"FROM WATER EVERY LIVING THING" : WATER MILLS, IRRIGATION AND AGRICULTURE IN THE BILĀD AL-SHĀM : PERSPECTIVES ON HISTORY, ARCHITECTURE, LANDSCAPE AND SOCIETY, 1100-1850AD

Charlotte Schriwer

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at the
University of St Andrews

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“From Water Every Living Thing”

Water Mills, Irrigation and Agriculture in the Bilād al-Shām: Perspectives on History, Architecture, Landscape and Society, 1100-1850AD.

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DOCTOR OF PHILOSOPHY

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20th September, 2006

Declaration

I, Charlotte Schriwer, hereby certify that this thesis, which is approximately 80 000 words in length, has been written by me, that it is the record of work carried out by me and that it has not been submitted in any previous application for a higher degree.

Date 20.09.2006 Signature of candidat

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Abstract

This work explores the role of the watermill in the history and society of Jordan, Syria and Cyprus from the 12th to the 19th century. Previous studies in this area have been limited, and have usually assumed the watermills in the Levant to date from the Ottoman period. This work aims to suggest that many of the mills still extant today in fact date from an earlier period. A review of the historical documentation and archaeological material is the main background of this study, while an examination of the watermills themselves aims to provide a permanent record of these before they disappear due to rural and urban development. A review of available reference material regarding the role of the mill in Levantine economy and society from the medieval to late Ottoman periods emphasises the importance of the watermill in rural and urban areas of the Levant in a historical period of fluctuating economic stability. The reference material consists mainly of historical accounts by travelers and chroniclers, legal documents such as treaties, charters and *waqf* documents, as well as archaeological, environmental and socioeconomic studies of the Levant from the medieval to the early modern period. The broad nature of this study aims to form a basis for future research with a more detailed focus in these disciplines.

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Abbreviations

AAAS	*Annales Archaeologiques Arabes Syriennes*
AASOR	*Annual of the American Schools of Oriental Research*
ADAJ	*Annual of the Department of Antiquities of Jordan*
AS	*Anatolian Studies*
BASOR	*Bulettin of the American Schools of Oriental Research*
BEO	*Bulettin d'Etudes Orientales*
EHR	*Economic History Review*
IJMES	*International Journal of Middle East Studies.*
JESHO	*Journal of the Economic and Social History of the Orient*
JFA	*Journal of Field Archaeology*
JMA	*Journal of Mediterranean Archaeology*
JNES	*Journal of Near Eastern Studies*
JRS	*Journal of Roman Studies*
LA	*Liber Annus*
METU JFA	*Middle East Technical University Journal of the Faculty of Architecture*
PEQ	*Palestine Exploration Quarterly*
QDAP	*Quarterly of the Department of Antiquities of Palestine*
RDAC	*Report of the Department of Antiquities of Cyprus*
SHAJ	*Studies in the History and Archaeology of Jordan*
SI	*Studia Islamica*
ZDPV	*Zeitschrift des Deutschen Palästina Vereins*

A Note on Dates

As this study uses both the Islamic as well as the Christian calendars, both dates will be shown whenever relevant, eg. AH 622/1222 AD. (AH= Anno Hegiri) The "AH" and "AD" are not used unless only one form of dating is uses, such as for example in Spain.

Notes on Transliteration & Pronunciation

Arabic

b	=	ب	z	=	ز	f	=	ف
t	=	ت	s	=	س	q	=	ق
th	=	ث	sh	=	ش	k	=	ك
j	=	ج	ṣ	=	ص	l	=	ل
ḥ	=	ح	ḍ	=	ض	m	=	م
kh	=	خ	ṭ	=	ط	n	=	ن
d	=	د	ẓ	=	ظ	h	=	ه
dh	=	ذ	ʻ	=	ع	w	=	و
r	=	ر	gh	=	غ	y	=	ي

Short: a = ´ ; i = ˏ ; u = ʼ

Long: ā = ا ; ī = ي ; ū = و

Diphthong: ay = اي ; aw = و

Turkish

Ç: pronounced "ch", like "church"
Ğ: soft, like the "y" in "you"
Ş: pronounced "sh"
Ü: same as German, like the "<u>ou</u>" in "you"

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INTRODUCTION

Aim of Thesis

Traditional watermills and irrigation systems, an integral part of rural agriculture across the world even in recent history, are scattered in abundance across a wide region of the Mediterranean and the Levant. Despite this, they have received limited scholarly attention in comparison to other aspects of historical and archaeological research, such as politics and the economy. The few studies on the watermill that have been conducted have provided some insight into its role in the rural setting over time, but these have rarely placed the watermill into a wider regional context. The main aim of this work is to provide an overview of the Levantine watermill, its role in history, landscape, society and economy from the AH 6th/12th AD to the AH 13th/19th century AD, using three detailed area studies as a foundation. Irrigation works will be taken into account as an integral part of the agricultural world, particularly as these go hand in hand with the presence of the watermill in the majority of the cases studied in the Levant. This work will mainly focus on Jordan and Cyprus, with some examples also taken from Damascus, Central and Northern Syria, as these three regions were historically linked between the 6th/12th and 13th/19th century through Crusader, Ayyūbid, Mamlūk and Ottoman rule. In addition, watermills and irrigation issues in Muslim Spain, as well as some case studies from Iran, Turkey and Morocco will be discussed briefly. The aim of this is to provide a good basis for cross-regional comparisons through the specific historical periods, although the focus will remain on the medieval period.

