THE ARCHAEOLOGY OF DRYLANDS
Living at the margin

Edited by
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we would hesitate to identify simple cause and effect, it would appear that increased population was linked, through a complex sequence of interactions, with the expansion of irrigated agriculture and increased centralization of authority. The increase in population not only required an increase in the amount of land irrigated but also provided the workforce necessary for this expansion to take place. Irrigation flourished during periods of political stability, often when a single polity ruled over the area, and declined in periods of invasion or unstable internal political conditions.

The decline of Merv can clearly be traced to the Mongol destruction of AD 1221–2. The Mongols took advantage of the fact that Merv, like most other settlements throughout Central Asia, was reliant on a single water source. In their rapid conquest of the region, the Mongols frequently forced communities to capitulate by disrupting water supplies and damaging irrigation structures, and all they needed to do at Merv was to destroy the main dam that controlled water in the oasis. Whilst the city was in part rebuilt, the irrigation systems were never fully reconstructed until the region once again came under the influence of another empire – that of the Soviets.

Significantly, the widespread environmental degradation that plagues Soviet-built irrigation systems in the region does not appear to have been a major problem in the past, suggesting that sustainable irrigation in Turkmenistan is not only feasible but has been the norm. Traditional irrigation systems were generally localized and often dependent on a single water supply that was not only limited but also liable to fluctuate considerably from year to year. Water management required considerable skill, hence the mirah bashi, responsible for highly important and often contentious decisions on water allocation and distribution, was one of the most senior officials in central government – indeed, the success of many political officials often hinged on their skill at managing local water resources. Yet whilst water was managed centrally, all water users were responsible for the upkeep of the system, with those gaining more being expected to contribute more. The fact that individuals could benefit as a result of their efforts gave all users a vested interest in ensuring that the irrigation network was maintained and that water was used efficiently. The Soviet system effectively broke this link, with the system managed centrally but from afar. Together with the collectivization of land, the imposition of central planning meant that benefits were no longer linked to duty; water users had no say in how the system was managed, nor were they responsible for its maintenance. The establishment of myriad agencies to oversee different parts of the network resulted in unnecessary bureaucracy and waste. In sum, traditional irrigation and water distribution systems tended to be small, highly productive, well managed, extremely efficient and sustainable over the long term. In contrast, Soviet-built systems are huge, inefficient, inflexible, poorly managed and, for the most part, unsustainable.

The decline in the water distribution and irrigation network since the break-up of the Soviet Union is thus unsurprising. What remains to be seen, however, is how this decline will be managed, and what can be done to
Table 6.1 Simplified chronological chart of prehistoric settlement in Turkmenistan

<table>
<thead>
<tr>
<th>Archaeological period and date (cal BC/AD)</th>
<th>Settlement</th>
<th>Irrigation systems</th>
<th>Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neolithic 6300–4800 BC</td>
<td>Small farming villages on piedmont of Kopet Dagh. Key site: Jeitin.</td>
<td>Crops cultivated in areas of high water-table; possibly also simple diversion of streams.</td>
<td>Main crop einkorn; also emmer, hulled and naked barley</td>
</tr>
<tr>
<td>Eneolithic (Chalcolithic) 4800–3000 BC</td>
<td>Larger, complex settlements, to 15 ha with shrines and fortifications in Middle Eneolithic (4000–3500 BC); spread of settlements to Geoksyur oasis in Middle Eneolithic but abandonment of oasis by E.B.A. Key sites: Alyyn-depe, Anau, Geoksyur, Namazga (phases I–III).</td>
<td>Simple irrigation assumed for piedmont and early occupation of Geoksyur; large irrigation canals identified in Geoksyur oasis in late Eneolithic (Namazga phase III).</td>
<td>Hulled barley, free-threshing wheat</td>
</tr>
<tr>
<td>Early Bronze Age (E.B.A.) 3000–2500 BC</td>
<td>Sites to 25 ha, restricted to piedmont zone. Key sites: Alyyn-depe, Namazga (IV).</td>
<td>Irrigation assumed for large settlements in piedmont but no direct evidence.</td>
<td>Hulled barley, free-threshing wheat, grape</td>
</tr>
<tr>
<td>Middle Bronze Age (M.B.A.) 2500–1900 BC</td>
<td>Sites to 50 ha; monumental architecture. Abandonment of piedmont sites at end of M.B.A. Major fortified settlements appear in Merv oasis in terminal period (2200–1900 BC). Key sites: Alyyn-depe, Namazga (V), Gonur depe</td>
<td>Smaller-scale irrigation at northern fringe of Merv oasis.</td>
<td>Main crop: hulled barley; also free-threshing wheat, lentil, pea, chickpea, grape</td>
</tr>
<tr>
<td>Late Bronze Age (L.B.A.) 1900–1500 BC</td>
<td>More dispersed, smaller sites (to 2 ha) in piedmont. Period of Bactrian-Margiana Archaeological Complex; abundant large sites in Merv oasis. Key sites: Namazga (VI), Gonur depe.</td>
<td>Sophisticated canal irrigation in Merv oasis, using water from main channels of rivers.</td>
<td>Broomcorn millet</td>
</tr>
<tr>
<td>Early Iron Age 1500–550 BC</td>
<td>Abundant settlements (to 15 ha) in piedmont and oases. Key sites: Tahirba, Yaz-depe (Merv oasis).</td>
<td>Introduction of qanat (kiariz) irrigation to piedmont. In Merv oasis settlement continues to shift to south.</td>
<td></td>
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</tbody>
</table>
by elected senior officials and maintained by over 12,000 workers, paid by the water users, who were also expected to take part in major construction schemes and in the annual maintenance programme.

