Kay Prag
The Manchester Museum,
Manchester University,
Manchester M13 9PL

Kay Prag

Water Strategies in the Iktānū Region of Jordan

Introduction

In pre-modern societies, the environment was the principal dynamic controlling human responses to the need for water and to constraints on consumption of water. Generally, the environment of the region is similar to that of other areas on the east side of the Jordan Rift, with low rainfall and very hot, dry summers. Despite the low rainfall, at its lowest, in the vicinity of the Dead Sea, the southern ghawrs provide a larger alluvial fan than is usual further north. The southern ghawrs include (from north to south) the Ghawr Nimrīn, the Ghawr al-Kafrayn and the Ghawr ar-Rāma (the last two were called the Ghawr as-Saysabān in the nineteenth century). They are watered by several perennial streams, the principal ones being: the Wādī Shu'ayb/Nimrīn, the Wādī al-Kafrayn/Gharaba and the Wādī Ḥisbān/ar-Rāma/Gharaba, all of which have their sources high in the plateau edge to the east. The upper and lower courses of these rivers are usually distinguished by different names, which has been a source of confusion to visitors in the past, and names and identifications may vary even on modern maps. These systems are tributaries to the Jordan River.

There are lesser flow systems in the area to the south of the ghawrs, some with just a seasonal flow direct to the Dead Sea. These are the Wādī Djarafa (Ijarfa), beginning just south-east of Iktānū and flowing past the important Chalcolithic site at Tulaylāt al-Ghassūl, the Wādī 'Ayūn Mūsā/al-Muḥtariqa/Tarfa and the Wādī al-Ḥirī/'Udhayma. The water dynamics of the ghawrs were therefore less dependant on the low local rainfall than on run-off from the high plateau to the east, and thus have demanded localized responses from past and present inhabitants of the ghawrs which are different from the practices of the inhabitants of the plateau to the east, where the dependence lay on a higher level of seasonal rainfall and springs (see, for example, Abujaber 1995). A major concern of the inhabitants of the southern ghawrs through time has been the control and harvest of the available water not just for consumption by man and animals, but for irrigation of crops.

River Systems and Springs

The river systems feeding the southern ghawrs are broadly similar. The Wādī Ḥisbān/ar-Rāma, which today passes a few hundred metres north of Iktānū is a river system less than 30km in length, but drops nearly 1200m in vertical height (Prag 1991: 48). It has therefore a rapid, gravity-linked flow that depended on springs in the plateau edge, not seasonal rainfall, to maintain a perennial status, but with a rate of flow which fluctuated seasonally and annually according to rainfall on the plateau and foothills. The Wādī Ḥisbān has its source above a spring ('Ayn Ḥisbān) just below the lip of the plateau, north of Ḥisbān, at contour ca. 800m amsl where the average modern annual rainfall is ca. 400mm, falling in winter and spring. The Ḥisbān is joined by lesser tributaries, and descends steeply through a deeply cut, narrow, almost gorge-like course, with some severe drops, to the lower foothills edging the Jordan Rift. The Early Bronze II Intermediate Bronze Age and Iron Age/Persian site at Tall Iktānū, situated on the last and lowest westernmost foothill, lies at ca. -120m bmsl, with modern average annual rainfall of ca. 164mm The site is located at the mouth of the river, the point where the water issues from the hills and emerges onto the plain. It overlooks the Ghawr al-Kafrayn and the Ghawr ar-Rāma to the north and west. From the top of the tall, there is a panoramic view across the plain to the Dead Sea, and further to Jericho and the hills of Palestine. The Jordan River, in its lower

trough, is not visible. The Wādī Ḥisbān at this point becomes the Wādī ar-Rāma until its junction with the Wādī Kafrayn, at virtually the western limits of modern cultivation in the ghawrs. As the Wādī ar-Rāma flows through the ghawrs, its bed is deeply incised into the alluvial soils, and its high banks are actively eroding. The joint streams reach the Jordan River as the Wādī al-Gharaba and ultimately the Dead Sea, the surface of which lies at ca. 400m. bmsl, where the modern average annual rainfall is less than 100mm.

