uniquely, specified that the water was to be supplied “throughout the day and night.” The values could therefore be taken as double.

§ This source is stated to have been “divided into three” [*fenkai san fen* 分開三分].

Seven out of 34 allocation groups thus summed to less than 10, and one to 11. Unless there are errors in the data, which faulty transcription makes a possibility in some cases, this looks like a system that once was regular, but whose regularity has become impaired over time. Those of the locations of the exceptions that can be identified are not particularly revealing. Location 16 is near or on the modern Jinqi 錦溪, the fifth stream south from the northern end of the Eighteen Streams (see Table 5 below, pp.57–8). It has the reputation of not causing disasters. In contrast, location 26 is the White Rock Gorge (Baishi jian), which is at the far north end of the Eighteen Streams, next to the modern Xiaqi 霞溪, and reputed to have a violent spate. The 1917 Dali county gazetteer notes that “In the summer and autumn every year, the waters from the mountain burst forth and routinely destroy farmland.”⁸⁴

The essential point for our present purposes is that this inscription shows that in the central part of the Erhai catchment during the early Ming period there was already a strategic seasonal shortage of water, with the military colonists the group most under pressure, and the need for government intervention to keep the peace.

The seasonal nature of the constraint is suggested by the observations of Xie Dongshan 謝東山 some time in later Ming on the start of his journey at the beginning of the winter from the west side to Mount Jizu on the eastern side:

“To climb the mountain,” I said, “but not to see the lake, is not a scenic tour.”

We ordered a rowing boat, and on the sixteenth day of the tenth lunar month set off early from the city suburbs. Wherever we looked there was nothing but fine arable fields. They went

Figure 6

The gorge above Butterfly Spring (Hudie quan 蝴蝶泉, see Map 2, a) and shrine to the God of the Mountain. West side of Erhai. The eastern flank of the Diancang Range is dissected by many such narrow gorges, the largest forming the headwaters of one or another of the Eighteen Streams. This gorge, which is among the smallest, was close to dry in March, when this picture was taken. A modern small-bore pipeline currently brings down drinking water from a spring near its summit, replacing a stone contour channel constructed earlier, but at an unknown date (photo: M.E.)



⁸⁴ Revd Zhang Peijue, *Dali xianzhi* [Dali county gazetteer] (1917; reprint ed. [ed. Zhou Zonglin], Taipei: Chengwen Chubanshe, 1974), Section on the Eighteen Streams, Xiaqi, appendix. The Xiaqi was the first of the ‘Eighteen Streams’, as shown on Map 2, and the eighteenth in Table 5 on pp.57–8.

⁸⁵ Qian Bang/Fan Chengxun, *Jizu shan zhi*, pp.492–3.

straight down to the lake and [up] to the foot of the Diancang mountains. What was more, there were frequently numerous rivers and springs pouring down between the fields, and emptying into the lake.⁸⁵

At this time of the year there was water to spare.

When human transformation of the environment began to cause emergencies, it was not in this part of the catchment but in the north, and, as we shall show, the crisis did not threaten to become acute until the second half of the eighteenth century.

4.0 *The Sediment Wars in the North*

⁸⁶ Duan Jinlu, *Dali lidai mingbei*, p.316: *Wei zongzizhe you tudi renmin, wei shuzi-zhe you tianzhuang pucong* 為宗子者有土地人民，為庶子者有田庄僕從. One can translate this giving somewhat different shadings to the terms, according to one's understanding of the nature of the society. The general implications remain the same: the A had local political power, landed property, and dependents. Elsewhere (p.314) the text describes the fifth in the succession, Min 旻 or Renfu 仁覆, who predeceased his father, as rebuking his 'serfs' (*tongpu* 僮僕) when they trampled on the grain in poor people's fields. These dependents of the powerholders were evidently an arrogant lot.

⁸⁷ Duan Jinlu, *ibid.*, p.315.

Our guess is that the Miju River caused little trouble in the early Ming, that is, during the later fourteenth century and the fifteenth. Dengchuan was ruled during this period by a succession of four hereditary magistrates of the A 阿 family, whose founder had established his position by rallying early to the Ming cause. A memorial stele to five generations of the A, set up in 1508, rhetorically describes the main line as "having the land and the people"—that is, political power, and the secondary lines as having "agricultural villages and serfs"—or economic and social power.⁸⁶ The family, during its years of tenure, is said to have done many good works, including "rebuilding ditches and dykes, and warding off natural disasters."⁸⁷ If the Miju had been the central problem it later became by the middle of the sixteenth century and in Qing times, it is hard not to believe that the inscription would not have specifically recorded the family's efforts to tame it.

The story that follows is complex, and the present section needs in places to be understood in conjunction with the section that follows on forest clearance, which was having a major impact on the northern subcatchment, and its neighbours further to the north, by the eighteenth century.

The earliest circumstantial detail about the hydraulic economy is as it happens provided by a stele of 1518 from Heqing 鶴慶, which lay just beyond the Erhai catchment to its north, but in close economic and social contact. It is entitled "Newly Opening the Black Dragon-Pool" (*xinkai hei longtan* 新開黑龍潭) but the *xin* almost certainly has the sense of 'renewal', indicating a revival and improvement. It was written by the Prefect Lu Dong 陸棟, who came from Yuyao 餘姚, on the south shore of faraway Hangzhou Bay (Hangzhou wan 杭州灣), an area with half a millennium of advanced hydraulic engineering. It is somewhat self-congratulatory:

My family lives in the hills [of east China] and takes a delight in farming. If they have a few tens of *mu* of poorish fields, they will grudge no effort in gauging what the soil is suited for, and in planting crops and harvesting them. Wherever there are springs of water that can [be made to] reach to distant places, all the young men in a district will excavate their sources and direct their flow, leaving none of them unattended to. Although it is hard work, it

produces a trend towards abundance, which is something in which pleasure may also be taken. I have been of the opinion that if one obtains an official post in charge of the people, one should likewise act in this way.

I was at first magistrate of Hejian 河間,⁸⁸ which is on the lower courses of the ancient Nine Rivers [Jiu he 九河].⁸⁹ The water accumulates and the soil is porous. After I had built dykes to ward off the overflowing waters, I further subdivided their flow in order to irrigate several tens of thousands of *mu* of fields that bordered on the rivers.

After this I was transferred to be prefect of Heqing. When I made enquiries of those natives of this prefecture who were living in the Capital, they said: “In this prefecture the fields on the east of the East Mountain River [Dongshan he 東山河] rely on it for irrigation. The fields on its west have only natural springs [*longquan*, literally ‘dragon-springs’] to depend on. There are more than ten of these natural springs, but the Black Dragon-Spring [Hei longquan 黑龍泉] confers the most benefits. It emerges below Mount Xuanhua [Xuanhua shan 宣化山] to the southwest of the prefectural capital, and passes by the [debouchments of] gorges cut by streams [*qijian* 溪澗], in all of which there are springs that come leaping out. If a place is high up, then its fertilizing benefit can [be made to] reach distant locations.”

Once I had reached this prefecture, I was about to begin planning this, but Mr Zhang Junyong 張君君用, the subprefect, had already told the ‘company commander’⁹⁰ Liu Yibei 劉儀輩 to get started on this project He envisaged that it would be completed in somewhat more than a month. I subsequently went with Junyong in the sedan-chairs that we had ordered to take us in an upstream direction [along the revived system]. The channel was 5 feet in width and almost 3 feet deep. It followed the curves of the mountain in 24 bends for a distance of more than 15 kilometres [After reaching the pool] we told those following us to chop down the decayed trees, clear away the weeds, and removed the disorderly boulders.⁹¹

Members of the local gentry, led by a certain Ru Xun 汝詢, had then put in a request:

The lower course of this river branches off into more than ten channels. In the case of that to the villages of Yingyi 迎邑 and Heyi 何邑, *in past times* a wooden flume was erected to carry the water across the obstacle presented by the Sanshuo Gorge [Sanshuo jian 三溯澗]. Mending the decayed and snapped timbers in this trough, and clearing away the accumulation of sediment was hard work every year for several hundred men, who had to get up to the spring before it would flow [? *dai quan fang liu* 迨泉方流]. [The water] was also grabbed by fierce people [*qiangbao* 強暴]. It was twice as much labour as the other channels, for half the results. Such was the suffering that farming faced with respect to water. In 1515, Ru Xun and Dong Yesheng 董叶省 ... visited Mr Zhang [Junyong] and pointed out to him that the southern slope could be cut through to make an [alternative] watercourse This was completed in the fourth lunar month, and for the last three years farming [here] has not had a problem with water. Since Your Excellency arrived, water-control work has suddenly prospered. Together with Mr

⁸⁸ In central Hebei province.

⁸⁹ *Jiu he*, rivers from the time of Yu 禹 the Great. They have since disappeared.

⁹⁰ *Baihu* 百戶, sometimes rendered ‘centurion’ as in H. S. Brunnert and V. V. Hagelstrom (1911), trans. A. Beltchenko and E. Moran (1912), *Present day political organization of China* (Shanghai: Kelly & Walsh, 1912; reprint ed., Taiwan, 1960), p.439, but in the southwestern provinces essentially a low-level officer in what this book calls ‘tribal government’.

⁹¹ Duan Jinlu, *Dali lidai mingbei*, p.323.

⁹² Ibid., pp.323–4. Emphasis added.

⁹³ Variant characters in this name include 萄 (*tao*) and 洞 (*dong*) and 口 (*kou*).