EXPANDING THE IRRIGATION SYSTEM: THE TSARIST AND SOVIET PERIODS

When Central Asia finally came under Tsarist control in the late 1880s, the new administration attempted to introduce reforms in the irrigation sector. These failed, however, and the authorities declared that irrigation would be run 'by custom'. Notwithstanding this, a number of subtle changes were made: most important, irrigation officials became part of the Tsarist civil service and as such were no longer controlled by water users. This act severed the link between water users and providers, so effectively undermining the traditional system of water management. State salaries for officials were low and there was no longer any incentive to control the system. The situation was exacerbated by the imposition of irrigation officials unaccustomed to the traditional method of management, resulting in increased problems within the system, which became subject to corruption and abuse by the wealthy and more powerful water users.

More significant than Tsarist interventions in water management, however, were the changes in agricultural policies. The authorities in Moscow, keen to end their reliance on America for cotton (particularly following the American Civil War when supplies almost ceased), recognized that Central Asia had the potential to become a major cotton growing region; in fact, the main factor behind initiatives to increase the amount of land irrigated was cotton production (Lipovskv, 1995). The subtle, but nonetheless important, changes in water management, coupled with increased demand and use of water, appear to have caused widespread land degradation. In the Merv oasis, for example, the irrigation network was expanded by some 33,000 ha (Zaharchenko, 1990), but poor management of the system caused local water tables to rise, resulting in salinization and widespread surface ponding that not only degraded the soils but also led to outbreaks of malaria (Pierce, 1960).

The Bolshevik Revolution and the subsequent emergence of the Soviet Union heralded a period of radical change in the way water was managed in Central Asia. In 1923 the Soviet administration decreed that water management was to be taken 'out of the hands of traditional elders and councils with whom it resided' (Black et al., 1991) and, like land, was to become a common resource for the benefit of all. Various government bodies were established to be responsible for the development of a regional water management strategy that would allow centrally-determined production targets to be met. With cotton production the priority for Moscow, huge sums of money were invested in the region in the development of massive, highly integrated systems of water distribution and irrigation (Micklin, 1991). Land was irrigated no longer by a single local source, as in the past, but by water often piped over considerable distances: the Kara Kum Canal, for example, considered to be one of the engineering feats of the Soviet era, now transfers in excess of 12.9 km³ of water from the Amu Darya along its 1,400 km length every year, irrigating an area of c.1 million ha (Hannan and O'Hara, 1998).

There has been much criticism of the management and maintenance of Soviet irrigation systems and the inefficiency of water use (e.g. Micklin, 1991). Losses occurred throughout the system, with problems of seepage and evaporation from the many thousands of kilometres of unlined irrigation canals creating huge problems with waterlogging and soil salinization. Within a few years of the Kara Kum Canal being constructed, for instance, the water table in the Merv region had risen over 20 m (Kornilov and Timoshinka, 1975) and vast tracts of land had become salinized (O'Hara, 1997). Water use at the field level also rose, as field size increased to accommodate increasingly bigger agricultural machinery, not only increasing the amount of time that it took to water fields, but also causing the traditional practice of night-time watering to be replaced by daily, and often continuous twenty-four-hour, irrigation. Yet despite an emphasis on the need to modernize the agricultural sector, furrow irrigation continued to dominate, with large and poorly levelled fields creating huge problems for irrigators. Moreover, unlike in the past, access to water was not a problem, with diversion schemes bringing what to many seemed an infinite supply of free water; people who had long viewed water as a scarce commodity forgot its worth and wasted it.