An attempt to place the role of the mill into the wider economic context will be made, as the case studies include both grain and sugar mills, which may have had different economic implications in different regions of the Levant. As there have been no previous efforts to provide a detailed typology for the mills in Jordan, Cyprus and Syria, this study also aims to place the watermills studied into various categories as a basis for a typology. The architectural features and composition of the mill will be discussed in a number of case studies from these three areas, some of the categories covering construction material, type of mill (grain or sugar), number of penstocks, degree of preservation, associated irrigation systems, situation in landscape, and location. The purpose of this is not only to compare the physical and technological features of the mill over a wider area of the Levant, but also to provide a reasonably detailed record for future reference, as many of these mills are disappearing from the countryside, particularly in Jordan. This is mainly because of the increase in the development of land for housing and agriculture which has taken place over the last 30 years or so, but technological advances in agricultural methods, such as the introduction of diesel powered engines and automated sprinkler systems, have no doubt also played a part in the abandonment and disappearance of the water mills, particularly from rural areas. In addition, rural agricultural architecture is rarely considered to be of historic monumental value, in the way that mosques, churches and castles are, and are thus usually not considered a high priority of preservation. The aim of this study is therefore also to compile a photographic and documentary record of these mills for future reference and as a basis for further, perhaps more detailed and focussed, study, and to draw attention to these as important historical monuments in the landscape. This is particularly important, as this area of agricultural history in the Levant has not been researched in any great depth with regard to the wider region as a whole.

The Structure of this Work

Originally, this work was intended to focus on the Ayyūbid-Mamlūk period, but as the information gathered was insufficient, the Ottoman period was also included. Although this has forced the study to be broadened considerably, the intention is to provide a portrayal of the water mill in both a historical and social environment, including additional geographical and political aspects, throughout the Levant from a time of religious turmoil until the end of a decaying Ottoman Empire. The nature of this broad subject, in an equally broad perspective of time, has provided not one single answer to one specific question, but rather placed the watermill into its agricultural, social and historical landscape.

Using an interdisciplinary approach with regards to the study of the watermills and irrigation systems in the Levant, including history, survey archaeology, architecture, landscape and social studies to provide a multi-faceted context in which the watermill can be placed, the structure of this work is reflected in these intentions. As already mentioned, a large part of this thesis will focus on the $6^{th}/12^{th}$ to $10^{th}/16^{th}$ centuries, because studies on water mills from these periods have been less common than studies on the later Ottoman period; indeed, this is reflected through a sometimes general assumption- where reliable documentation does not exist- that the watermills date from the Ottoman period (although this excludes the sugar mills as these have related documentation from a much earlier period). Part One (Chapters One to Four) of this work will focus on documentary sources, both from the Crusader charters and Arabic sources, which will be examined to establish similarities and differences in the social and administrative issues pertaining to watermills and irrigation. After exploring the historical landscape and relevant administrative issues, the physical landscape is discussed in Chapter Four. Part Two (Chapter Five) will be presented as a catalogue of watermills surveyed in Jordan, Syria and Cyprus, including architectural descriptions and photographic details. The concluding body of this work, Part Three, will place the case studies into the context of the archaeological, historical and social landscapes. Chapter Six presents a comparative overview of the case studies, as well as some further examples from other parts of the Islamic world such as Palestine, Iran, Turkey and Morocco. Chapter Seven will cover the archaeological sites and settlements surrounding the mills in order to formulate an idea of the relationship between the mills and the archaeological-environmental landscape. Finally, in Chapter Eight, the information gathered through the primary sources, the study of the physical and archaeological landscapes, as well as the administrative aspects, aims to provide a general picture of medieval Levantine watermills and irrigation in the wider context of Levantine history, economy and society, and its importance as an economic and social tool.

PART ONE

Landscapes and Watermills in Levantine History

AH 500/1100 AD to AH 1200/1800 AD

CHAPTER ONE

WATER, POWER & TECHNOLOGY

Water as a Source of Power

In the development of rural and industrial economies and societies, water as a means of sustaining life and a source of power has played an important role; this is particularly the case in drier climates where water is a more precious resource than it is in the wetter climates of the north western hemisphere. The need to harness water efficiently in arid and semi-arid climates such as those of the Levant has been an important consideration throughout history. Water provides not only the very basic element necessary for the survival of man, but even today is an essential source of energy; the attempt to use water for energy has been ongoing for thousands of years in the Near and Middle East. Waterwheels were depicted on ancient Sumerian stone carvings of Mesopotamia and the technological improvements of irrigation systems by the Nabateans- and later the Roman- in ancient Jordan are well known.[1] The Greek scholar Vitruvius, writing in the first century B.C., discussed various aspects of technology and architecture, providing one of the earliest treatises on the use of water as a source of power.[2] In this he included various types of watermills, such as the Greek Mill, also known as the Norse mill, and the vertical mill. The earliest reference to a watermill came from the Roman geographer Strabo, who mentioned a mill at Cabeira (modern-day Niksar, in north eastern Turkey), in the first century B.C.[3]; Vitruvius described this same mill in his work. In the Levant, eleven extant vertical and horizontal watermills on the Crocodile River in ancient Caesarea Maritima in Israel have been dated back to the mid-fourth century AD by C14

[1] For further reading on ancient water systems, see Oleson, J.P. (1984) *Greek and Roman Water-lifting Devices: the history of a technology*. University of Toronto Press: Toronto; Wikander, Ö. (ed.) (2000) *Handbook of Ancient Water Technology*. Brill: Leiden; Schiøler, T. (1973) *Roman and Islamic Water Lifting Wheels*. Odense University Press: Odense.
[2] Vitruvius. (1999) *De architectura*. Vitruvius: ten books on architecture. Transl. Ingrid D. Rowland. Cambridge; New York: CUP.
[3] Wilson, A.I. (2001) "Water-mills at Amida: Ammianus Marcellinus 18.8.11". *Classical Quarterly* 51:1, 231-236.