Although many springs in the foothills provide additional water sources, there are very few located in the ghawrs. Some appear at the edges of the Dead Sea, as at 'Ayn Suwayma.

The available water moves by gravity, not just in the major river systems, but also as run-off and seepage from the foothills, which contributes to the water-content, aggradation and erosion of alluvium in the ghawrs. Heavy rain turns the alluvium to deep mud, unsurfaced tracks become impassable to wheeled traffic, and surfaced roads may be cut by flood waters. This dynamic underlies the agricultural processes of the ghawrs. Heavy rainfall on the cliffy edges of the Rift can result in short-lived but powerful minor spates and waterfalls, which in turn create devastating erosion in the deep alluvium and especially in recently ploughed soils (FIG. 1).

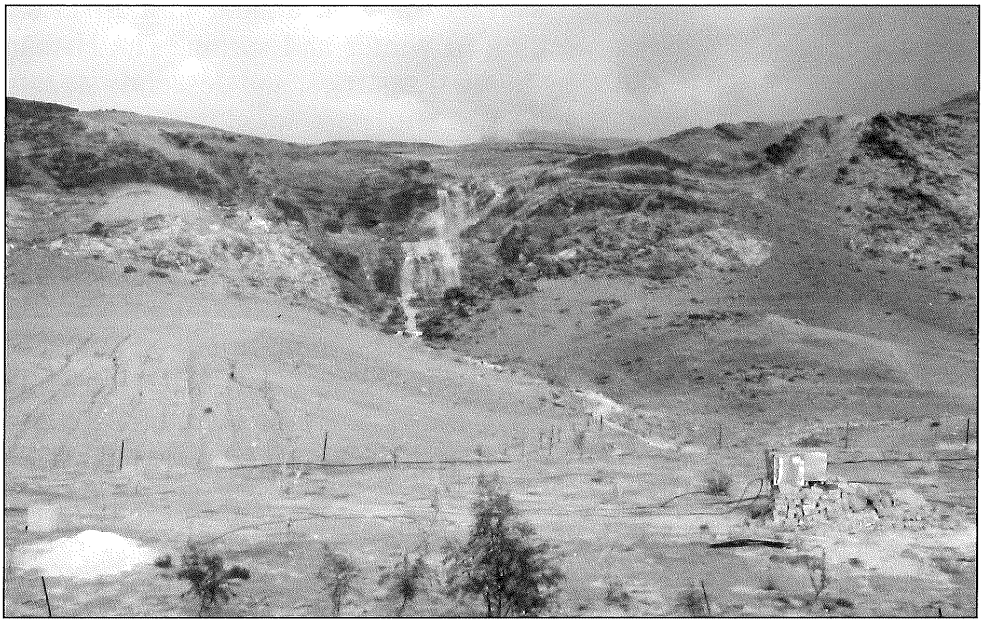
The structure of the responses and strategies at different times can be seen to vary from small to large scale, fed variously by private or public investment, but at all periods water-use was dependant on communal, integrated systems which required stable political and environmental conditions.

Irrigation Systems

In the past generally, dry farming was the natural resource for cultivators of the plateau region, and although dry farming of winter crops and early summer harvesting in the warmer southern ghawrs were possible strategies, irrigation of the alluvium in the ghawrs has for millennia been important, the flat, rich soils being readily tilled and permitting multiple cropping. Irrigated field systems were undoubtedly developed early. As with the documented Jericho estates in the Roman and Crusader periods, the land of the ghawrs could be a rich resource, and in Roman times the eastern ghawrs also (e.g. Hepper and Taylor 2004). Replaceable, variable, and easily repairable systems were required to contend with problems, arising from erratic flow, a high level of seasonal variation, flooding, erosion, periods of severe down-cutting of stream systems, and deposition of silt/alluvium, and probably to support systems of crop rotation and fallow.