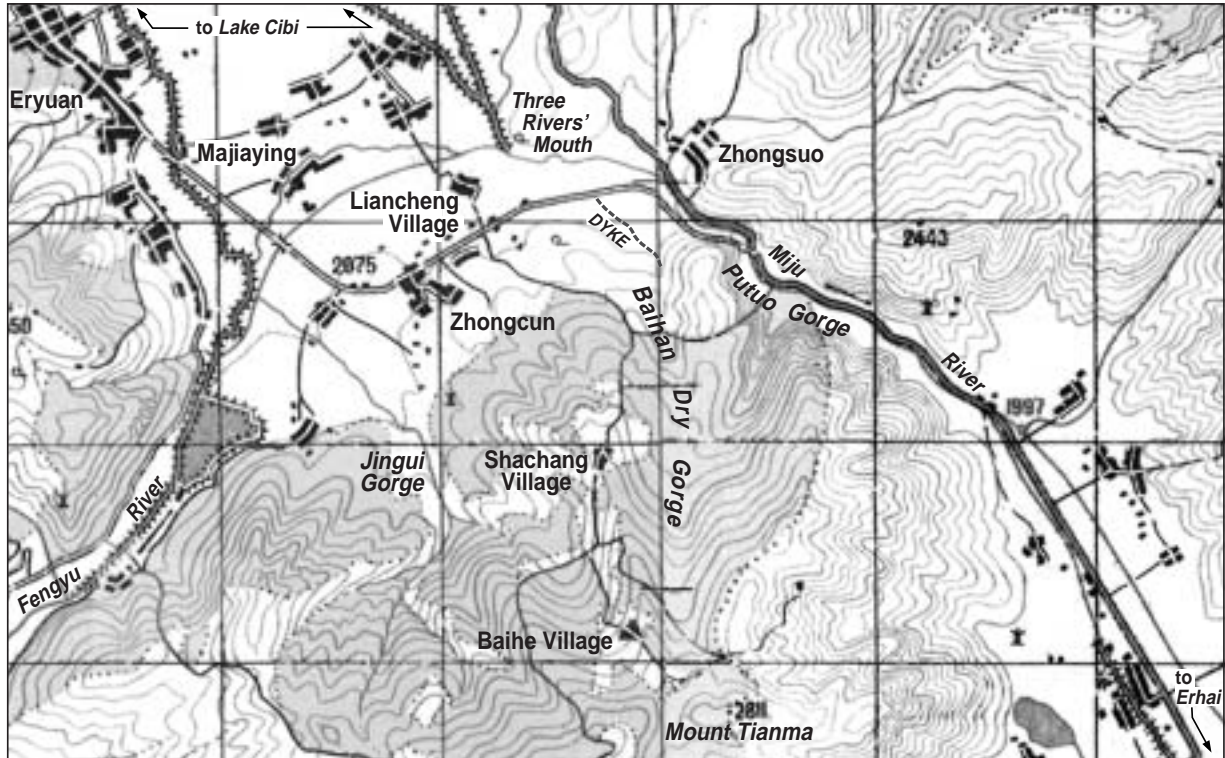
⁹⁴ Also called Mount Luoping 羅平山 and Mount Niaodiao 烏弔山.

Zhang you have scrutinized farming, gone in person along the courses of the channels, and had them deepened and widened. The flow from the springs is almost everywhere, and seizures [of water] by the powerful have receded of their own accord.⁹²

The phrase ‘in the past’ and the evidently well-established local experience of hydraulic work entitles us to assume that it went back at least some generations. The need to clear the flume every year shows that parts of the system were already liable to get caught in the familiar maintenance trap: the response of the hydrological system to human interference continuously imposed costs.

Later in the same century, the sixteenth, the line was crossed, with the first clear case of an ecosystem reaction vigorous enough for its onset to have left well-defined traces in the historical record, the criterion that we laid down at the outset of this study. The crisis occurred in the northern part of the catchment, in what was then Langqiong county, around and immediately south of present-day city of Eryuan. This was where the waters of the upper Miju River (then known as the Mici River (Mici he 彌茨河) along this part of its course), the outflow from Lake Cibi (or Ning Lake), both from the north, the Fengyu River (Fengyu he 鳳羽河) from the west, and a smaller stream from Nine Dragon-Springs (Jiu longquan 九龍泉) from the northeast, joined together at or near Three Rivers’ Mouth (Sanjiang kou 三江口) or Channel (qu 渠). From here they poured southwards through the narrow Putuo Gorge (Putuo kong 蒲陀崕),⁹³ and thence into what was then Dengchuan Department (Dengchuan zhou 鄧川州), and finally into the northern end of the Erhai. The present-day hydrology (see Map 3) is not quite the same as the late-imperial hydrology, because of anthropogenic changes, such as the canal that now leads the Fengyu River north into Lake Cibi, but provides geographical identification for various places mentioned below.

There were three sources of water flowing into the Eryuan subcatchment from the mountains to its south. The most important was the Fengyu River, which drained a basin off to the west below Mount Fengyu⁹⁴ through a narrow valley called River Gate (Tongjiang men 通江門) (which is where it enters the map at the lower left). Immediately to the east lay the next most important, the Jingui Gorge (Jingui jian 金龜澗), whose river cut through the north slope of Mount Tianma (Tianma shan 天馬山), and which seems also to have been known as the Tianma Gorge (Tianma jian 天馬澗). It joined the Fengyu. Before 1760 this latter river curved around in an arc eastwards after leaving the River Gate, passing by Liancheng Village (Liangcheng cun 煉城村), and joined the southward-flowing Mici River at Three Rivers’ Mouth. “Because the lie of the land was level, sediments and stones gradually accumulated,” says the county gazetteer, “and it would break out both north and south, damaging people’s farmland.” In 1760 the Fengyu broke its dykes and moved to a more northerly eastwards arc, passing near Majiaying 馬家營. Sediments piled up both at the Three Rivers’ Mouth and at the outflow from Lake Cibi to the north. This was solved by engineering: rerouting the



Fengyu around the northeast side of the county capital so that it emptied directly into the lake. There was the usual price. The new channel was so constricted that every year labour had to be compulsorily mobilized to dredge it and rebuild the dykes. But disasters at Three Rivers' Mouth were eased.⁹⁵

The third source only flowed in the rainy season. This was the was the Baihan Gorge (Baihan jian 白漢澗). It ran down the northeastern side of Mount Tianma, and roughly parallel with the Jingui Gorge. At some time, exactly when is unclear but presumably before the Qing dynasty, the summit of this was surmounted by a tower, the Zhenhuang ta 鎮蝗塔. This marked the place where the spirit Qiaoqing (Qiaoqing shen 樵青神) was said to have created a watershed. The villagers held a festival there on the 8th of the 8th month, the tower's 'birthday', in order to pray for a good harvest. This suggests that farming had long been established in this area. Some time later the tower collapsed, and the peak was known as Tower Base Mountain (Tapan shan 塔盤山).⁹⁶ The history of this seasonal gorge is discussed in detail later.

A chronological outline of the complex story is provided by Fan Zhaoxin 樊肇新 in his historical essay *The Three Rivers' Channel* (Sanjiang qu 三江渠), probably written some time in the late 1830s.⁹⁷

Map 3

Baihan Dry Gorge and the location of the dry cross-dyke discussed on pp.35–42. See also the photograph of its bed in Figure 7.

Base map: Soviet 1:100,000 (1978), from the copy held in Cambridge University Library

Scale: grid square = 2 x 2 km (Coombs Cartography Unit, Australian National University)

⁹⁵ Zhou Kang/Luo Yingmei, *Langqiong xianzhi*, pp.65, 71–3, 180–1.

⁹⁶ *Ibid.*, pp.645–6.

⁹⁷ *Ibid.*, pp.523–7. On Fan's dates see *idem*, p.255.

Figure 7

The bed of the Baihan Dry Gorge showing the deposited gravels. Locals quarry these materials, and a small working, typical of many, can be seen near the lefthand edge of the photograph (photo: M.E.)



⁹⁸ Reading *xin* 訢 as *su* 訴.

⁹⁹ *Pasuo* 爬索—following the ‘Record of Work’ for Dengchuan in Hou Yunqin, *Dengchuan zhoushi*, p.527, which says: “over the years the people of Langqiong have used huge claws [*jupa* 巨爬] to push the clogging piled-up sediments at the Three Rivers’ Mouth downstream,” and ignoring the note (on p.527) that claims that *pa* and *suo* are units of archaic shell money.

¹⁰⁰ Dedicated to a Tang-dynasty official who had died there and turned into a god. See Zhou Kang/Luo Yingmei, *Langqiong xianzhi*, p.198.

¹⁰¹ In contrast to the normal V-shaped gorges. This translation is a guess based on several contexts. Thus the Baihan ‘gorge’ was also sometimes called a *chang* 廠 or 敞, which indicates ‘high, level land’. See *ibid.*, pp.462, 475, and 485. See also the picture above of the bed of the Baihan Gorge (Figure 7).

The waters of the Ning River and the Fengyu together flowed into it. The cross-flow created an obstruction, with the sediments and stones blocking the swift current. This caused the waters of the Ning River to be unable to proceed smoothly on their way and drowned the paddies and dry fields of the soldiers and civilians.

In 1598 the gentry of the county wrote a statement⁹⁸ to Governor Chen, who gave his approval to the county magistrate to act. The magistrate of the day, Wang Chengqin 王承欽, made plans to do so. The scholars and commoners raised labourers to clear it by dredging, and this was good enough for [the fields] to rise above [the water].

The next magistrate, Li Zai 李在, made plans for and held discussions on the opening of a subsidiary river [*zihe* 子河] in order to split up the position-power of the water. He then went off to have an audience [with the Emperor]. In this year, 1600, there happened to be heavy rains and disasters from flooding of increased severity.

In the winter, the vice-prefect of Yongchang, Li Xianfen 李先芬, came in to cover the job of the county magistrate. He followed the proposals of the masses [in other words of the gentry and scholars] to make use of grippers and ropes⁹⁹ but he had to employ workmen to clear the place. It was forthwith dredged clear.

Prior to this he had opened a subsidiary river in front of the Temple of Datangshen [Datangshen miao 大唐神廟],¹⁰⁰ linking it with the waters from the lake [Cibi] to take them around the foot of the mountain and so down. He also cleared the course of the river of stones at Tuomu Flatbed Gorge [Tuomu chang 拖木廠].¹⁰¹ After about fifty days, when the use of the grippers and ropes had not yet been applied, half of the work was already completed. Many of the fields that had replaced the [shores of the] lake had harvests, for which the scholars and commoners gave him credit.

Coming to the present [Qing] dynasty, in 1651 County Magistrate Luo Shisheng 羅時昇 undertook a major clearance by dredging. County Magistrate Wu Yilu 吳一鷺 made detailed requests to clear it by dredging. County Magistrate Zhao Gong 趙珙 led the work in person, dredging from time to time as needed.

In 1730, Governor-General E’ertai 鄂爾泰 sent instructions to County Magistrate Wu Shixin 吳十信

to do more work on repairing and dredging along the 5 kilometres from Zheng Family Village [Zhengjiazhuang 鄭家莊] to the Dengchuan border, and to build in addition a long dyke of more than 4,000 feet, to increase the height of the small dyke at the Three Rivers' Mouth by several feet, and to emplace 50 wooden coffers filled with stones to intercept the sediment-laden waters without obstructing the profits from the [reclaimed] lake fields.

In 1762 [imperial or provincial-level] assent was given to a petition that at the Three Rivers' Mouth in Langqiong County a low cross-dyke should be built to prevent disasters from flooding. However, both the subsidiary river opened in the past to destroy the position-power of the water, and the anti-sediment dyked bank have long since disappeared, and are untraceable.