dating, providing some of the earliest known examples in this region.[4] Although whether the watermills in the Levant were first introduced by the Romans is still a contentious issue, there is no doubt that the Roman engineering knowledge had a marked influence on the agricultural development of these lands, as did the Sasanians and Nabateans.[5] Historical documents allude to the value of water and efficient irrigation systems since the early medieval period, and this is reflected in the remains of such systems in the Levant today. In addition to water supply for irrigation, the knowledge of using water as a source of energy is also evident; apart from archaeological finds, documentary references to the use of horizontal water wheels exist from as early as the $3^{rd}/9^{th}$ century AH, and a technical explanation and drawing of a horizontal watermill was provided by

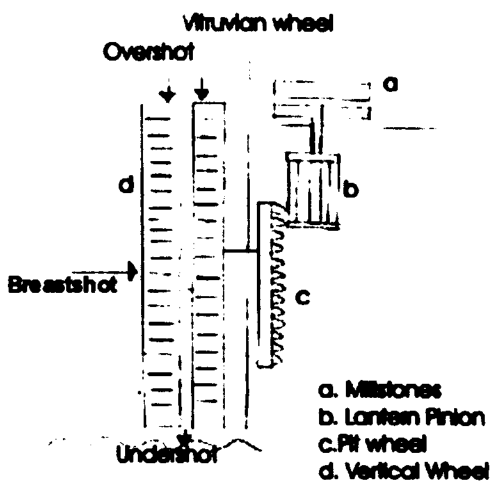

Fig. 1.1 Vitruvian vertical mill

Fig. 1.2 Natura

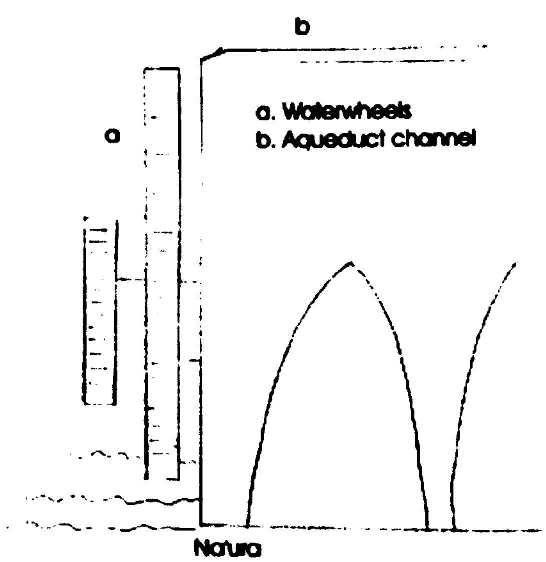

Figure 1. 1-1.2. Fig. 1.1 shows vertical wheels attached to a gearing mechanism (b, c) which are connected to the millstones above (a). Fig. 1.2 is a *na'ūra*, or water wheel; the scoop-buckets on the wheel raise the water into the aqueduct channel above, which carries it to fields further away to irrigate them.

[4] Oleson, J.P. (1984) "A Roman Water-mill on the Crocodilion River near Caesarea." *ZDPV 100*, 137-52; Schiøler, T. (1989) "The Watermills at the Crocodile River: A Turbine Mill Dated to 345-380 A.D." *PEQ* 121(2), 133-142.

[5] See, for example, Ruben, I. (ed.) (2003). *The Petra Siq: Nabatean hydrology uncovered.* Petra National Trust: 'Ammān.

al-Jazari in the 7th/13th century.[6] Numerous references also exist to the use of tidal mills and boat mills in modern-day Iraq and Iran[7]; we also know of the such as the construction of watermills and canals in Mosul during the time of the caliph Hishām and the mills of Baghdad in the early Islamic period, indicating a precise knowledge by Islamic engineers and scientists of the exploitation of water for power,[8] and the use of the water wheel for irrigation in Syria.

Medieval mills in most of Europe (with the exception of Spain) do not tend to have the technology seen in the mills present in the Levant; the European formula overwhelmingly uses a vertical wheel and gearing, of either overshot, undershot or breast shot variety depending on the situation of the mill in relation to the river. **(Fig.1.1)** This is almost certainly due to the greater availability of strong water currents in the form of large rivers. There are exceptions in Europe, however; horizontally wheeled watermills, dating to the 7th century AD, exist in Ireland, and evidence of these have also been found in the British Isles and Denmark.[9] In his studies on watermills in Spain, Glick states that "the horizontal mill was known in Christian Spain from as early as A.D. 800, the vertical mill probably not until the mid-tenth century."[10] This could suggest that the appearance of the horizontal mill coincides with the arrival of the Muslims there in the 2nd/8th century A.D. Wilson, on the other hand, disputes this by claiming that many of the irrigation methods and milling technologies attributed to the Arabs were already known during the Roman period.[11] However, the horizontal mill is also known to have existed in China in the medieval period, so the issue of technological development and diffusion is by no means clear. The debate about the development of the vertical versus the horizontal wheeled

[6] Al-Hassan, A. & Hill, D.R. (1986) *Islamic technology: an illustrated history.* Cambridge University Press: Cambridge.

[7] Beazley, E. & Harverson, M. (1982) *Living with the Desert. Working Buildings of the Iranian Plateau.* Aris & Phillips: Warminster, 84.