Further exasperating the situation was the fact that government agencies rather than individual water users were responsible for, amongst other things, maintaining the irrigation infrastructure, dredging canals and ensuring that the drainage system was clean. At the farm level, maintenance became the responsibility of a few collective workers. In all cases, the bulk of the work was done using heavy equipment. Consequently, water users had little if anything to do with the management or maintenance of the water distribution and irrigation system. Despite Soviet successes in expanding the irrigation network and increasing agricultural output, the systems they built were (and still are) inflexible and highly inefficient. By the 1980s, agricultural land in Turkmenistan was being abandoned at a rate of over 50,000 ha per annum (Zaharchenko, 1994): clear testimony to the fact that this huge irrigation system is not sustainable.

CONCLUSION

In Tables 6.1 and 6.2 we summarize the major trends in settlement and agriculture in southern Turkmenistan. It is evident that there is a strong correlation between the degree of urbanization and population size (themselves correlates of centralized political control) and the sophistication of irrigation technology. The range of crops likewise increases through time. Although
information about the occupation of the area may be obtained by discussion with local

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Bronze age settlements throughout the Near East. Late bronze age samples from Tahrbaj Tepe in the Merv oasis were also dominated by hulled barley but add broomcorn millet (Panicum miliaceum) to the repertoire of crops (Nesbitt, 1994).

Iron age settlements in the Kopet Dagh foothills are widely distributed and often continue on the same sites as bronze age settlements, but are smaller and marked by less material complexity (Kohl, 1984). In the Merv oasis, iron age sites are concentrated in four ‘micro-oases’. The northernmost two, Takhirbai and Togolok, contain bronze age settlements, while the southernmost two, Yaz depe and Aravali, represent new occupation, thus forming part of the pattern of southward movement of settlements that continues until the Achaemenid period (Bader et al., 1996; see below). This shift in settlements is most plausibly explained by increased extraction of water upstream by settlements using more sophisticated canal systems, collecting water near the head of the delta. However, early sites in the upper part of the oasis may have been masked by alluvial deposition, accounting in part for this pattern.

ACHAEMENID TO MEDIEVAL: URBAN SOCIETIES

The Achaemenid period (530–330 BC) marked two important transitions for the Merv oasis: it was the first of several periods when Merv came under the control of an empire based to the south; and for the first time a series of urban centres emerged in the oasis. From this time onwards, Merv was also militarily important as a frontier city at the northeastern part of firstly the Achaemenid and later the Seleucid (330–140 BC), Parthian (140 BC–AD 220) and Sasanian (AD 220–651) empires. Surveys of the magnificent ruins of Merv’s urban centre show a steady increase in its size. The earliest city, Erk Kala, had walls enclosing an area of 20 ha. It later became the citadel of the adjoining Seleucid city of Gyar Kala (400 ha) (Fig. 6.2), which continued to be occupied for a period of over a millennium, even after the construction of the nearby city of Sultan Kala in the eighth century AD. Survey work in rural areas in the north of the oasis confirms this basic pattern of expansion, with increasing residential areas from Achaemenid to Seljuk times (Bader et al., 1993/94; Gubaev et al., 1998). At its greatest extent, the oasis covered c.700 km². The area cultivated appears to have fluctuated, with a decrease in rural settlement in the Hellenistic period, and a marked increase in cultivation and, probably, the first construction of a large central dam and canal network in the Parthian period.

Although written sources state that Merv was destroyed by Mongol invasions in AD 1221–2, there is archaeological evidence for a substantial post-Seljuk occupation, and in the early fifteenth century a new, much smaller, city was built by the Timurids. Notwithstanding this, the oasis declined in importance, and the Timurid city was abandoned by the nineteenth century. Overall, therefore, changes in settlement pattern suggest three key phases in...
In the Proposition of the Year by the City Planning and Development Department (1969), the city's agricultural lands are proposed for conservation and preservation. The city's natural lands, which include farms, orchards, and rural areas, are considered essential for maintaining the city's ecological balance and providing fresh produce to the residents. The city has taken steps to protect these lands from development and ensure their long-term viability.

The expansion of urban areas has led to the relocation of many agricultural lands to the outskirts of the city. This has resulted in a decrease in the size of farms and an increase in the cost of agricultural land. To address this issue, the city has implemented policies to encourage the development of new farms and the expansion of existing ones. These policies include financial incentives, tax breaks, and technical assistance for farmers.