During the nineteenth and twentieth centuries AD, the simple gravity flow channel maintaining water flow to the fields at a level above the down-cut streams was the norm for field irrigation in the ghawrs (Prag 2001: 182, fig. 1), and the practice still survives. Remnants of older systems only survive in the areas that have not been subject to modern agricultural development involving mechanized ploughing or, increasingly, on the upper fringes of the ghawrs, bulldozers, which have created vast level tracts for modern irrigation or are used in large gravel extraction projects.

In the sides of the Wādī Ḥisbān in the foothill zone there are old rock-cut water channels where



1. A storm passing over the edge of the Rift, east of ar-Rawḍa. At centre rear the waterfall (normally dry) is in spate, with the little gully below indicating the long term effects of erosion. The deep cracks in the fields to the left show recent erosion in ploughed land arising from less channelled run-off from the cliffs behind. In the foreground, rain pools on the alluvium where a modern tank feeds plastic pipe for drip irrigation to newly planted fruit trees. IKS785; photograph Kay Prag, 11/2/1989.

rock faces provided a suitable route. Channels had to be cut at a calculated level so that the rate of drop maintained control of the speed of flow of the water reaching the fields. Rock-cut sections were supplemented when necessary by built sections, which have long since eroded. The systems are not dissimilar to those which survive in the as-Sīq at Petra, for example. Beyond the wadi mouth, old stone-lined and plastered channels dug into the ground can still be seen leading into the alluvium, particularly in the more remote lower Wādī ʿAyūn Mūsā (see below).

Modern channel systems in the alluvium today range from concrete channels and pipes and plastic piping to simple earth channels with banked or stone-lined sides. Traces of the latter will be virtually invisible in the archaeological record. Principal feeder channels run mainly from east to west, and have lesser branches taking water to adjacent fields, as recorded in air photographs taken in the 1950s. The flow of water can be readily controlled and directed as required by even ephemeral channels dug or blocked, as needed, even on a daily basis (FIG. 2).

Such systems, involving small communal schemes and agreements – with dug, rock-cut or built channels, probably existed from at least the third millennium, and possibly earlier (Wright *et al.* 1998; Barker *et al.* 2000). The development of irrigation may lie in the fourth millennium as a result of a long, slowly developing process of iridisation, culminating in drier conditions with lower rainfall towards the end of the third millennium. During the fifth millennium the major Chalcolithic sites, especially Tulaylāt al-Ghassūl at the south-western

2. Temporary irrigation channel dug in the Ghawr ar-Rāma, north-east of Tall Iktānū, a concrete pipe has been used to bridge an army excavation. IKS643; photograph Kay Prag, January 1989.

edge of the Ghawr ar-Rāma, may have benefited from wetter conditions, with nearby slow-moving fresh water (Webley 1969: 21-23). The shift of population from major Chalcolithic sites on the western fringes of the Ghawr al-Kafrayn and Ghawr ar-Rāma to walled Early Bronze Age sites at the mouths of the rivers on the higher eastern fringes of the ghawrs (Prag 1995: 79), may be due to drier conditions and greater dependence on the river systems for irrigation. A location at the mouth of the wadis, at the point where the water issues onto the alluvial soils of the ghawr, gave both political and economic control of the water and thus of the rich irrigated fields on the alluvium, whereas a location at the lower end of the system presented contrastingly grave disadvantages, not least the inability to control or escape seasonal flooding from upstream on the river systems.

Supporting this pattern of site distribution, the mouths of the three northern perennial streams are the location of quite large and complex EBA sites Tall Mustah on the Wādī Shuʿayb, Tall al-Ḥamān on the Wādī Kafrayn, and Tall Iktānū on the Wād Ḥisbān. All these sites have not just control of the distribution of the river water at this point, and excellent visual control over the fields lying to the west, but strategic locations on high ground. During the Early Bronze Age the harnessing of resources including control of gravity-fed irrigation from the foothills, is very clearly indicated in settlement patterns as a major factor in settlement distribution.