[8] Lassner, J. (1970) *The topography of Baghdad in the early Middle Ages: text and study.* Wayne State University Press: Detroit, 75-76; Al-Azri, Zakariya Ibn Muḥammad. (1967) *Tarīkh al-Mawṣil.* Higher Education Council of the United Arab Emirates: Cairo, 43

[9] Lucas, A. (2006) *Wind, Water, Work. Ancient and Medieval Milling Technology.* Technology and Change in History 8. Brill: Leiden/Boston, 39-41.

[10] Glick, T. (2005) *Islamic and Christian Spain in the Early Middle Ages.* The Medieval and Early Modern Iberian World. Brill: Leiden/Boston, 264.

[11] Some theories of technological invention and diffusion in the Roman and early Islamic periods is discussed in Wilson, A. I. (2002) "Machines, Power and the Ancient Economy". *JRS 92*, 1-32; and Wilson, A.I. (2004) "Classical water technology in the early Islamic world". In C. Bruun and A. Saastamoinen (eds.) *Technology, Ideology, Water: from Frontinus to the Renaissance and beyond.* (Acta Instituti Romani Finlandiae, 31) Roma, 115-41. Technological diffusion is discussed further in Chapter Eight.

mill is equally contentious. The development and diffusion of the horizontal and vertical watermill across the world clearly remains a fervently debated topic of discussion.[12]

Water in Irrigation

Water supply, as the lifeline of rural and urban society, has always for climatic reasons been a particularly crucial element of life in the Near and Middle East. Traditional methods of irrigation in the Levant included wells, springs, streams and underground channels, such as *qanawāt.*[13] In aid of these, *sāqiya* (animal-driven water wheels) were used to extract water from wells, and *nawā'ir*[14] (**Fig. 1.2**) fed water to aqueducts, which were able to carry the water to irrigate lands some distance away. The use of damming to harness rainwater flowing through *widyān* (river valleys) was also common.[15] There were numerous methods in use, such as the *shadūf* (scoop-bucket), still common in Egypt, but the canal systems were managed and controlled to a greater or lesser extent by the government departments there in Ayyūbid, Mamlūk as well as Ottoman times.[16] Al-Hassan and Hill provide an example from Iran to emphasise the importance which was placed on irrigation there during the 4th/10th century:

> "Some idea of the magnitude of importance of the administration of irrigation can be gained from a report made in the fourth century AH (tenth century AD) about the region of Merw in Khurasan. The superintendent of the irrigation systems based on the River Murghab had more authority than the prefect of Marw, and supervised 10000 workers, each with a specific task."[17]

Further historical texts refer to the importance of irrigation and mill systems; al-Muqaddasī, writing in the 4th/10th century, refers to *nawā'ir* and mills in Khuzestan, built

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[12]Wilson 2004.
[13] (s.) *qanāt*; underground or over ground water channels.
[14] (s.) *nā'ūra*, a water-driven water wheel.
[15] al-Hassan & Hill, 80-81.
[16] Al-Hassan & Hill; Ibn Mammāti. (1943) *Kitāb qawānīn al-dawāwīn.* Edited by 'Azīz Sūryāl 'Atiyah. Jam'iyat al-Zirā'yat al-Malakiyah: Cairo, 452-453; Poliak, A.N. (1939) *Feudalism in Egypt, Syria, Palestine, and the Lebanon, 1250-1900.* Royal Asiatic Society: London, 69; Sato, T. (1997) *State and rural society in medieval Islam: sulṭāns, muqta's, and fallaḥūn.* E.J. Brill: Leiden/ New York, 225.
[17] Al-Hassan & Hill, 86; they fail to quote the original source for this information.

by the Buyid *amīr* 'Adūd al-Dawla, which irrigated 300 villages.[18] In the mid-6th/12th century, al-Idrīsī described irrigation systems involving dams, sluices, regulator and dividers on the Guadalquivir River in Córdoba, where there were three mills, each with four wheels, supplying water to the city.[19]

Horizontal watermills in particular are in need of a constant, efficient water supply to maximise the potential of the milling device, and this can only be achieved through a network of water channels either linking the mills to each other, or linking them to a larger source of water. The sophistication of these channel networks may vary from country to country, but also from region to region; in addition, the primary function of the mill may have an influence on the nature of this complexity. Irrigation playing a major role in agriculture, at least as much in medieval times as it does today, many of the channel networks supplying water to the mills were also made use of for irrigation purposes, frequently through slight but effective alterations or additions to the channelling systems.

Water and Sugar Mills in the Levant: An Introduction

The water mill is a simple mechanical device whose function is based on the basic principles of physics and kinetic motion. Although watermills in the Levant and further East can differ markedly from those in the West, there are architectural elements that are common to both areas of the world, and necessary for the proper functioning of the mill. Apart from grain and sugar mills that were powered by water, other types of mills were also in use throughout history, the most popular of these being oil mills (for pressing olives), fulling mills, and cotton mills (to cleanse the cotton of seeds). These were not always powered by water; in many cases, the use of animals to drive mills was more common, as was often the case for many sugar and grain mills in Egypt. The simplest, and most ancient, device for grinding grain is the hand mill, where a quern stone and

[18] Al-Muqaddasī. (1994) *The Best Divisions for Knowledge of the Regions*. Transl. B.A. Collins. Centre for Muslim Contribution to Civilisation. Garnet: Reading.