The city has also worked to increase public awareness of the importance of agriculture and its contribution to the city's economy and environment. Public events and educational programs have been organized to promote the appreciation of farming and the role of agriculture in the city's development.

The city's agricultural lands are a vital resource that must be protected and preserved for future generations. The city's efforts to conserve these lands and encourage sustainable agricultural practices are commendable and should be supported by all residents.
conditions similar to today developed somewhat later than previously thought (just as wetter environments characterized the early Holocene in the Levant: Chapter 4). Further support for this hypothesis is provided by a recent analysis of plant remains from the site, suggesting that cultivation may have been possible without irrigation (M. Charles, pers. comm.). Despite this uncertainty, though, it is evident that there is a long history of agriculture in this region and that by the fifth millennium BC agricultural settlements were spread along the piedmont from Kyzyl Arvat in the west to Tejen in the east.

ENOEITHIC TO IRON AGE: PIEDMONT SETTLEMENT AND EXPANSION TO THE OASES

The establishment of agricultural communities such as Jeitun in the Neolithic was followed by several millennia of continuing settlement, largely in the piedmont of the Kopet Dagh, during the Eneolithic or Chalcolithic (c.4800–3000 BC), Early Bronze Age (c.3000–2500 BC) and Middle Bronze Age (c.2500–1900 BC). Sites grew significantly in size – eolithic settlements such as Altyndere, Anau and Namazga cover up to 25 ha – and there were two key changes in settlement pattern: the expansion into the Geoksyur oasis in the Eneolithic and the emergence of state-level urbanism in the piedmont zone in the terminal Early Bronze Age.

The Geoksyur oasis (Fig. 6.1) is situated on the Tejen River delta and, unlike other oases in the region, is contiguous with the foothills of the Kopet Dagh. Nine prehistoric sites comprising large, widely scattered, mudbrick houses, have been found in the oasis, dating from the earliest Eneolithic (Kohli, 1984), but the oasis appears to have been abandoned by the end of the Eneolithic. Earlier eolithic settlements are at the end of branches of the river delta, suggesting that a modified form of floodwater irrigation was practised. Later in the Eneolithic, well-developed artificial irrigation systems are documented for the first time in Turkmenistan (Namazga III period, c.3500–3000 BC). Aerial photographs and excavations have shown that land around the site of Geoksyur 1 was irrigated by three parallel canals, each up to 3 km long and 5 m wide, possibly irrigating an area of about 50 ha by means of small arks (irrigation canals) branching off and leading to fields (Listinsia, 1969). The water flow into secondary canals was controlled by inlet structures where they joined the main canals (Listinsia, 1981).

In the piedmont proper, the last part of the Early Bronze Age witnessed a transformation of settlements with the appearance of specialized production areas, fortification walls around settlements, increased status differentiation in burials, and evidence of much interaction between settlements throughout the Kopet Dag region, all consistent with a state-level society (Hiebert, 1994). These trends continued into the Middle Bronze Age, and by its terminal phase (2200–1900 BC) the foothills contained a number of very large sites such as Namazga (50 ha) and Altyndere (25 ha). This period of expansion came to an end in the Late Bronze Age. The settlements at Anau and Namazga, for example, were considerably smaller, now covering only a few hectares. Relatively little is known about agriculture in the piedmont zone in the Eneolithic and Bronze Age. Irrigation canals have not been located in the piedmont, but this may reflect deposition and erosion in this geomorphologically-active zone. The presence of bread wheat and six-row hulled barley in eolithic samples from Anau dated to c.4500–3000 BC has been cited as possible evidence for irrigation (Miller, 1999), but both cereals were grown in many regions of the Old World without irrigation (Maier, 1996).

Paralleling the decline of settlement on the northern piedmont was the spread of irrigation to the lower reaches of the Murgab river at the end of the Middle Bronze Age, although this occurred while some sites such as Altyndere were still very large. A number of factors has been cited for this shift in agricultural settlement. Masson (1957), for example, suggested that a rise in population stretched resources to the extent that people were forced to migrate, whilst some authors have highlighted the potential impacts of climate change. Lewis (1966) argued that there is no evidence of a major shift in climate during this period, but, as mentioned above, evidence is emerging for a shift to drier conditions c.5000–4500 years ago, coinciding with the rise of agriculture in the Murgab oasis. It is possible, therefore, that conditions became sufficiently dry to precipitate change.