Geomorphological Changes

To what extent geomorphology has played a role in the control of the water resources is uncertain and is thus far insecurely dated. Tectonic agency may have led to or hastened the disappearance of water sources at al-Ghassūl, and to abandonment of sites in the western Ghawr ar-Rāma. It may well have been responsible for the severe down-cutting of river beds in the alluvium, although shrinkage and drop in level of the Dead Sea/Lisan Lake during the late Holocene or lower rainfall in the fourth millennium would also affect river flow by increasing the depth of fall of the river systems reaching the lake, leading to incision of wadi beds. In the Iktānū region, the bed of the Wādī Ḥisbān/ar-Rām is today many metres below the irrigable surface of the alluvium (FIG. 3), and to bring the water to the adjacent fields would require either manpower or other energy resources to lift water from the river

3. The down-cut bed of the Wādī Ḥisbān with the township of ar-Rawḍa in the background. IKS629; photograph Kay Prag, January 1989.

bed. The more practical, cheaper solution was to bring it from higher levels upstream to the fields by means of channels or pipes.

Alongside the down-cutting of river beds, the surface of the alluvium has risen over the centuries. Epi-Palaeolithic, Early Bronze and Intermediate Bronze Age sites on the eastern fringes of the Ghawr have been located at depths of one to two metres beneath the modern surface and well above the deeply incised bed of the Wādī Ḥisbān/ar-Rāma (Prag 1990: 123 and 126, 2001: 183, fig. 3; Edwards 1999). This rise in alluvial soil is presumably the result of the deposition of silt from the foothills to the east, with the alluvial fan created principally by the rivers, but augmented by localized spates and run-off. This process of aggradation must have affected mainly the eastern edges of the ghawrs (the land surface within the Rift slopes down to the centre), and it is likely that many early sites today lie beneath the alluvium in that area.

The area of Iktānū is also subject to severe dust-laden gales from the east (*sharqiyya*), and to sand-laden storms from the south (*khamāsīn*) and thus some build-up of soils in the ghawr may be due to Aeolian deposits. Exposed ploughed soils, on the other hand, suffer depletion as dust is carried west and north.

Mills

The rivers also provided energy. In modern times the stream water was harnessed for whole systems of water-powered flour mills along the course of all the perennial streams (Shu'ayb, Kafrayn and Ḥisbān), where the products of a major cereal-growing area were processed. These were located especially on the upper and middle courses of the rivers, but mills were also built at the wadi mouths on the edge of the foothills and in the ghawrs. At least two mills were located at the mouth of the Kafrayn, and one at the mouth of the Ḥisbān, another several hundred metres into the alluvium on the Ghawr ar-Rāma. Of these, two have been destroyed during the last forty years, the one in the Ghawr ar-Rāma very recently as it stood in the way of agricultural development. On the upper and central Ḥisbān, the Ḥisbān Project (LaBianca 1990: 193, fig. 6.12; Ibach 1987: 194) listed 10 mills. Byzantine sherds found during survey appeared to be associated with many of the mills and according to LaBianca (1990: 194) "The possibility that most of these mills might originally have been constructed during the fourth or fifth century AD should be seriously considered...because water-driven flour mills of various kinds became a widespread phenomenon throughout the Roman Empire". Without additional evidence associated with the mills he concludes "The Hesban region reached the height of its maximization drive during the Early Byzantine Period....Roman-style....water mills were added on a scale never before seen in the region" (LaBianca 1990: 200). Alternatively, Ibach concluded (1987: 194) "The date of these mills could not be determined by direct evidence, but some indirect evidence suggests they belong to the Ayyubid/Mamluk period. The masonry style and the state of preservation of the mills indicate they are not of great antiquity". Rogan (1995: 756) also favours a date in the Mamluk period for the origin of the mills below as-Salṭ on the Wādī Shu'ayb. The mills in both Wādī Shu'ayb and Wādī Ḥisbān were certainly seen in use by travellers in the mid-nineteenth century, and the Ḥisbān mills were then owned by the 'Adwān tribe; the cereal production and processing of grain reflect reasonably settled circumstances in areas then under 'Adwān tribal control (FIG. 4).