[19] Al-Idrīsī, Abū 'Abd Allāh Muḥammad Ibn Muḥammad. (1975) *Nuzhat al-mushtāq fi ikhtirāq al-āfāq*. Opus geographicum : sive "Liber ad eorum delectationem qui terras peragrare studeant." / Consilio et auctoritate E. Cerulli [*et al.*] una cum aliis ediderunt A. Bombaci [*et al.*]. Istituto Universitario Orientale di Napoli, Istituto Italiano per il Medio ed Estremo Oriente. Vol. IV: Naples, 579.

hand stone are used, usually in small rural communities where each family grinds its own grain. This developed into a larger rotary quern, which involved a larger, upright millstone with handles that could be rotated on its edge on top of a flat millstone by two individuals. Wind mills were also commonly used for grinding grain, mainly in windy plateau areas, such as can be found on the Iranian plateau, as well as on many of the small Mediterranean islands, such as Crete and Rhodes. Despite the windy nature of the Jordan plateau areas, no remains have yet been found of any buildings that could be interpreted as windmills, although windmills were known to exist in Syria.[20]

Watermills have been classified into three main categories.[21] These include the **horizontal wheeled mill**, the **vertical-wheeled mill** and the ***arūbah* penstock mill**[22]. The horizontal wheeled mill, otherwise known as the "Greek" or "Norse" mill, can be the least efficient of these types of water mills. It operates by a flow of water hitting a horizontal wheel with protruding paddles (effectively a **turbine wheel**) to create a slow revolution.[23] The water flows through a simple construction, such as a hollowed-out log, rather than a constructed tower.[24] A more efficient type of turbine mill was also used in the Roman period, where the water enters a vertical shaft (similar to the *arūbah* penstock), at the bottom of which is the wheel; an outflow is constructed below the wheel through which the water can exit. The millstones are connected through a spindle above the tower. **(Fig. 1.3)**

[20] A *waqf* document from Jerusalem, dating from 959AH/1552 AD, lists a windmill located in Sahyūn (Saone), in Antioch province. See Stephan, St. H. (1944) "An Endowment Deed of Khasseki Ṣulṭān, dated to the 24th May 1552." *QDAP X*. Pp. 170-194; also Rifai, M.F. (1990) "Waterlifting Practices in Aleppo District before motorization," in B. Geyer (ed.), *Techniques et pratiques hydro-agricoles traditionelles en domaine irrigué : approche pluridisciplinaire des modes de culture avant la motorisation en Syrie : actes du Colloque de Damas, 27 juin-1er juillet 1987*. P. Geuthner: Paris, 313-320. There may also have been a windmill on the Crusader castle of *Crac de Chevalier*, near Ḥoms, in Syria. (Hugh Kennedy, pers.comm. 2006)

[21] Hodge, A.T. (1992) *Roman Aqueducts and Water Supply*. Duckworth: London; McQuitty, A. (1995) "Water-Mills in Jordan: Technology, Typology, Dating and Development." *SHAJ* V. 'Ammān: Department of Antiquities, 745-753.

[22] This is a Hebrew word, meaning chimney, and according to Schiøler (1989) was invented by Professor Avitsur.

[23] A glossary of mill terminology can be found in the Appendix of this work.

[24] McQuitty 1995, 746.