In 1761 and 1762 sediments and stones from the Baihan Gorge rushed into the water's mouth [the Three Rivers' Mouth?]. County Magistrate Lin Zhonglin 林中麟 took charge, together with the local official Wang Zhicheng 王芝成, and at the mouth of the gorge for the first time built a dry cross-dyke [*yu jiankou chuangzhu hanba* 於澗口創築旱壩] for several thousands of feet. He obtained permission for there to be minor maintenance every year, met by 120 ounces of silver from salt monopoly surplus funds, and major maintenance every third year, costing 320 ounces. In addition the department of Dengchuan was to furnish a subsidy of 50 ounces of silver for locks and dykes.

In 1771 County Magistrate Liu Huanzhang 劉煥章 led the local official Wang Zhicheng in opening another subsidiary river In 1803, and in 1806 and 1807, the waters of the [Baihan] gorge burst forth and caused even worse disasters. The large and small dykes collapsed from one end to the other A later county magistrate, Chen Wei 陳煒, rebuilt the dry dyke from east to west for several thousands of feet, and caused the sediments and stones to accumulate on unused ground in front of Liancheng Village. He further joined the west bank of the old river to the dry dyke, and built a low-level field-dyke [*geng* 埂] more than a thousand feet in length on which he planted several tens of willow trees to guard against the sediments and stones.

In 1815 County Magistrate Chen Qigao 陳齊誥 assigned members of the gentry and scholars to lead the repairs according to [assigned] sectors. He remained in office for eight years, and saw fairly substantial results.

In 1824 County Magistrate Lin Dashu 林大樹 took the lead, with the gentry and scholars, in repairing the dry dyke and the willow dyke from time to time. All of them were raised several feet in height, the river was without obstructions, and for the first time we enjoyed the good fortune that it flowed along peacefully.

Essentially what had been done in the last period was to provide an almost level, long, raised causeway, separated from the exit gorge by a rampart that had over the years to be raised higher and higher, where the stone and sediments intermittently carried by the spate-period downrush of the Baihan Dry Gorge could be deposited before they choked up the river. This massive creation is still an impressive feature of the landscape today, and we have marked its location approximately on Map 3 (p.35). Figure 8 (p.38) shows the view from the top of this rampart.

¹⁰² Ibid., pp.161–2.

That the Baihan was situated just above Putuo Gorge is clear from the essay by magistrate Lin Zhonglin on his arrival in Langqiong in the mid-eighteenth century coming north up the Putuo and emerging at its top:

My arrival was by entering what is called Putuo Gorge. I observed the cliffs of its two mountains facing each other, and the single river flowing between them The general explanation is that it gathers a number of drainage systems that run into a single lake [Cibi] and it drains out the water accumulated in this lake through a single gorge.

Since [the water] enters it deeply, it must not be obstructed from coming out. If there is the disaster of even a modest landslide then the flooding spreads across the region at the lower end of the [Langqiong] drainage system, and the lives of several tens of thousands of families become those of fish or turtles, this being the matter of but an instant.

Next, after not many paces [*bu shu wu* 不數武], there was a bank of sediment spreading out widely. The two rivers [coming down] struck a gorge in the mountains to the west, whose position-power was especially loud with the clamour of waters. Its sediments and stones were rushing swiftly into the rivers, constituting a disaster How perilous it was! I later investigated this in the county records, and made enquiries of the fathers of families and the elderly. From them I learned that this was the Baihan Flatbed Gorge [*chang* 廠]. It had been a menace for a long time.¹⁰²

The suddenness with which a crisis could arise was thus due to the synergistic effects of multiple inputs being abruptly combined.

The question is, why did these problems arise at this particular time? The answer seems to be the opening up of hill lands for cultivation and, where there was forest cover, which was not everywhere, the accompanying cutting down of trees. To a great extent this has to be inferred indirectly from the way in which sediment began to pile up in formerly

Figure 8

Looking south along the dry dyke at the foot of the Baihan Dry Gorge. Before it was built the floodwaters emptied out through the valley mouth to the left (photo: M.E.)



free-flowing rivers, but there is also some direct evidence, and more than a little collateral evidence from nearby areas. We give below a partial translation of the sections in the 1902 gazetteer for Langqiong on the Three Rivers' Mouth and the Baihan Gorge, italicizing the key points ¹⁰³:

Three Rivers' Mouth: This is located southeast of the county capital below the temple of the Datangshen at the foot of Winding Dragon Mountain [Huilong shan 迴龍山]. Its name derives from the confluence here of the Cibi Lake, the Mici River, and the Fengyu River. *In times past the rivers' mouth was extremely deep*, and the current abrupt. If boats travelled down to this point, and were somewhat inattentive to the situation, they could be rapidly swept downstream. *Today it is so silted up that it has become a level flow-over [pingyan 平行] that one can ford by holding up one's clothes.*

Along the Fengyu the sands and muds are extremely abundant, and easily block the water, so that the current does not flow smoothly, but overflows and causes damage. The flood disasters recorded in the old gazetteer for the most part arose from here, one after the other. *Today the Fengyu has been moved north*. All the sand and muds are piled up between Edun 鵝墩 and Handeng 漢登. *They have silted up to form fields*, and this place is no longer a menace. It is necessary, however, to open up the water deeply in its lower reaches, so that the current flows smoothly in its path.

The old rule of using cattle to trample [the river] used to be practised every year at the end of the fourth lunar month or the beginning of the fifth after the breaking of the cross-dykes [zhe ba 折壩].¹⁰⁴ This was because it was not practicable to use hoes to remove [the mud] as aquatic plants interwove themselves across [the river], obstructing the waterway, but cattle could be used to stamp them down *so as to help the water get through*. People of modest means in the villages relied entirely on the strength of their cattle for the spring ploughing,

¹⁰³ Ibid., pp.172–9.

¹⁰⁴ Once dredging had been finished.

Figure 9

Putuo Gorge. This shows the lower part of the gorge in the dry season. The level is even lower than it would otherwise be because much of the water is now diverted higher up into a large pipe that runs along the right bank (to the observer's left but not visible here) to feed a small hydroelectric plant at the foot of the gorge (photo: M.E.)



¹⁰⁵ But note that *ba* is usually a verb.

¹⁰⁶ Today the southern end of Cibi, which has been dyked, creating some degree of reservoir effect, lies about 4.75 km NNW of Three Rivers Mouth. During our fieldwork we were not yet aware that the mention of a backup effect from blockage in this document was going to raise the question of the relative difference in height between the lake and the Mouth, and therefore did not examine it on the ground. Two reasons may suggest that at this time it was not that great: (1) around 1760, when the Fengyu river broke its dyke it moved northward, that is, in the direction of the lake, across the plain south of the lake; and (2) the outflow from the lake is today enclosed within dykes all the way to the Mouth, suggesting that the land at some times of the year lies below the level of the water.

however, and once these were undertaking work on behalf of the public they could not deal with private concerns. Going back and forth in the clogged up mud moreover exhausted their strength, and when the strength of a cow or ox is worn out, they can sometimes topple over and die. At the present time, orders have been given to the families with oxen to hire small boats at their own expense, and use human labour power to employ hooks and grippers [*yong diaoba* 用鈞扒¹⁰⁵] to drag them out in a downstream direction. This is economical and convenient in comparison ...

Even so, still another transferred cost of economic development.

Baihan Gorge: Its source emerges to the west of, and high up above, the flow of the river, from Tower Base Mountain, which is to the southeast of the county capital, and it faces the military patrol villages high above opposite.

From the exit of the gorge to the summit of the mountain is 15 to 16 *li* [7.5 to 8 km] The top of the mountain used to have a stone tower. Today it has fallen, leaving only the base, hence the common name 'Tower Base Mountain'.

The spring emerges from below the base and pours into the Yangcheng Pool [Yangcheng tan 洋成潭], which is more than 10 feet across, but with a depth of less than a foot. Below lies Baihan Gorge. The regular flow from the spring is exiguous in the extreme, and it before long runs dry. The two walls of the [main] gorge are precipitous, and there are more than ten [lesser] gorges of varying size in the interstices of these precipices. All of them flow into the Baihan Gorge. *Everytime the heavy rains of the summer and autumn fall, the water in each of these gorges emerges and joins with the others in their descent. Sands and muds collect together, and rush ahead to choke the flow of the river, thereby causing flooding of the fields, gardens, and dwellings of the people who live on the edge of the lake* [presumably Cibi¹⁰⁶].

Previously, in 1753, County Magistrate Lin Zhonglin proposed facing [the river banks] with stone from the exit of the gorge past Zhenjiang Temple [Zhenjiang si 鎮江寺] and on downstream, and building a dry cross-dyke [*hanba* 旱壩] that would cut off the sediments and stones at the southeast foot of the mountain. The exit of this cross-dyke would have direct access to the flow of the river: when the river was in seasonal spate and flowing at high speed [*shihe liu tuanji* 時河流湍急] the sediments would reach the exit of the cross-dyke where the water would transport the sediment away [but leave the stones behind?] ...

After 1757 and 1758 the hills in front of and behind Tower Base were gradually opened up for farming. These hills had neither vegetation nor trees to give them protective cover. As soon as there was a heavy rain, the sediments and stones came down in a transverse fashion and obliterated the dry cross-dyke with their pressure, striking and choking the body of the river. The result of this was that from 1769 and 1770 to 1780 and 1781 disasters were repeatedly reported, and remission and relief were repeatedly given. The agricultural tax was not forthcoming, and both officials and commoners were burdened.

At the end of July 1808 there were heavy rains for three days and nights. *Those hills beside the gorge that had been ploughed collapsed totally.* A

quantity of sediment-laden water beyond any reckoning, and huge boulders several measures of 8 feet in size [circumference?] burst forth into the river, filling the body of the river for more than 800 feet. Not a drop of water flowed. In the county capital, and the north and south corners [of the city wall], everything became a domain of marshes [as the river backed up]. More than a thousand men were assembled to dredge clear the sands and muds, and to split apart the huge boulders. Only then did they clear a through passage.