Leats or lades were run by channel from river to mill, and sometimes served more than one mill before the water was returned to the river or used for irrigation. Although these mills are described by nineteenth century travellers, many were operating well into the twentieth century (Prag 1991: 59). A mill at the mouth of the Wādī Kafrayn was driven by an oblique chute, but most of those surviving on the Wādī Ḥisbān are of the arubah penstock variety, with a vertical drop shaft (see e.g. McQuitty

4. Water mill in the Wādī Ḥisbān, just south of Shunat Saqr (Ibach 1987: 226; Prag 1991: 50, fig. 3, incorrectly identified as the barn of Diyab). The aqueduct/leat is on the right, the drop shaft on the left. The mills were repaired at various times, and the masonry in this mill is testimony to three or four phases. There are quite large, rectangular, dressed (probably re-used Roman/Byzantine) masonry blocks visible in the lower four courses, at least one phase of smaller, squared blocks above (Ottoman period?) with rubble exposed at the top. HIS10; photograph Kay Prag, spring 1992.

1995: fig. 2).

Aqueducts

Aqueducts were built in the Iktānū region at least as early as late Hellenistic and Roman times; traces of two can be seen outside the forts at Barakāt and Ḥabbāsa above the lower Wādī Kafrayn, and were intended to supply drinking water for the garrison (Prag and Barnes 1996: 50, 53-55). At both Ḥabbāsa and Barakāt the stone-built aqueducts were fed by rain water run-off from catchments on the adjacent stony hillsides, which was led by channel to aqueduct, and then to multiple cisterns within the forts. These aqueducts represent considerable investment of public or state funding. The functioning of these aqueducts was linked to the fortresses they served, which were abandoned sometime in the Byzantine period at latest; and only the foundations now survive. They were vulnerable to enemy action, tectonic activity, and they and their catchments must have required some degree of maintenance. Many aqueducts of the late Hellenistic/Roman periods were built west of the Jordan also.

Aqueducts serving as raised mill leats were also in use along the perennial streams in the nineteenth century and were probably built earlier (FIG. 4) to bring water to the drop shafts of flour mills (for further illustration, see *e.g.* Greene 1995: figs. 4 and 5). The evidence described by Rogan (1995: 753-756) shows that the mills could be readily repaired, but it was an expensive undertaking, even on a small scale, and more likely to be done by central authority, or by a consortium of people, to spread the risk and investment. At Salṭ in the late nineteenth century Rogan noted a pattern of transfer by purchase of ownership of these mills from tribal heads to merchant townsmen, particularly to merchants from Nablus who had settled in the town.

In modern times the major aqueduct/canal (the Point Four development) serves modern irrigation, but the water is derived from outside the system described here, and represents major modern development.

Cisterns and Tanks

Covered cisterns and open holding tanks or reservoirs relating to channel systems are still well-preserved in arid parts of the region.

Fine Herodian-type covered cisterns, partly rock-cut and partly masonry, with strong hydraulic plaster and evidence of vaulted roofs, which could have contained water fit for human consumption, survive at the Ḥabbāsa fort above the Kafrayn, with less well-preserved examples at Barakāt (Prag and Barnes 1996). The lower sections of the cisterns are cut in the limestone foothills of the eastern Rift Valley. These monumental structures of the Roman period conform to contemporary state-funded activities known at Machaerus and west of the Jordan.

Relatively few ancient water-storage facilities are known to have survived in the cultivated alluvial soils of the ghawrs. An open tank/ reservoir survives at Maturdja (variants Tall al-Matarji/Muḥtariqa/ Rujum al-Muḥtariqa), at the edge of the foothills on the north bank of the Wādī ʿAyūn Mūsā, in the arid south-eastern edges of the ghawr. Although there has been much modern army disturbance at this site, it was still (in 1995) possible to trace the feeder channel for ca. 2km along the north side of the central course of the wadi, passing at the mouth along the south side of a hill and two lesser knolls, before turning north to the north side of a third knoll at the edge of the alluvial soils. The channel at this point was stone-built and plaster-lined, with a total width of 0.60m. The plastered water channel itself was ca. 0.30m wide, allowing for a reasonable volume of water (FIG. 5). Two sherds from the channel plaster were of late Byzantine/Umayyad/Abbasid date (Pamela Watson pers.