The bronze age settlements of the Merv oasis covered an area of 100 km north–south by 50 km east–west, which is almost five times larger than the later medieval and classical oasis to the south. Hiebert’s recent re-analysis of the ceramic chronology and survey data suggests that the colonization of the oasis was rapid (Hiebert, 1994). The sites cluster in ‘micro-oases’, forming linear patterns that presumably followed old river branches (Fig. 6.2). Settlements are characterized by large fortified building complexes with intervening fields, which, as Hiebert points out, typify Central Asian oasis architecture of the time. Initially, settlements were located on the northern margins of the oasis, with the system expanding southwards some 400 years later (Hiebert’s Gonur Period 3). Initial settlement was at the northern fringe of the oasis because large-scale canals were not used. Instead, fields were irrigated by ditches carrying water from the smaller streams into which the Murgab river split near the edge of the delta. As Bader et al. (1996) comments, settlers from the Kopet Dagh would already have been familiar with the technology of using streams of the piedmont.

Archaeobotanical analysis indicates that, over time, greater numbers of plants and animals were domesticated. By the Bronze Age, the variety of crops grown had increased significantly compared with those in the Neolithic: samples from the middle bronze age site of Gonur Depe in the Merv oasis, for instance, are dominated by hulled and naked barley, with free–threshing wheat, lentils, peas, chickpeas and grape also present (Miller, 1993; Moore et al., 1994). These finds are consistent with those from the bordering Geoksyur oasis (Listinsia, 1969; Listinsia and Prischepenko, 1976), and are typical of
consequences would be enormous and could ultimately undermine regional security. The question of sustainable irrigation is therefore urgent. Given that Central Asia not only has a long history of irrigated agriculture but has witnessed the rise and fall of a number of major empires over the last few thousand years, it may well be that lessons can be learned from the past. An assessment of former irrigation and water management practices may highlight whether sustainable irrigation is a feasible option, and if so how it might be achieved.

Here we review the history of settlement, agriculture and irrigation over some 8,000 years in southern Turkmenistan (Fig. 6.1). A large body of archaeological evidence is available for this region, much of it resulting from the establishment of the South Turkmenistan Multi-Disciplinary Archaeological Expedition (YuTAKE) in 1946. Many of its publications were not widely distributed, even within the former Soviet Union, but we have been able to draw on a wide range of useful syntheses published in western journals. A more recent phase of fieldwork involving a number of international research teams has resulted in a series of renewed excavations at several important sites including Jeitun, Anau, Gonur Depe and Merv. Although many of these projects are ongoing, important papers pertaining to the area have emerged (Harris et al., 1993, 1996; Herrmann, 1997; Herrmann et al., 1998, Hiebert, 1994), providing valuable information on changes in environment and society over this period. Historical sources are more problematic. Although literate civilizations have existed in the region since the Achaemenid period, there is no systematic body of texts comparable to the clay tablets of Mesopotamia. For the medieval period, we are largely dependent on short descriptions in accounts by Arab or Chinese travellers or Arab historians. Some Sasanian records have survived through their use by the Arab historians. Prior to this, we are again dependent on brief travellers' accounts and histories compiled far away to the west, in classical Greece and Rome. Our understanding of the political dynamics underlying the increasingly well-documented settlement archaeology is therefore currently less sophisticated than in the Near East proper.

ENVIRONMENT

Turkmenistan covers an area of 480,000 km², 90 per cent of which is covered by the virtually uninhabited Kara Kum Desert (Babaev, 1996). Most of Turkmenistan comprises lowlands, with mountains being confined to the southern and western parts of the country. It lies within the temperate desert zone (Babaev, 1994) and has a marked continental climate (Orlovsky, 1994). Precipitation mainly falls as snow or rain in winter, with almost none in the agriculturally-active summer months of June through to September. Average annual precipitation varies from 90 mm in Dashouz to nearly 400 mm in the southwest highlands of the Kopet Dag, but in much of the country it
INRODUCTION

MARK NESSERT AND SARGH ORHA

Long-term perspective from Turkmenistan

Increased demand for water as population rises. Should the system hold up?

The system could be expected to change with population growth and increased usage. Technology and infrastructure need to improve and increase in order to sustain the system.

Environmental and social factors play a key role in the creation of a system that can sustain large-scale water systems.

Future analysis and implementation of water management policies should be a priority. The water distribution and infrastructure system should be designed to accommodate growth and future needs.

The system must be able to adapt to changing conditions and be resilient to changes in water availability.

Central Asia is facing a crisis of water shortage and the need to implement sustainable solutions.

(INFORMATION: PAGES 697-712)