Chen Wei 陳煒, who was acting county magistrate, took over the work of restoration. Because it was hard to remove the accumulated water, and the fields beside [Cibi] Lake could not re-emerge as dry land, he asked the authorities to cancel over 500 piculs of the commoners' grain owed as tax, and held discussions with the gentry, the scholars, the elders, and [other] commoners. Because nothing was left of Magistrate Lin's earlier cross-dyke, and a gently flowing current would not be able to send down [enough suspended] sediment, as would have resulted from their following the old regulations and merely dredging and completing [the system] afresh, they¹⁰⁷ therefore 'climbed the summits and went down into the plains' and subjected the topography to a mature scrutiny. They decided to rebuild a dry cross-dyke 1100 feet long from the mouth of the gorge to the eastern and western feet of the mountain. It was to be 20 feet high and over 10 feet in width. The spare land where no grain grew, to the rear of Liancheng Village, was to be used as a sediment deposit, and they further linked it with the tail-end of the dry cross-dyke in a curving arc.¹⁰⁸ To the north they built a low earth-dyke [*geng* 埂] of over 1000 feet. Behind this low dyke they planted a hundred willow trees so that their roots might coil around [and stabilize it]. In addition, at the end of the low dyke they opened exits to release the water. *The water came out but the sands and muds remained, piled up within the low dyke. They were not caused to enter the river and block it up.* Furthermore, within the dry cross-dyke they opened a deep dry channel [*hanhe* 旱河]. Although it was filled up entirely with sediment-laden water, even when full it helped to direct [the runoff] and could supply the [ditch] below the willow dyke.

¹⁰⁷ Or 'he'—similarly afterwards.

¹⁰⁸ Translation problematic.

There follows an extended discussion by the gazetteer editors, of which we quote some of the more essential parts:

The building in times past of a dry cross-dyke at Baihan Gorge was an extremely good plan. In recent times [early nineteenth century to 1902] that there have been no major disasters has been due to the excellence of the strategy bequeathed to us by His Excellency Chen Wei. Nonetheless, as regards the lower reaches [in Langqiong] it is unavoidable, given the nature of water to be open or blocked up, that we use both the old and the new preventive measures *At the present time the sediments within the cross-dyke increase and grow thicker every day, and are almost level with the dyke-parapet* [*ti* 堤, which normally just means 'dyke' but has to have a sense like this here]. The earth of the cross-dyke is pared away and grows thinner by the day, so it cannot match the power of the water. What is more, the low willow-dyke has not survived. It is to be feared that if, one day, 'ant-holes' [that is, fissures] are able to penetrate, [the water] will flow out without hindrance, and that, in this event, the silt accumulated over so many years

¹⁰⁹ Shenju 甚鉅 in the last phrase means ‘a great deal’, the opposite of the sense given in the translation. I suggest, for reasons of internal logic, that the *ju* is a misprint for *zhu* 銖, a near-homophone whose character has the same radical and that means ‘a weight equal to a 100 grains of millet’, and is conventionally used to indicate a trifling quantity.

¹¹⁰ Zhou Kang/Luo Yingmei, *Langqiong xianzhi*, pp.631–2.

will go straight downstream under the pressure of its collapse. *It must be reckoned that the water of the entire river would not be able to expel this incalculable quantity of sediment. The disaster would be unimaginable.*

In our humble view there are about four ways of controlling it:

1. Dredge the lower reaches deeply
 2. Build up and repair the old cross-dyke. Every year, from within the cross-dyke, excavate the dry river, and use the sediment to heighten the dyke-parapet [*tí*]. This is the old method. It is essential, however, to pile all the excavated sediment onto the face of the dyke-parapet, and not to let it collapse because of its loose texture. Continue increasing the height, and make use of this to protect it. If the old way of piling it anywhere handy is still followed, then, when the [flood] waters come, they will push [the cross-dyke] into the body of the river, so wasting years of repair work, which will in the end have amounted to nothing.

3. Open another diversion channel [*yindao* 引道]. The water emerges abruptly from the mountains, and its position-power is extremely fierce. It strikes in transverse fashion against the dyke-parapet and low dyke [*tígeng* 堤埂], which makes it somewhat difficult to resist. It is necessary to open a diversion channel on the north bank and cause the water in the gorge to go north, and then come down, following the mountain. Then its force will be subdivided and easily weakened, and no danger will be caused.

4. *Forbid digging in the mountain gorges where rivers have their sources.* There are two villages in the mountains, Shachang 沙場 and Baihe 白鶴 [see Map 3, p.35]. *The Luo* 猺 [that is, the Luoluo 猺獠] *people dig up the loose soil in the mountain gorges whose nature is light and unstable. When the rains come they wash it down so it fills the dry river, and [we] suffer hurt from this.* Uncultivated waste is widespread in the mountains, and can be opened for farming where people please. These mountain people must be told that they are clearly to understand that it is only permissible to dig the south-facing slopes of the mountains [*shanyang* 山陽]. The ravines on the north-facing slopes are all of them forbidden. Since what they get from them does not amount to much, they will lose very little by from this.¹⁰⁹

The association of development with increased erosion is clear, and contemporary observation was keen-eyed enough to have noted the more damaging runoff from north-facing slopes with their relatively lower rate of evaporation and longer periods of saturated soil.

The Luoluo in Langqiong lived in the mountains to the north, west, and south of the county capital. They all grew buckwheat (*qiao* 稷, *Fagopyrum esculentum*). Those in the west and south also herded sheep, and those in the west gathered firewood. They were described by the Chinese as people having dark, sallow faces, wearing short clothing and straw sandals, with sheepskins across their backs. They were said to have an archaic honesty when they came to the markets, but “the more cunning of them are gradually taking up the rustling of cattle and horses.”¹¹⁰ One senses in the last remark the increasing incursions of a more developed economy.

5.0 Forest Clearance

The collateral evidence is that in some parts of the catchment and just to its north, deforestation had become such a problem by the 1780s that programs of forest protection and even reforestation were beginning to be put into effect. The earliest evidence we have found for forest protection and restoration in the catchment comes from northern Zhaozhou at the south end of Lake Erhai, in a stele inscription written by a member of the local gentry, one Zhang Wenmin 張文旻, in 1780:

Hitherto, where the Earth has had magical powers, the human beings have been heroes [*dilingzhe renjie* 地靈者人杰]. Even though our village, being located at Chipu 赤浦 [east of Xiaguan], is reputed to rest against the foot of the mountains and to face Jade Table [*yu'an* 玉案], it is still a matter for regret that Mount Master [Zhu shan 主山] has deficiencies. Human efforts are required to remedy these. The most notable means for making good what is missing is the shady cover provided by forest trees. Because the authorities urged the people to plant them, the entire village united everyone's determination in this endeavour, and enthusiastically planted pines in 1773. As the result of this, dark greens and pale greens are [now] luxuriantly apparent on Mount Master. Once they have been cared for over a long period, moreover, they may be turned into beams or rafters, or serve as [planking] for boats or oars. If materials of good quality are produced here, then, when the rooves of temples collapse in decay, there will be no concern that resources are lacking for their repair.

In the future Mount Master, which has been planted with pine trees by the community of the entire village, shall be a public mountain [*gongshan* 公山] in perpetuity. The entire village is not to be deemed, in improper fashion, its landlord [*hengren dizhu* 橫認地主], and may not perform burials in personal, private fashion. It is, however, permitted for them to revere and sweep clean all existing ancient graves.

This is the means whereby the trees on Mount Master have in the past been beautiful, and we also think it is a way of having an inexhaustible supply of timber. Achieving an inexhaustible supply of timber depends entirely on axes not being used in the forests in a casual fashion [*fujin buke qingru linzhong* 斧斤不可輕入林中] ... If any ignorant fellows with their hopes set on long-lasting profits, hew them down in thievish fashion and destroy them, they are not to be spared punishment.

Speaking generally, the primary objective is restoring the mountain. Obtaining materials is the secondary one. Even when one does not speak of profit yet the profit is there.¹¹¹

The high value placed on forests (in contrast with useful or decorative trees) was not part of the classical Chinese tradition,¹¹² though in mediaeval times poets and officials and others had sometimes been keen planters of trees, Su Dongpo 蘇東坡 being perhaps the most famous.¹¹³ One may perhaps suspect an element of non-Han minority tradition at work here.¹¹⁴ There are

¹¹¹ Duan Jinlu, *Dali lidai mingbei*, p.498.

¹¹² A point dealt with at length in chapters 3 and 4 of M. Elvin, *The retreat of the elephants. China's history in an environmental perspective*, forthcoming.

¹¹³ Su Dongpo (Su Shi 蘇軾) (Song), *Su Dongpo quanji* [Complete works of Su Dongpo], 7 collections in 13 vols (Seoul: Hanguo Wenhua Kanhanghui, 1983), vol.2, p.137 ("Tengxianshi tongnian xiyuan") and pp.199–200; also Lin Hongrong, "Historical forests of Sichuan," in Lin Hongrong, "Sichuan gudai senlinde bianqian" [Changes in the ancient forests of Sichuan], and "Lishi shiqi Sichuan senlinde bianqian" [Changes in the forests of Sichuan during the historical period], in 4 continuous parts, *Nongye kaogu* 9.1 and 10.2 (1985): 218. On pine plantations from Tang times onward, see N. Menzies, "Forestry," in Joseph Needham, *Science and civilisation in China*, vol.6, *Biology and biological technology*, pt 3, *Agro-industries and forestry* (Cambridge: Cambridge University Press, 1996), pp.570–1.

¹¹⁴ As it did with the Dong 侗 minority as discussed in M. Elvin, "Three thousand years of unsustainable growth: China's environment from archaic times to the present," *East Asian History* 6 (Dec.1993): 7–46, at 27–8.

¹¹⁵ See N. Menzies, *Trees, fields, and people. The forests of China from the seventeenth to the nineteenth centuries* (Ann Arbor, Mich.: UMI, 1991), ch. 2.3, "Clans, communities, and commons."

¹¹⁶ Laojun was a religious Daoist term for Laozi conceived of as a supreme power.

¹¹⁷ *Tingshan* 廷山. *Ting* may have the sense of 'straight up and down', but this is problematic.

¹¹⁸ Duan Jinlu, *Dali lidai mingbei*, p.501.

a number of late-imperial parallels in other parts of China for such collective or communal property.¹¹⁵ What is interesting in the passage just cited, apart from its date, is the consciously prioritized tension between the sensed need for a natural environment in which the best human qualities flourish and the pressures of the economy.