5. The stone and plaster lined water channel on the north bank of the Wādī ʿAyūn Mūsā/Muḥtariqa, at a point just above/ east of the tank. The A4 notebook indicates the width of the channel. IKS1244; photograph Kay Prag, 27/9/95.

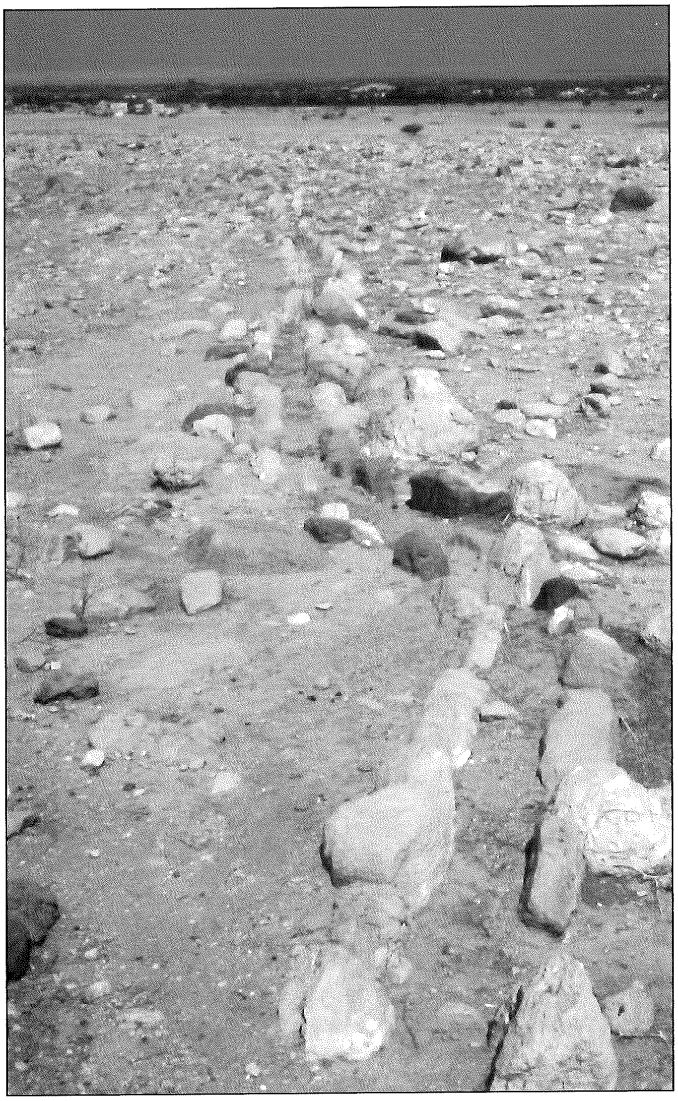
comm.). Although a section of the channel had been recently bulldozed, it formerly led to an open reservoir or tank, which it entered at the south-east corner. The tank itself is rectangular, with the long sides oriented north/south, ca. 27 x 13m (paced, not measured). The stone lining wall on the west side varied from 1.35 to 1.90m in thickness, with large stones set at the corners. The inner face of the east wall was exposed up to ca. 1.20m high, with five or six rough courses, mostly of rough rubble with patches of cement/plaster. This wall appears to be thickened at both ends, possibly for steps (FIG. 6). Thus unroofed holding tanks for water for agricultural/animal use also existed as part of the extensive system of rock cut and built channels associated with the rivers, and were intended either to store

6. The east wall of the tank at Muḥtariqa, with steps at the north-east corner; from the south-west. IKS1243; photograph Kay Prag, 27/9/95.

surplus water in winter or permit greater control of irrigation systems (for recent use of open tanks, see e.g. Abujaber 1995: 743).