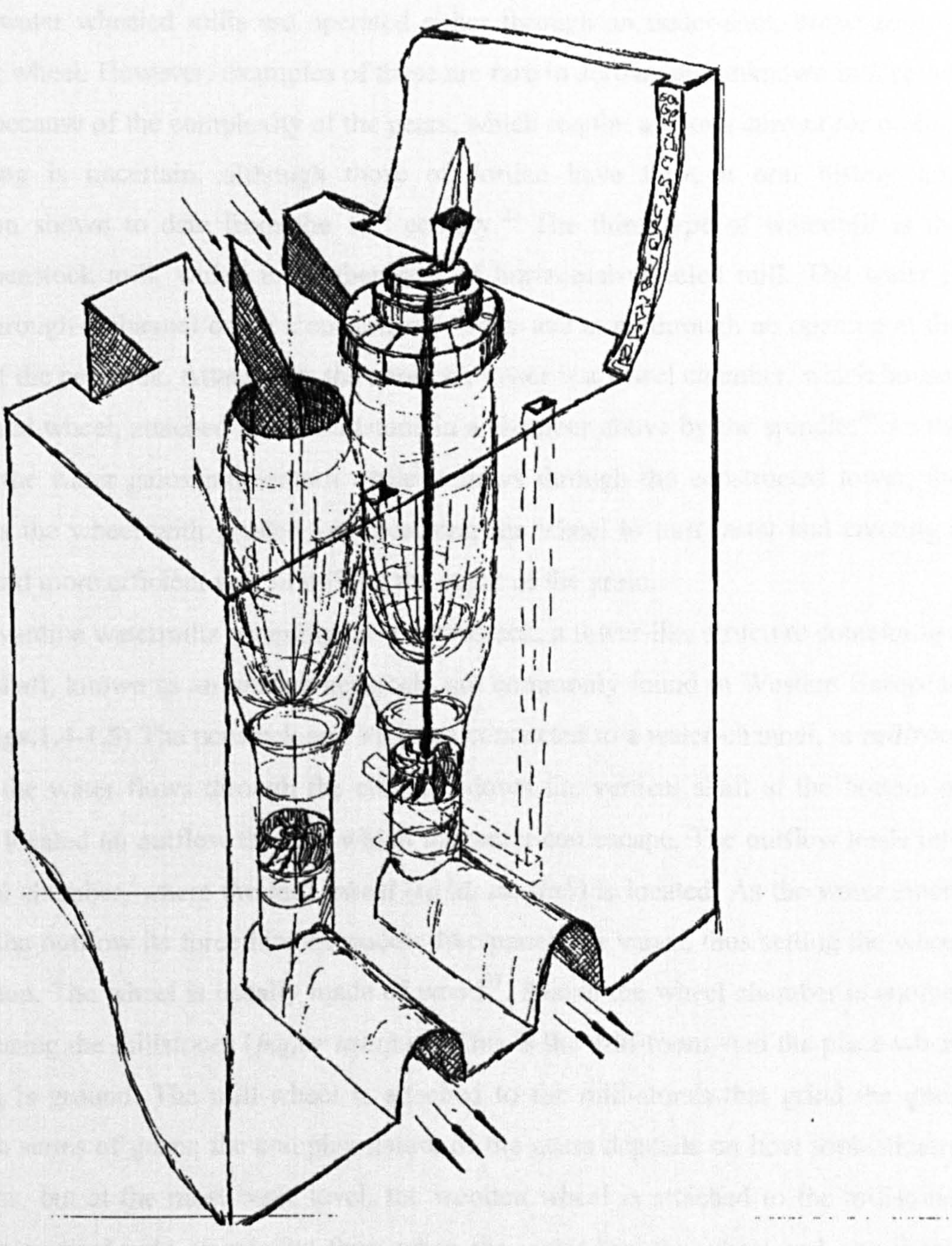

Figure 1. 3. Sketch of turbine-type mill. The horizontal wheel is located at the bottom of the shaft, but above the floor of the outflow to maximize the water power; the millstones are attached through a spindle above the penstock. (From Schiøler 1989)

Vertical water wheeled mills are operated either through an under-shot, breast-shot or over-shot wheel. However, examples of these are rare in Jordan and unknown in Cyprus, perhaps because of the complexity of the gears, which require a strong current for motion. The dating is uncertain, although those of Jordan have through oral history and excavation shown to date from the 19th century.[25] The third type of watermill is the *arūbah* penstock mill, which is another type of horizontal-wheeled mill. The water is guided through a channel down a constructed tower and exits through an opening at the bottom of the penstock. Attached to the penstock tower is a wheel chamber, which houses a horizontal wheel, attached to the millstone in a chamber above by the spindle.[26] As the force of the water gains momentum while it flows through the constructed tower, the water hits the wheel with greater force, causing the wheel to turn faster and creating a quicker and more efficient way of milling the sugar or the grain.

Rural Levantine watermills generally have a penstock, a tower-like structure containing a vertical shaft, known as an *arūbah* penstock, not commonly found in Western European mills. **(Figs.1.4-1.5)** The penstock and shaft are connected to a water-channel, or ***millrace (qanāt)***; the water flows through the channel, down the vertical shaft at the bottom of which is located an outflow through which the water can escape. The outflow leads into the wheel chamber, where the mill ***wheel*** (*raḥā, dawlab*) is located. As the water enters through the outflow its force hits the paddle-like panels, or vanes, thus setting the wheel into motion. The wheel is usually made of wood[27]. Above the wheel chamber is another room housing the millstones (*ḥajjar ṭaṭaḥan*). This is the mill-room, and the place where the grain is ground. The mill-wheel is attached to the mill-stones that grind the grain through a series of gears; the complex nature of the gears depends on how sophisticated the mill is, but at the most basic level, the wooden wheel is attached to the millstones through a vertical pole or spindle; thus, when the water hits the wheel and sets it into motion, the grinding stones will also turn and grind the grain. The upper millstone, or ***runner stone*** (*ḥajjar fuqāni*), can be adjusted in relation to the lower millstone, or ***bed stone*** (*ḥajjar taḥtāni*), to grind the grain more or less coarsely. The wheel can be

[25] Pers.comm. Bert de Vries, in McQuitty 1995, 746
[26] Gardiner, M. & McQuitty, A. (1987) "A Watermill in the Wādi el-'Arab, North Jordan and Watermill Development." *PEQ* 119 (1), 24-32.
[27] In more recent times, where water mills have still been in use in the second half of the 20th century, the wheel has been made of iron, with the paddles resembling miniature oblong scoops.

controlled through the use of a ***lightening rod,*** which, if necessary, can be disengaged without stopping the flow of water into the wheel chamber.[28] **(Fig. 1.6)**

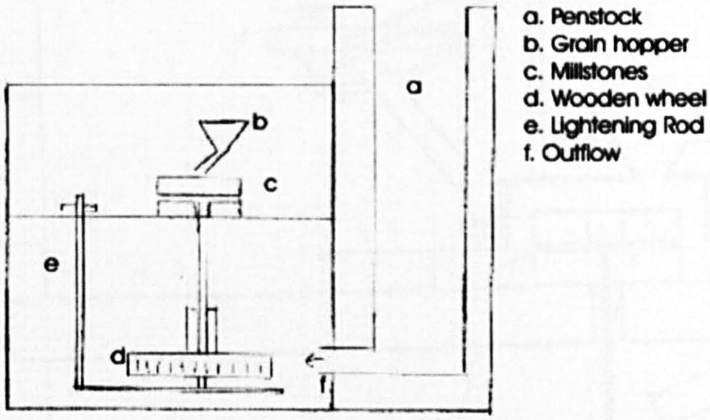

Fig. 1.4. Horizontal *arubah* penstock mill.

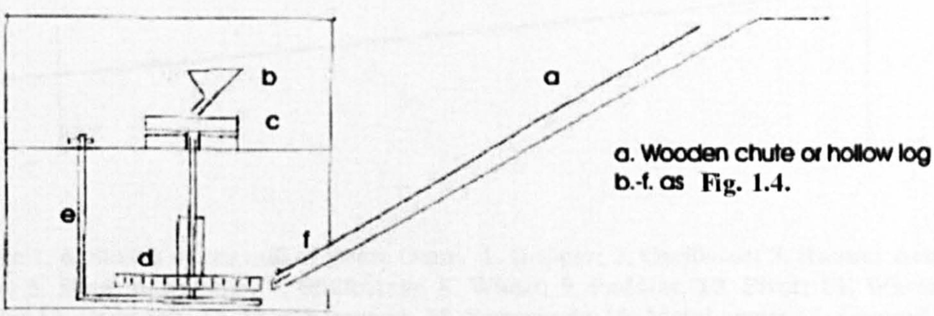

Fig. 1.5. Norse Mill.