In 1783 some of the local gentry in Jianchuan Department (Jianchuan zhou 劍川州), on the northwest edge of the Erhai catchment, had a stele cut that shows how new economic pressures were in conflict with a mixture of collective magical reverence for natural forces and a rational desire to stop environmental damage. The department magistrate had received a petition from them that stated:

Old Lord Mountain [Laojun shan 老君山¹¹⁶] in the west of Jianchuan is the ancestor of all of Yunnan's mountains, and an important place for the entire department. Recently the area below it has been occupied by the military degree-holder Yan Ren 顏仁 and those whom he leads ... They have cut the trees on the entire mountain,¹¹⁷ and burned it by giving a free course to fire. This has caused the sources of water to run dry, and made the growing of crops difficult.¹¹⁸

The magistrate's investigation led him to the conclusion that "not only should Yan Ran and the others not be occupying [the mountain], but even the department of Jianchuan should not treat it as being its private property." The felling of trees and of "opening up and digging up the area for fields" had been going on for several decades, and "the trampling down has extended across several tens of *li* [perhaps 15 kilometres]." He continued: "I have found by investigation that their documentary proofs are a forged contract of sale from one Hewazi 禾瓦子, and a permit improperly issued by Native Administrator Mu [Mu *tuguan* 本土官] ... I would observe that this place is an official mountain [*guanshan* 官山]. How could Hewazi have come to possess this land? There is no trace of any past history of this ... Furthermore, the contract only grants permission for pasturing livestock, and contains nothing about erecting houses and living there, cutting trees down, or opening the land [for farming]. What is more, there never was such a person as Hewazi ... As to the permit from the Native Administrator, this is even more hateful. He is not an official in charge of the land, but has nonetheless had the audacity to ally himself with these evildoers and grant permission for the opening up by digging of an official mountain on our boundary divide." He was to be banished.

Since Yan Ren and his accomplices had wisely made their escape, the magistrate could only issue some prohibitions:

Old Lord Mountain is the arterial source of the entire department. Because of its links with farming and water supply a collective effort is needed to preserve it in its integrity ... How can people be allowed to invade it at will, thereby destroying that by which the population nourishes its life?

So he put a ban on cutting down trees at will, an interdict to be enforced by

‘mountain protectors’ [*kanshanren* 看山人]. No one was to occupy the lands opened up by Yan and his associates, cut down living trees where springs emerged, set the mountain on fire, fell young trees, dig up tree roots, or buy and sell timber.¹¹⁹

This last point is perhaps the most interesting. It suggests that the trade in wood had reached this remote area around this date, very possibly reflecting growing scarcities elsewhere, and was intensifying the pressure on resources. This hypothesis is reinforced by the final document in the deforestation dossier, which comes from 1883, a century later, but looks back fifty or more years earlier. It is a stone inscription on the planting of pine trees in Lianqu Village (Lianqu cun 蓮曲村), located not far below the bottom of the Putuo Gorge in Yousuo district (Yousuo xiang 右所鄉):

At the back of Lianqu Village stand bare mountains.¹²⁰ Prior to this their trees gave a covering of shade that was lush and profoundly lovely when seen from far away. But on the day that *the trees became timber*, it was inevitable that they should have been selected to serve as beams and rafters (*ran shumu cheng cai zhi ri, bi wei dongliang zhi xuanju* 然樹木成材之日，必為棟梁之選舉).¹²¹ In the years of the Daoguang 道光 reign-period [1821–50], once the axes had laid them low, their luxurious lustre vanished. In this situation the old and young men talked about it among themselves. Finally, in the sixth month [July/August] of 1882, workers were sent out on a household basis to plant pine seeds [*songzi* 松子]. In total these came to exactly 5 *dou* 斗 [= 5 x 10,350 cm³ = 51.75 litres] [per household?]. It took each family more than 20 *gong* 工 [a unit of work in hydraulic projects linking distance travelled and weight carried]. Was this not both hard toil and suffering, too? As to causes of anxiety, they were especially apprehensive that in the course of time good-for-nothing fellows would appear in the village who would do things far away from the local community before coming home, making a pretence of the public interest to serve their private advantage. If these people felled on their personal account and without authorization, the pine trees planted by the village would become a case of hard labour that had achieved nothing.¹²²

The names of all the twenty-five or so who had sent out workers to do the planting, presumably heads of households, were therefore inscribed on the back of the stele, it seems, though it is not clear, in order to debar those who had not, or their descendants, from using the wood. The crux though is that the trees had ‘become timber’. Cutting down the forests in order to make farmland had a history that went back centuries, even millennia, into the past. This was now increasingly being joined by chopping them down for building materials for sale.

There is thus a *prima facie* case that the rapid increase in the volume of sediment carried by the Miju and other rivers in the north of the catchment in the later Ming dynasty and the first two-thirds of the Qing dynasty was due to hillslope land being cleared for farming, with or without deforestation, and to an increase in tree-felling driven by a new or much augmented commercial demand for timber.

¹¹⁹ Ibid., pp.501–2.

¹²⁰ *You hongshan yan* 有紅山焉. This could also be taken as referring to a ‘Red Mountain’.

¹²¹ Emphasis added.

¹²² Duan Jinlu, *Dali lidai mingbei*, p.604.

¹²³ Li Zhiyang, *Dali fuzhi*, 1:57a.

¹²⁴ Hou Yunqin, *Dengchuan zhouzhi*, pp.46–8.

¹²⁵ Li Zhiyang, *Dali fuzhi*, 1:56b.

¹²⁶ *Ibid.*, 1:57a. Emphasis added.

6.0 *The Suspended River*

By 1552 the trouble had moved south of the Putuo Gorge. This is the first year for which it is recorded that the Miju River broke through its dykes. “A great flood drowned a thousand *qing* of farmland.”¹²³ The records of ‘Auspicious and Uncanny Events’ for Dengchuan start in 1478, but do not mention this flood, the first such entry being for that in 1663.¹²⁴ The remaining breaches recorded under this heading during the period up to 1849 are given in Table 3. Other types of flood have not been included. The sudden appearance of the breaking of the dykes is evident, as is the increase in frequency.

Repairs under official auspices are first recorded for the Yongle 永樂 reign (1403–24), and three more times down to 1506–21. Colony soldiers did the dyke on the east side at this time, and commoner-civilians that on the west.¹²⁵ A bureaucratic system for the regular yearly repair of the dykes is said to have first been put into place by the local government some time between 1436 and 1469, but cannot have worked well, as there was a crisis in the middle of the sixteenth century. The 1563 gazetteer for Dali prefecture says, or quotes someone as saying, without being clear about the exact dates concerned,

For the last thirty years no one has been paying close attention [*wu ren jiangqiu* 無人講求], and [the dykes] have almost completely fallen in ruin. Those who have debated the issue have decided to order workers to be levied according to the acreage [owned by the landlords served by the system], and boundaries for sectors to be established and inscribed on stone as a visible record of permanently fixed regulations.

Every year in the first lunar month, on the day following the rural district drinking meeting [*xiangyin cirì* 鄉飲次日], *without waiting for anyone to lead him*, each person shall proceed to the work of banking up the earth and planting trees. Anyone who arrives a day late shall be fined according to what is announced by a collective discussion [*zhongyi gaofa* 眾議告罰]. This is to be done constantly every year.¹²⁶

Table 3

Breaches by Floods in the Miju River Dykes (period covered: 1478–1849)

Year	Season	Location	Comments
1552	-	-	First major breach
1663	Autumn	Zhongsuo	-
1691	-	-	-
1713	Autumn	Zhongqiansuo Bridge	West side
1726	Autumn	Zhongqiansuo Bridge	West side
1730	Autumn	Jingpang	East side
1731	Autumn	-	-
1743	Autumn	Liugongying	East side

1758	Autumn	Xiashankou	Close to the gorge
1767	Late summer	Above Yinqiao	-
1775	Autumn	Zhongqiansuo	West side
	Autumn	Xiashankou	East side
1794	Autumn	Guanwu	E side, close to gorge
1815	Autumn	Xiashankou	-
1816	Late summer	Zuosuo	West side
1817	Late summer	Below Majiayi	West side
	-	Yousuo	-

¹²⁷ Ibid., 1:57a.

¹²⁸ This presumably refers to timber already cut and stacked for use, and so a particularly tempting target.

¹²⁹ Li Zhiyang, *Dali fuzhi*, 1:57b.

It is not certain that this was ever actually done, but it affords us a glimpse of a more relaxed, community-based maintenance system at the end of the period when the challenge was still limited enough for tight bureaucratic control not to be felt to be necessary.

The débâcle of 1552 prompted a strong response from officialdom. The quantitative details of maintenance work were laid down, such as the number of ‘dragon caves’ (*longdong* 龍洞)—lateral open conduits—to be provided for draining off water. They concluded by remarking: “That the soldiers are exhausted at the present time, and the commoner-civilians impoverished, is not due to any lack of fertility in the soil but to inadequacies in the management of water [*shuli bu zu* 水利不足].”¹²⁷ There was even a plan to move the entire river eastwards so that it ran along the foot of the mountains, but this was not done. The cost of repairs in terms of the timber and stone need, as well as in labour, remained high, and the 1563 gazetteer describes a society already under serious pressure:

Those who own land sometimes have to sell it. Those without land are sometimes obliged to perform hard labour-services, their hair becoming grey because of their lack of rest. Nor are the women and children in tranquillity. In emergencies they demolish their fences and walls to block up the breached dykes. When times are calmer they steal the timber used for the engineering work to supply their private cooking.¹²⁸ Those who watch over the system [*kanshouzhe* 看守者] are not capable of dealing with these vexations. Those who do the reconstruction are wearied with their sufferings. At the worst it even happens that landlords along the east-side dyke criminally breach the dyke to the west, and landlords along the west dyke criminally breach the dyke to the east.¹²⁹

In fact, the system proved sustainable. What has to be taken into account is the price.

Organization seems to have been improved between 1628 and 1643, with more changes shortly after 1736. The responsibility for specific lengths of dyke were assigned on the basis of taxes paid by landowners. Workers were sent out in the middle of the first lunar month and at this period normally worked for a month, their effectiveness being checked on by the officials. Further changes introduced by the department magistrate shortly before 1795

did not yield good results, however. The organization was overhauled once more in 1818, and then again twice more by three different department magistrates. These repeated efforts were probably what principally ensured a period of stability after the disasters of 1815–17. The hydraulic engineering above the gorge at the Baihan may also have played a part. We plan to present a separate study of the details of the Miju system in a later work. In the context of the present survey it represents the mounting economic burdens that could be incurred by progress beyond certain complex environmental limits, and the way in which they were not necessarily carried by those who had caused them. This displacement of responsibility is perhaps the main reason why effects of this type have proved so hard to stop. For example, the Luoluo opening new mountain land above the Baihan did not have to rebuild the Miju dykes downstream.

Essentially, what was happening was that the increased loads of sediments carried by the Miju River, because of land clearance and deforestation upstream, raised its bed, and made it necessary both to keep dredging it and

Figure 10

The Miju River near Zhongsuo 中所 running above the level of the fields (photo: M.E.)



building the dykes higher and higher. It was estimated that from 1828 to 1843 the river bed in the upper course below the Putuo Gorge rose by 10 feet in spite of dredging. Stone columns were then installed as markers to provide a measure of the depth of dredging needed.¹³⁰ By some time in the later Ming dynasty a substantial proportion of the course of the Miju immediately south of the gorge was probably running above the level of the rooftops of houses on the surrounding land, as it still does today (see Figure 10). By the early nineteenth century the clearing and dredging required sixty thousand men during the period from the first lunar month to early in the fourth month, though not continuously, and half again that number to rebuild the embankments.¹³¹

¹³⁰ Hou Yunqin, *Dengchuan zhouzhi*, p.82.