To the west of the tank at Maturdja there is a stone wall ca. 0.40-0.50m wide, parallel to the south wall of the tank, but some metres further to the south, traced for ca. 29m to the west, and at least one rectangular stone structure ca. 7 x 20m, on a slightly different orientation, about 25m west of the tank. There were few associated sherds, and little else to be seen in the vicinity, but nearly 300m to the north-west a 40-50m stretch of stone-lined channel led away to the north-west in the direction of ar-Rāma (FIG. 7), before disappearing in ploughed land. It may have served the fields in the immediate vicinity, or run further (ca. 3km) to serve the cultivation around ar-Rāma.

This site, with structures, channels and tank, is probably the Byzantine farmhouse on the north bank of the Wādī ʿAyūn Mūsā referred to by Mallon (Mallon *et al.* 1934: 149) but it almost certainly survived into Umayyad/Abbasid times, and may also be considered in the context of the Umayyad/Abbasid site of Sahl as-Sarābīṭ immediately south of ar-Rāma (Suleiman and Betts 1981). Four trenches on a low mound, ca. 30m in diameter, occupied in Umayyad/Abbasid, and again in Ayyubid/Mamluk times, were excavated in a rescue operation in advance of building work. In the Umayyad/Abbasid level, as well as buildings, a stone-lined cistern ca. 2.50m in diameter, fed by channels from both east and west, was (partly?) excavated. Its depth is not recorded. The excavators suggested that the site might have been used for an industrial purpose because of the presence of glass and sand and the provision of water, but it may as well have been linked to a major cultivation system in the ghawr.



7. The water channel below and to the north-west of the tank at Muḥtariqa, with the Ghawr ar-Rāma in the distance. IKS1246; photograph Kay Prag, 27/9/95.

However, both Maturdja and as-Sarābīṭ provide evidence that channels, tanks and cisterns were cut in the alluvial soils and lined with stone and plaster in the Late Byzantine, Umayyad and Abbasid periods.

It is certain that intensive cultivation on even the fringes of the ghawr had a very long history, although in modern times these locations are very arid and have been used recently only for a little dry-farming of barley.

Dams

Evidence for ancient dams in the region is slight, though possible remnants of one on the Wādī Djarafa just south-west of Iktānū indicates that in the soft soil of the Ghawr such structures could well be washed out quite rapidly in heavy winter rains. The Djarafa in recent flooding cut the modern surfaced road from Ar-Rāma into Nahda. Due to rapid seasonal flow and high silt content, dams were probably an uneconomic investment in the past. The modern dams, on the Shu'ayb, al-Kafrayn and Ḥisbān, are also vulnerable to silting.

Conclusion

Seasonal flow in the river systems, with high but short-lived flooding following heavy rain to the east, was difficult to control. Channelling the water to the fields enabled the inhabitants to control the quantity, direction and speed of water reaching the fields, and also to construct leats to power mills. Access to drinking water provided other problems, which could be met by large scale investment in cisterns. No evidence for cisterns pre-dating the Hellenistic/Roman period have yet been discovered in the area, and it seems likely that prior to that date water was mainly drawn direct from the rivers and springs at a higher level, and held in jars and skins for domestic use. The investment in rock-cut channels and in channels built in stone and plaster was considerable, but these were probably long-lasting and could be maintained and repaired relatively cheaply. The construction of water mills was a greater investment, and in the nineteenth century the costs often a shared enterprise (Rogan 1995, 753). The document discussed by Bordreuil and Pardee (1990) and Cross (1996), if indeed it is to be associated with Iktānū, may suggest milling was a major enterprise in the region at least as early as the Iron Age, and site distribution patterns suggest that villages and towns began to colonize the central areas of the ghawrs during the Iron Age, spreading out from the major sites at the eastern edges, and developing into large towns in the Roman and Byzantine periods. Certainly cereals were being grown in the area from at least the fourth millennium. The construction of stone aqueducts, vaulted cisterns, and perhaps dams, represented state intervention and funding, or larger scale commercial or tribal activity. All the systems were relatively fragile and required regular maintenance. Damage to major installations, such as built aqueducts, and silting of dams, which were major investments, represented large losses to the economy.

Acknowledgement

I acknowledge with thanks the British Academy grant OCG-38158 towards the cost of attending the

conference in 2004.

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