Figure 1. 3-1.4. In 1.3, the water enters the penstock (a) via a channel, and exits at the bottom. The force of the water turns the wheel (d), which connected to the mill stones (c) that grind the grain entering from the hopper (b).The lightening rod is attached to the pivot of the wheel so the wheel can be stopped when necessary. The procedure is identical in 1.4, but the water enters through a hollow log or wooden chute.

The outflow from the penstock chute can vary in size, depending on the volume of flow from the water source directed through the water channel; some watermills have been known to have had adjustable outflows, usually fitted with wooden rings of different sizes depending on the time of year and the availability of water.[29] There is an opening, usually in the form of an arched entrance, from the wheel room, to enable the water to leave the chamber as it turns the wheel. Watermills are usually situated near, or on the banks of, a river; although they may not get their water power directly from that

[28] For definitions of technical terms, please refer to the Glossary.
[29] Harverson, M. (1993) "Watermills in Iran." *Iran* 31, 149-177.

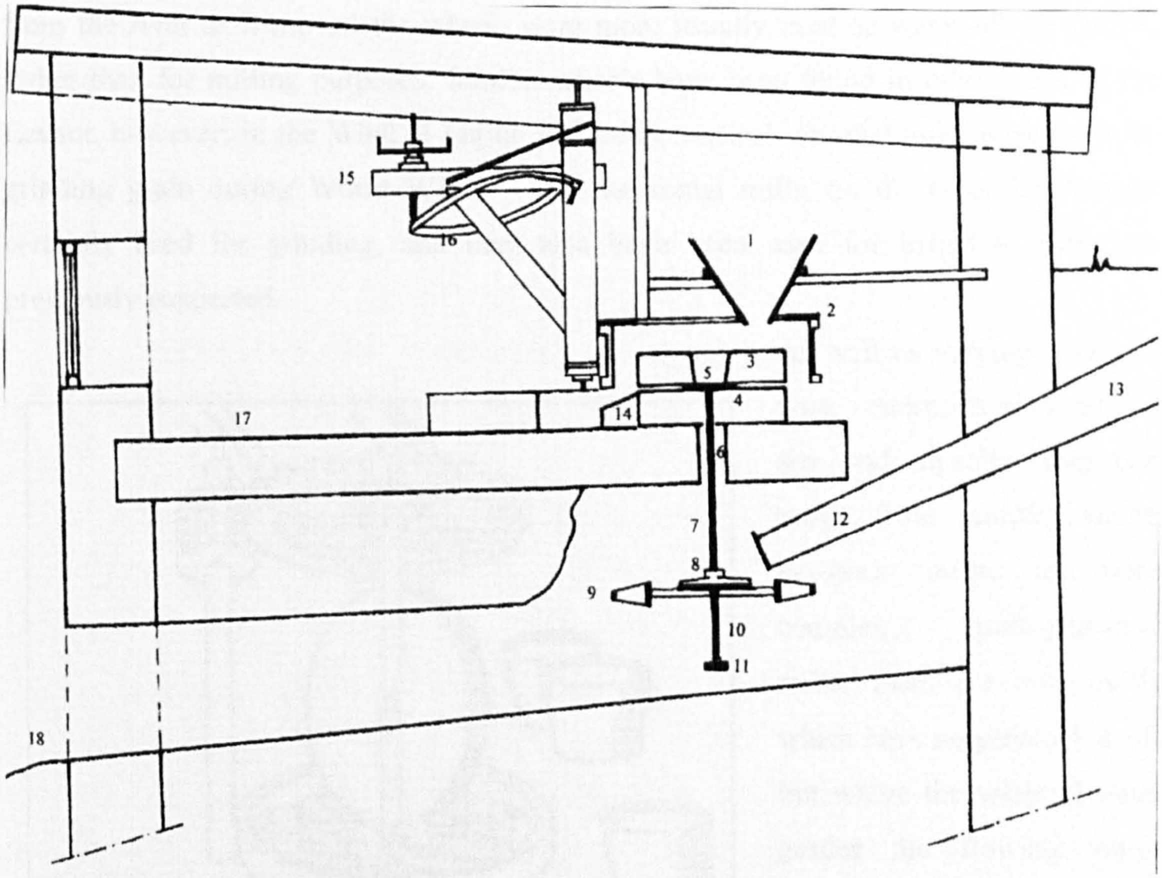

Figure 1. 6. Sketch of the mill of Bekir Onur. 1. Hopper; 2. Oscillator; 3. Runner stone; 4. Bed stone; 5. Rind; 6. Spindle; 7. Shaft/Axle; 8. Wheel; 9. Paddles; 10. Pivot; 11. Wheel bed; 12. Chute; 13. Penstock; 14. Lower hopper; 15. Screwjack; 16. Metal arms; 17. Ground level; 18. Water outlet. (From Donners *et al* 2002)

particular source- depending on the type of mill- a channelling system may facilitate the circulation of water, thus supplying the watermill to grind the grain before it pours back out into the river. It is possible that the water exiting the wheel chamber was also used for irrigation purposes in agricultural areas, perhaps through a system of channels and canals. Indeed, there are usually channel networks in varying degrees of complexity near the watermills frequently with sluice gates to regulate the flow of water, suggesting perhaps that as well as supplying the mills these were used for irrigation purposes.