¹³¹ *Ibid.*, pp.79, 82.

There is a useful overview written by an unidentified local who for many years was the General Manager (*zongli* 總理) of the Miju dykes, probably from the middle Qing period, though the exact date is not clear:

Ordinary rivers travel *through* the land. Only the Miju travels *above* the land. Ordinary rivers all penetrate deeper [with time], but the Miju fills up every year with deposited sediment. These are the major contrasts In the region of the Mao Family Gorge [Maojia jian 毛家澗] everything is broken peaks, hateful precipices, streams that lose themselves [*baiqi* 敗溪], and fragmented valleys [*suigu* 碎谷] gathered together or scattered about. They unite at Three Rivers' Mouth. Whenever a wind from the northwest arises, mountain soil, whirling dust, and flying stones frequently strike one in the face. With the arrival of summer and autumn the continuous heavy rains destroy the ridges and split the valleys open. Stones from the mountains and sediments in the gorges come down in the frenzied current, a flood like a landslide, its breakers roaring with a sound like stones falling. On every side it is blocked off, with no way through. It only drains out by way of Putuo Gorge, but over the years the people of Langqiong have used huge claws [*jupa* 巨爬] to push the clogging piled-up sediments at the Three Rivers' Mouth downstream. Under these circumstances, water and stones from all directions have treated Dengchuan as their drainage ditch. The origins of the afflictions suffered by the Miju river in fact lie in this.

When it goes south from here there are the mountains of the Black Ants Gorge [Heima jian 黑螞澗] and Serpent Gorge [She jian 蛇澗]. All of them are bodies without a full covering of skin [that is, they have areas without vegetation or, possibly, soil cover]. They are inserted in the river's bed, lofty and vertical. Their sands fly about and their stones shift along, more and more helping the [river's] power to fill up the Erhai. Thus the route of one long river receives the sands and gravels [*shali* 沙礫] of a hundred courses. To begin with, it is as if bound in the coils of ravines and gorges [*tongxia* 峒峽]. When it reaches the Upper Gongsha [*shang* Gongsha 上公沙] ... , it suddenly opens out and rushes along rumbling like startled thunder, speeding like a myriad horses almost wishing to take all sixty *li* of level plain and soil embroidered [with crops and houses] for the pleasure of its swiftly sweeping position-power. In all the spatial structure of the river there is no danger to equal that which is here.

Next, downstream from Wangwu 王五 ... the entire river is as perilous

¹³² Reading *wěi* 尾 for *wěi* 委.

¹³³ Hou Yunqin, *Dengchuan zhoushi*, pp. 90–103. Emphasis added.

¹³⁴ *Yili* 疫癘, the second character of which suggests swellings, hence buboes, hence plague.

as suspended scaffolding. Wherever there is a bay or bend, one further feels the flying foam and the press of the spray. The shaking is out of the ordinary. It is always here that there are flooding over and breaches that are naturally caused [*zilai huijue* 自來潰決 ...].

In summer and autumn the current is turbid. Silts and sands come down together, but sediment that accumulates in the river has always entered the Erhai, [so,] with the passing of time, the mouth of the Erhai has become obstructed, and the tail-end of the river has also grown congested. For this reason, 30 years ago the place where the river entered the Erhai was [just] downstream of the Lock Water Pavilion [Suoshui ge 鎖水閣]. Today [*circa* 1854–55] it is about 5 or 6 *li* [2.5 to 3 km] distant. [A linear extension rate approaching 0.2 km per year.] ... It is undoubted that there are advantages for the people living in the neighbourhood, but harm is caused to the upper reaches. The reason is that greed for the profits from fields formed by the accumulation of silt [*yutian* 淤田] and [the consequent] lack of dredging clear, causes the tail-end of the river to narrow to the extent that it will not admit boats. If the anus is not wide open, the digestion is incommoded. The disaster of flooding over arises from this. Furthermore the disaster of sediments and stones are endured all the way from the source to the tail ¹³² ...

Dengchuan's disasters are from water, but *what provokes these disasters in fact comes from the mountains*. In all the mountains the aethers of metal [*jinqi* 金氣] are weighty, and many of them lack vegetation cover [*bumao* 不毛]. If it has no vegetation cover, the surface of a mountain will be bare and reddish [*tongcheng* 童禿] and it will be easy for it to be stripped and [for material] to fall, and for it to become permeated with water [*jinyin* 浸淫]. When the cliffs and valleys are full of holes, the heavy rains that fall set the sediments in flight off lines of ridges and contiguous ranges. Shifting rocks and speeding currents form landslides and floods with a tumultuous hubbub, competing for a way through as they come down. This is the reason large rivers flood over and branch streams become choked with alluvium. An array of discussions of policies, from both ancient and modern times, to keep rivers in check exists but I have never heard of keeping mountains in check.¹³³

These concluding remarks suggest a sharpening awareness of how environmental problems were interconnected. The point to bear in mind is that they were prompted by events that in terms of historical experience were new.

At the same time there are hints that by the first half of the nineteenth century population pressure was also making itself felt in a way that it had not done before. The gazetteer for Dengchuan department of 1854/5 contains this pen-portrait of Yangtangli 羊塘里, one of its component cantons:

Fifty years ago an epidemic¹³⁴ was so severe here that almost nine out of ten households were left empty. For this reason the fields and cleared areas [*tianye* 田野] became overgrown with thorns and weeds, and were not properly under control. ... Today the vegetation has been cleared, and the smoke from the canton [fireplaces] fills the village lanes and a multitude of humble dwellings are spread there like nets of stars or counters on a go board. Even among the perilous peaks and deep river-ravines [*suijing* 邃箐],

if there is a scrap of farmland and a ladleful of drinkable water, there will be several reed-thatched houses again with their sloping rooves among the thickets of vegetation, no different from chicken houses or cattle sheds, either in fractional groups of from three to five households, or else as isolated 'villages consisting of a single family' *Generally speaking, in times past land was plentiful and no one ever suffered from a shortage of it, while today people in their abundance are threatened by more than just poverty.*¹³⁵

¹³⁵ Hou Yunqin, *Dengchuan zhouzhi*, p.37. Emphasis added.

¹³⁶ *Ibid.*, pp.34–5. Emphasis added.

This impression of pressure on resources is confirmed by the account of Xizhuang canton (Xizhuang li 西莊里):

It is on the elevated ground below Mount Tianma and Mount Shishe 獅舌山. The spring that comes down from Potuo 陂陀 is irregular, either overflowing or drying up, but suitable for wheat, taro, or tobacco. *The acreage is insufficient, so they go into the deep mountains to cut firewood and kindling which they can exchange for a measure of grain.* The men carry it on poles, the women on their backs, until their muscles and bones are exhausted, they feel reduced to almost nothing, and are haggard with their affliction.

On its eastern side Xizhuang Canton has the Lingyuan Marsh 靈源澤, the benefits from whose water are relatively extensive. In the seventh and eight lunar months, however, the floods off the mountains converge together, and there is a lot of salt in the accumulated water that swirls around. The farmland beside the East Lake is especially hard and gravelly. It is necessary to excavate it deeply and pile it in layers, letting the wind and sun warm it and make it crumble. After a long time the richness of the soil emerges. It requires more diligence than 'ploughing with fire' [*huogeng* 火耕 ≈ slash and burn]. Stone is produced in the mountains There are a number of families of stone masons who have made this their hereditary profession.¹³⁶

People were being pushed into agriculturally marginal areas and surviving on by-employments that often did not yield an income comparable with that from farming. While the skilled and specialized masons may have done better, since we are told that their bluish-white stone was "a must for palaces, mansions, tombs, and dyked banks," the adverse hydrological effects of continued wood-cutting and the clearance of fragile upland slopes hardly need stressing.

7.0 *The Puzzle of West-Side Hydraulic Degradation*

The gazetteer for Dali prefecture published in 1563 shows the irrigation systems of the west side in a state of administrative neglect, and in some cases allegedly irrecoverable decay. The hectoring and sometimes anxious tone of the section on the channels is an unusual one to find in official handbooks of this sort. The compiler, Li Zhiyang 李之陽 seems at times to be scolding the local authorities. We quote below virtually the entire section to show that at this time almost none of the water supply from the Eighteen Streams used for farming was under proper control. The important points are italicized:

¹³⁷ Li Zhiyang, *Dali fuzhi*, 2:52a–b. Emphasis added.

¹³⁸ *Ibid.*, 2:52b.

Four *li* Channel 四里溝 north of the prefectural capital: This channel irrigates more than ten *qing* [70+ hectares]. *In the season for heavy rains, its floods cover over [fumo 覆沒] the cultivated fields.* It is necessary to dredge it when the winter comes.

Tower Bridge Channel 塔橋溝: The floods from this channel cover over the cultivated fields, and *the inundated area is gradually increasing year by year.* If it is dredged clear in winter, *it can still be saved.*

Shangyang Channel 上陽溝: This channel should be dredged *at the earliest possible moment.*

Bay Bridge Channel 灣橋溝: For a long time the floods from this channel have been covering the farmed land. *If it were to be dredged in winter every year, further disasters could be avoided.*

Xizhou Channel 喜州溝: The floods from this channel cover a large number of fields. If it were dredged every year in winter, *one-tenth of these could be saved.*

Elang Channel 峨崑溝: *It has already become impossible to open up for farming the area flooded by this channel.* It should likewise be dredged, so that the water is made to leave the midst of the land [*shi shui you di zhong* 使水由地中], after which *it could still be saved for ploughing and planting.*

Zhoucheng Channel 周城溝: *The agricultural land covered by floods from this channel is already impossible to save.* If the residents were to open another channel, there would still be some land that could be spared for farming. *It is to be regretted that there is no one to take on the direction of this among the superior authorities.*

Ten *li* Channel 十里溝 south of the prefectural capital: it should be dredged every year. *If this is not done, then the sediments and stones overflow everywhere, which is a disaster for the cultivated fields.*

Crane Bridge Channel 鶴橋溝: it should be dredged every year. It is essential that this be led by those in authority [*zaiweizhe* 在位者]. The residents would then be able to remedy their circumstances. *If this is not done, the disaster of widespread inundation will grow worse day by day.*¹³⁷

The editor comments that, with the Eighteen Streams pouring off the Diancang Mountains, “other counties cannot equal the benefits from irrigation” enjoyed by the west side. However, “within the last hundred years, rich soil has been turned into sands [*sha* 沙, also ‘sediments’] and stones. The people are in great trouble, the reason being that water control has been neglected.”¹³⁸

The accounts given of the levees and barrages [*tiba* 堤壩] tend to suggest that, in this period, where there was a compelling public interest, successful efforts were usually made to do maintenance work, but rarely otherwise. In the first category was the Disaster Prevention Dyke [*yuhuant* 禦患堤] south of the prefectural capital next to the moat. It was said that “if the sun-baked mud and the sands and rocks are left for a second year without being dredged, they will become as high as the dyke.” Some time between 1488 and 1505 a huge flood did in fact break into the walled city, destroying half of the ordinary people’s houses, but as a result arrangements were made to dredge

the moat annually. The same importance was given to the outflow of the Erhai, which was cleared every third year: “Once they had cut channels through the choked-up accumulation of sands and muds, so changing the impact of the spate floods from the mountain, the fields along the banks of the river were not caused to be drowned [*dao shani zhi yuse, gai shanlao zhi chongshe, ze binhe zhi tian, bu zhi yanmo* 導沙泥之淤塞，改山潦之衝射，則濱河之田，不至淹沒].” The excavation of channels through the sediment was done by building a temporary cross-dyke, drying out the river below it, and shovelling.

Contrast the levee along the channel north of the prefectural capital. Because—so the gazetteer says—the inhabitants in several places had let their pagodas fall into disrepair, there had been “changes by the flood-dragon” [*jiaobian* 蛟變], in other words disasters, and “good fields have been flooded, and many of them become rank with weeds.” There had been a proposal to cut channels through them so they could be farmed, but “because people had shrunk from the expense, it had stopped in mid-course, which was a pity.” As a result, “benefits remain in the land [unused], while people have a famished appearance.” In similar fashion the three channels that ran through the prefectural capital, partly to provide water for fighting fires, and partly for irrigation of the fields just outside, had long been choked up for lack of dredging. “This has caused a hundred *qing* of rich land to turn into saline waste.” Evidence of long-run unsustainability? It was the same story with the Mahuang Gorge (Majiang jian 麻黃澗). “The old course of this stream entered the Dama River [Dama jiang 大馬江] north of the military training-ground. Because this course had become choked up, when there were heavy seasonal rains, the surging floods sped forth and made breaches, coming down the main road by the training-ground instead, striking the west gate on their way.” Proposals were made to excavate the old course but “Alas! It was merely empty talk.”¹³⁹

Sedimentation was presumably the result of tree-cutting on the Diancang mountains, but it seems unlikely that this was severe. Table 4 summarizes the information on forest cover on the Nineteen Peaks given in the 1917 Dali county gazetteer. We know that trees were still being felled there at this time, and there is a slight suggestion that stocks were beginning to decline in the observation on Malong Peak that “there is a profusion of bamboos and trees, but they all grow on the summit and the journey for woodcutters is an exceedingly long one.” Some trees, such as those on Foding and Wutai Peaks, were ‘timber trees’ (*caimu* 材木). We are also told that though the trees in the gorges of Yingle Peak (Yingle feng 應樂峰) were “plentiful,” at the end of the Manchu-Qing, “a certain provincial commander-in-chief occupied it as his personal property. For his buildings and his cooking fires heated with bellows [*chuicuan* 炊爨] he cut down nearly all [the trees].”¹⁴⁰ But this implies that they were still there to cut in the early twentieth century, and, although trees can of course regrow if given the chance, they were presumably even more abundant in the late Ming.

¹³⁹ Ibid., 2:53b–54b.

¹⁴⁰ Zhang Peijue, *Dali xianzhi*, pp.90–1.

¹⁴¹ Ibid., p.99.

¹⁴² Ibid., pp.1550–1. Emphasis added.

Qualitative evidence from the later Ming also supports this impression of slopes still covered in many places with trees. Even allowing for a degree of poetic licence, this emerges from some lines in a poem by Li Yuanyang 李元陽 called “South of Sunny Slope Temple.” This was the Yangnan si 陽南寺 which was in the subcatchment of the Nanyang Stream 南陽溪, at the southern end of the Diancang, as described by the gazetteer when it says that “the source of the Yangnan Small River-Ravine [Yangnan xiaojing 陽南小箐] emerges from the foot of the northern spur of Maer Peak [Maer feng 馬耳峰 [to the east of the South of Sunny Slope Temple)].”¹⁴¹ He was on horseback:

I ask how to find the way to the South of Sunny Slope Stream.
The stream’s remote, and I meet, by chance, with herdsmen *and cutters of wood*.

Tired out, and their parasols opened up, my grooms
Look about them with every step at the creepers *and bamboos*,
Then, sitting down in the cool of the clouds, allow the horses to rest.

A nearby rock has the squared-off shape of a box that’s used as a grain-measure,
Something that tells me there’s not much further to go to the Buddhist temple.

So I pierce a path through the lower slopes by the vigorous use of my whip
Where tens of thousands of pines are as dense as the scales on a fish.
The uninhabited valley with verdant colours fills
As a fresh, bright light shines back from Ten Thousand Flowers Cliff.¹⁴²

The steeper, higher slopes of the Diancang range were not and are not suited to farming, which is probably why they kept so much of their forest cover for so long.

Table 4

Forest Cover on the Nineteen Peaks circa 1917

Name	Plentiful	Some	Sparse or absent	Bamboos	No information
Zhonghe 中和	*		*		
S →					
Longquan 龍泉		*			
Yuju 玉局		*		*	
Malong 馬龍	*			*	
Shengying 聖應		*			
Foding 佛頂	*			*	
Maer 馬耳					*
Xieyang 斜陽					*
N →					
Guangying 光英			*		

Yingle 應樂	*				
Xueren 雪人			*		
Lan 蘭		*			
Sanyang 三陽		*			
Heyun 鶴雲					*
Baiyun 白雲			*		
Lianhua 蓮花		*			
Wutai 五臺	*			*	
Canglang 滄浪	*				
Yunlong 雲弄		*			
Totals	6	7	3	5	3

Note: Peaks 2 through 8 lie south of Zhonghe, peaks 9 through 19 lie north of it.
Source: *Dali xian zhi*, pp.89–91.

These fragments of evidence leave us with several problems, made more difficult by an approximately three-hundred-year gap in the evidence. An intricate, decentralized complex of small traditional irrigation systems based on the Eighteen Streams, and many smaller sources like springs, was still functioning in the early twentieth century, apparently successfully. How did they recover from the late Ming hydraulic decline in this area? How far were they revived and how far new? And how were they managed? The 1917 gazetteer only gives passing hints on this last question, though it appears that the part played by the state was minimal, in contrast to the Miju system. Their small scale made community management practicable, though, as almost always, we have to assume in the context of the history of water-control in China generally¹⁴³ that quarrels would at times have prompted intervention from above to settle. This gazetteer does, however, provide a descriptive overview that offers a basis for some careful speculation.¹⁴⁴

These water systems were gravity-driven:

The water flows down from the heights. They divert it for [powering] hammering mills [*dui* 碓] and let its impact [work] grinding mills [*wei* 碓]. For irrigating the fields they do not have to toil with counter-balanced balancing-buckets [*jiegao* 桔槔, i.e. the shadûf]. Therefore the people's toil is uniquely free of effort.¹⁴⁵

In structural terms, the larger systems in the southern two-thirds of the west side of the lake commonly consisted of four sections: (1) one or more sources (*yuan* 源); (2) a 'stream mouth' (*qikou* 溪口) where a watercourse began to be treated as a means for irrigation; (3) a spreading network of 'branches' (*zhi* 支) and 'smaller branches' (*xiaozhi* 小支) from which the greater part of the irrigation water was drawn, most of them man-made, and some with 'water-dividing places' (*fenshuichu* 分水處); and (4) 'river tails' (*shuiwei* 水尾), outflows that led the water back to the 'big spine' (*dagan* 大幹) or main course, often providing a further measure of irrigation water as they did

¹⁴³ This comment is based on decades of reading through local studies by Japanese scholars. For a quick sketch of some typical patterns, see Mark Elvin, "On water control and management during the Ming and Ch'ing periods," (*Ch'ing-shih wen-t'i* 3.3 (Nov. 1975)) For the Japanese literature generally, see Mark Elvin, H. Nishioka, K. Tamura, and J. Kwek, *Japanese studies on the history of water-control in China. A selected bibliography* (Canberra: Institute of Advanced Studies, Australian National University; and Tokyo: Center for East Asian Cultural Studies for Unesco, 1994), especially Introduction.

¹⁴⁴ Unless otherwise stated, all the items that follow are drawn from Zhang Peijue, *Dali xianzhi*, pp.96–112.

¹⁴⁵ *Dali xianzhi*, p.366.

¹⁴⁶ Emphasis added.

¹⁴⁷ *Dali xianzhi*, pp.1242–5.

¹⁴⁸ See the Soviet 1:100,000 map of China (1978) cited above (Maps 2 and 3).

so. The slowing of the current caused by creating these diversion networks would of course have been a major cause of the deposition of sediment, so removing the need to place too much explanatory weight on the removal of vegetation cover. Towards the northern end of the west side of the lake the systems that only flowed strongly in the wet season were to some extent replaced by dam-reservoirs (*tang* 塘) and barrages (*ba* 壩, 埧) that retained the seasonal runoff for controlled release as needed.

The main streams varied greatly both in the amount of water they provided, and the degree of seasonal variations. Some, like the Tao and the Yinxian, were dry much of the year; some were relatively stable, like the Jin; others regularly destructive in spate. (See Table 5 below for the structure of the streams.) Thus it was said of the Yang that “every autumn it overflows on all sides, and does considerable damage to the farmland.” The same was true for Sandy Level Gorge (Shaping jian 沙平澗). “At normal times its flow is extremely exiguous. As summer turns to autumn, though, when there are heavy rains, its course flows sideways, flooding over in all directions.” Also for White Rock Gorge (Baishi jian). “In the summer and autumn of every year the waters from the mountain burst forth and routinely destroy farmland.” Whatever the reason, people seem to have been content to live with these problems rather than trying to control them.

Allocation of water was based on customs long established, but it is not clear when, how, or by whom. Thus,

The source of the Pin River [Pinshui 品水] emerges at the foot of Foding Peak. The acreage that its water supplies with irrigation is that of Dajingpang 大井旁, Zhuanyao 磚窯, Zhongyi 重邑, and Taiyi 太一 of Taihe 太和 villages. Every time the solar period Grain Fills comes round [21 May–5 June], these four villages share out the water according to which day it is [*anri fenshui* 按日分水]. When a cycle is complete, they return to the beginning again. The custom has become a regular law.

Other groups of villages used similar cycles. Others had inherited rules, working on principles not specified. Thus we learn of the Nanyang Stream that:

It has two sources, one on the left and one on the right, each of which constitutes a distinctive flow. Only when they reach the foot of the mountain do they join into one. They flow straight to the centre of Baolin 寶林 village, where there is a water-dividing place [*fenshuichu* 分水處] that splits it into four branches:

The first branch goes south from the foot of Xieyang Peak, then turns east to descend. In general the acreage of the Third *jia* of the Fifth Army at Xiaguan [*Xiaguan zhi wujun san jia* 下關之五軍三甲] and the two surnames of Zhao 趙 and Li 李, Tuideng 推登 village, and Daguanyi 大關邑 settlement *all depend on the settled regulations to divide up the irrigation [water between them].*¹⁴⁶

The gazetteer does not tell us what happened when there was conflict over the implementation or interpretation of these regulations.

If we judge by the number of names in common, the anthropogenic channel structure of the west-side complex of irrigation systems in 1917 bore only the slightest relationship to that of 1563 or that of 1426–35, just as these latter two had only a most limited mutual relationship, especially if we exclude the waterways through and immediately around the prefectural capital. The Mahuang Gorge, written variously as Mahuang jing 馬蝗箐 ‘Horse-leech Ravine-River’ (reading *huang* 蝗 as *huang* 蟻) and Mahuang jian 麻黃澗 ‘*Ephedra sinica* Gorge’ is one of the few—perhaps the only one—to be found beyond any doubt in all three. Some few others, such as the White Rock Gorge (Baishi jian), can unambiguously be found in the first and third, but note that these, like Mahuang Gorge, are mostly natural features, not artificial channels. Different names may of course have been given at different periods to the same reality, but equally the same or similar names may have been given at different times to nearby but different channels. Our speculation is however that, while the main Eighteen Streams themselves, and most springs and gorges, remained more or less constant over time, their debouchments into the Erhai perhaps excepted, *the man-made irrigation-system channels that they fed were being slowly but continuously shifted by human action across the lower lakeside slopes of the Diancang Mountains to circumvent the problems created by sedimentation*. In oversimplified terms, while the challenge that developed on the Miju was vertical, namely to make the dykes higher and the river bed lower, for the Eighteen Streams it was horizontal, to find a way to relocate laterally. The former required an ever more onerous annual state-run bureaucratic mobilization of labour, resources, funds, and managerial skills; the second needed only intermittent small-scale excavations as appropriate. This may also explain why the documentation generated on the Miju became so much more voluminous: it was a huge concern of the bureaucracy and it was the bureaucrats who mostly produced the gazetteers.

The structure of the Eighteen Stream complex is outlined in Table 5.

Table 5

The Structure of the Eighteen Streams circa 1917

Number	Name	Branches	Sub-branches	Sub-sub-branches
1	Zhong 中溪	1.1 1.2 (→ 8 and 1.1) 1.3 1.4	1.1.1, 2 1.4.1, 2, 3, 4, 5	
	<i>Springs: 2</i>			
→ S				
2	Luyu 綠玉溪	2.1 (→ 1) 2.2	2.2.1	2.2.1.1

				2.2.2	
	<i>Springs</i> : 3				
3	Long 龍溪	3.1	3.1.1		several
			3.1.2		
		3.2 (-> 2)	3.2.1, 2		
4	Qingbi 清碧溪	4.1, 2			
	<i>Springs</i> : 3				
5	Mucan 莫殘溪	5.1, 2			
	<i>Springs</i> : 3				
6	Tingming 亭莫溪	6.1	6.1.1, 2		
		6.2			
	<i>Springs</i> : 2				
7	Nanyang 南陽溪	7.1, 2, 3, 4			
		7 A.1			
		7 A.2	7 A.2.1, 2, 3		
	→ N				
8	Tao 桃溪	8.1			
		8.2 (→ 1 and 2)	8.2.1, 2		
9	Mei 梅溪	various			
10	Yinxian 隱仙溪	10.1	several		
		10.2	several		
		10 A	10 A.1, 2		
11	Yuanyang 鴛鴦溪	11.1	11.1.1 (-12)		
		11.2			
12	Baishi 白石溪	12.1	several		
		12.2	several		
		12.3			
		12 A	12 A.1, 2		
13	Lingquan 靈泉溪	13.1, 2			
		13.3	several		
		13.4	13.4.1, 2		
14	Jin 錦溪	14.1			
		14.2	several		
15	Mangyong 芒湧溪	15.1	several		
		15.2, 3, 4			
	<i>Springs</i> : 1				
16	Yang 陽溪	16.1			
		16.2	several		
		16.3			
		16.4	several		
		16.5	16.5.1, 2, 3		
	<i>Springs</i> : 2				
17	Wanhua 萬花溪	17.1	17.1.1, 2		
	<i>Springs</i> : 1				
18	Xia 霞溪				
	<i>Springs</i> : 5				

Notes: 'Springs' are small separate systems listed as being the in the area of a given major system. These are sometimes also called 'wells' in the gazetteer.

'A' indicates a larger separate system listed as being in the area of a given major system. An arrow '→' after a number indicates a cross-link between systems.

Commas are used to demarcate separate last-order branches in order to save space. Streams 2 through 7 are south of the Zhong, streams 8 through 18 north of it.

Source: *Dali xian zhi*, pp.96–112.

The decentralized, and very slightly anastomotic character of the complex is immediately evident.

What did it take to open a new channel on the lower slopes of the Diancang? Some time in the Qing dynasty, Li Xiaozhi 李孝治, the county magistrate of Taihe, in other words Dali, organized the construction of a new diversion channel rather more than 3 kilometres in length to take water from the Xiangshui ravine-river (≈ Xiangshui jing 響水箐) to the Jiangjun Temple ravine-river (Jiangjun miao jing 將軍廟箐) to increase the supply to the Longwei domain (Longwei dian 龍尾甸). The Jiangjun Temple ravine-river is a small watercourse that descends from the southern end of the mountains on the north side of the Erhai outflow, and faces the western end of the city of Xiaguan on the opposite bank. If we have identified it correctly, the Xiangshui lies further downstream on the outflow than the Jiangjun but upstream of the Dapo ravine-river (Dapo jing 大坡箐). The Longwei domain is, or was, farmland on the west side of the Erhai but south of the most southerly of the Eighteen Streams, the Nanyang. Because the Nanyang could only irrigate a part of it, many of the fields were dried up or covered in weeds before the new channel was built. Magistrate Li, who inspected the terrain in the company of local elders, agreed with their view that the large quantities of “unstable sediments” made seepage likely if the diversion from the Xiangshui was made at a low level, and the channel was therefore brought down from a point high up on the ravine-river and more than half of it lined with stone. Making water “flow upstream” in this way, to use Li’s own words, and “following the salients and re-entrants” along strongly corrugated contours on steep slopes was a far from trivial feat of engineering, but it was done in 3 months, that is at a rate of about 33 metres a day. Regrettably, we are not told the size of the labour force. The new channel was later given Li’s own ‘style’ as a name, becoming the Qingqi 清溪, or Qing stream, in his honour.¹⁴⁷

Making new channels on the alluvial fans, or on the exposed lake shore of the main part of the west side, would have been much easier. We can conclude that work of this sort would have been at most a substantial undertaking, but not a monumental one.

8.0 *Discussion*

If our conclusion about the nature of long-term flexible hydraulic adaptation on the west side can be validated this would indicate that, even systems with a high degree of relative ‘sustainability’ may not have been absolutely sustainable over the long run (given the assumption of a constant technology), except at the cost of periodic restructuring in addition to ordinary maintenance. It is of course a matter of judgement how far a system can be restructured and still be defined as ‘sustainable’. Likewise how far ‘stability’ can be reasonably allowed to contain ‘dynamic’ elements as con-

tributing to any sense of 'equilibrium' (a term with an uncomfortable amount of baggage). More importantly and more generally, the contrast between the four sides of the Erhai lake shows that, within the general framework of the concept of 'traditional Chinese irrigated agriculture', we need to draw significant distinctions between *differing degrees* of 'sustainability' depending on the types of interaction with the environment required.

There was also a *variety of patterns* of ecosystem reaction across time to premodern Chinese-style development. In some cases, such as that of the Miju River, a long early phase of relatively widely spaced human innovations to exploit natural opportunities or provide 'solutions' to natural problems, with little trouble during the intervening periods, could be followed by a dramatically intensifying sequence of crises, especially if other factors to some degree outside the hydraulic system—such as upstream stripping of mountain forest and vegetation cover in the case of the Miju—had an increased input into the complex of causes. This transition could often leave a significant imprint on the historical documents in contrast to the lesser impact of more routine operations that had a lower historical visibility, but were as intrinsically as, or more, important to the human economy.

Analytically, the pattern of *spatial connectivity* appears a crucial determinant in creating the Miju type of acute crisis. Water systems on the east side of the Erhai were small and relatively isolated; problems were mainly those of adequacy of supply. Those on the west side were marginally anastomotic in places, but likewise predominantly independent of each other; clearing deposited sediments and restructuring were costs, but localized. In contrast, the Miju in the north was to all intents and purposes a single dendritic system in which perturbations in sediment loading in a multitude of inputs had a cascading effect as they reinforced each other downstream. Differences in scale mattered too. The Boluo River system in the south was also dendritic but its annual discharge into the Erhai (using modern figures) was only 22% of that of the Miju. Its *gradients* overall also tended to be somewhat less: the highest peaks to the east and west of the upper Miju subcatchment were respectively about 900 and 700 metres higher than those to the east of the Boluo, and about 1300 and 1100 metres above those to the Boluo's west.¹⁴⁸ While slope is only one of the many parameters determining erosion and sediment transport, we may speculate—pending further investigation—that this may have eased the erosive impact of the removal of vegetation cover on the higher slopes. Given that the repertoire of premodern farming techniques was to all intents and purposes identical in the two subcatchments, these simple observations already go some way to suggesting an explanation for the greater historical stability in the south of the region.

Environmental microvariation matters.

Mark Elvin

Division of Pacific and Asian History
Research School of Pacific and Asian Studies
Australian National University
Canberra ACT 0200 Australia
email for sinological correspondence:
Mark.Elvin@anu.edu.au

Shen Ji

Nanjing Institute of Geography and Limnology
(Chinese Academy of Sciences)
73 Beijing Dong lu
Nanjing China 210008
shenji63@hotmail.com

Darren Crook, Richard Jones, John Dearing

Department of Geography
University of Liverpool
Liverpool L69 7ZT United Kingdom
email for geographical correspondence:
dcrook@liv.ac.uk