The horizontal mill is most commonly found in this study of the Levant, although cities like Damascus, Ḥoms and Ḥama are also known for the use of the vertical water mills situated along the Barada River. These different types of mills had similar functions, in the West as well as the Levant, but may have varied within a local area. For example, the numerous *nawā'ir* mentioned above, with their large wheels and 'buckets' lifting water from the river as it moved the wheel, were more usually used as water-lifting devices rather than for milling purposes. Similar wheels have been found in other areas of the Levant, however; in the Wādi al-Lajjūn in Jordan, vertical wheeled mills were used for grinding grain during World War I.[30] The horizontal mills, on the other hand, were certainly used for grinding, and may also have been used for irrigating crops, as previously suggested.

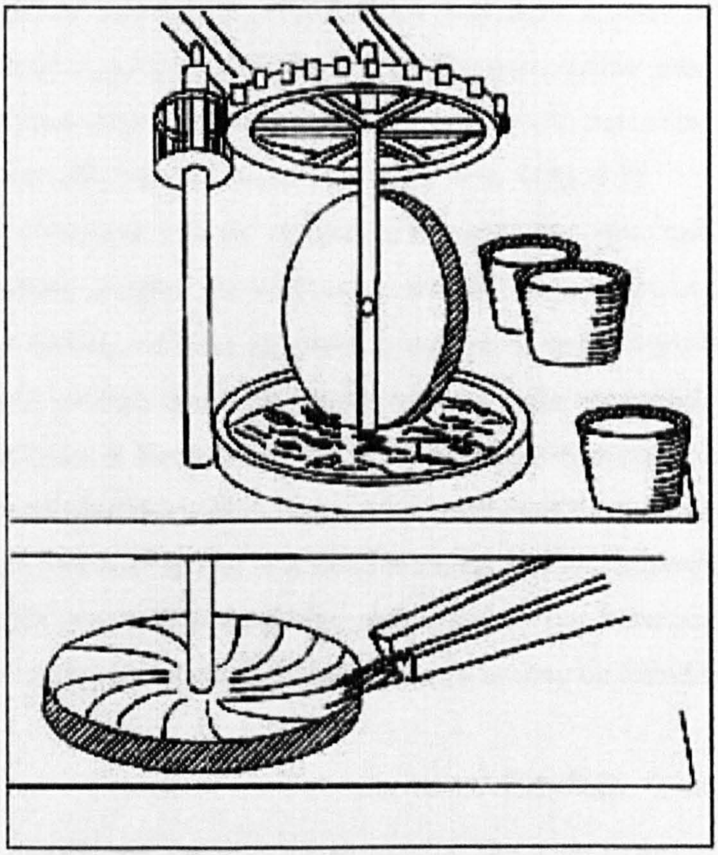

Figure 1. 7. Machinery for the sugar mill. The upright mill stone is the edge runner stone, which moves through attached mill gears (upper drawing). The wheel is located below the mill stones and gears, and is powered by water which enters by via the water chute (lower part of drawing). (After www.pef.org.uk/Pages/Zoara/htm)

As well as varying in wheel type, watermills also vary in size and capacity- they can range from simple, single penstock mills, to more complex multi-penstock mills; there are even mills which have no penstock at all, but where the water channel guides the flowing water directly into the wheel chamber. The shape of the penstock can often also vary, usually either having a flat façade, or a sloping one.

Sugar mills are of a different construction technique than grain mills, although they also rely on waterpower to function efficiently. The basic principles are the same: water

[30] McQuitty, A. (2004) "Harnessing the Power of Water: Watermills in Jordan." in Bienert, H.-D. & Häser, J. (eds.) *Men of Dikes and Canals. The Archaeology of Water in the Middle East. International Symposium held at Petra, Wadi Musa [H. K. of Jordan] 15-20 June, 1999.* Orient Archäologie 13. Verlag Marie Leidorf: Rahden/Westfalen, 261-272.

flows through a channel leading to a penstock at the bottom of which is an outflow through which the water flows to the wheel chamber. Rather than being attached to a spindle connected to the grinding stones above, the wheel in the sugar mill is attached to a series of complex gears, which are joined to the bed stone in the mill chamber. Running along the edge of this bed stone is the ***edge-runner stone***. This is the equivalent of the runner stone in the grain mills, but it does not lie flat above the bed stone. It moves along the edge of the bed stone in a vertical position. This is because the sugar cane needs to be crushed rather than ground for the maximum amount of sugar syrup to be squeezed out. Some sugar mills have two vertical stones, rather than a horizontal bed stone with the vertical edge runner stone, but it is difficult to determine which of these would have been more efficient in crushing the sugar cane. **(Fig. 1.7)**

In comparison to the simpler grain mill, the sugar mill was more like a factory than a milling complex; in addition to the mill, there were usually additional rooms and areas for boiling, refining and storing, as well as workshops. However, this varied from area to area, perhaps depending on the owners of the sugar mill. For example, the royal Lusignan factories at Kouklia-Stavros and Episkopi had storage rooms as well as workshops, while the Hospitaller mill at Kolossi had neither of those, and in addition to the water mill, had only the boiling hall and stoke rooms to process and refine the sugar. In Jordan, the sugar mills are smaller in design and often do not have accompanying processing facilities immediately attached to the mill, such as may be found in sugar mills in Cyprus.

Typology

Within the basic typology mentioned above there exists also a sub-typology; each of these types of mills- the Norse mill, the vertical mill and the *arūbah* penstock mill- have several different types belonging within their respective categories. This study will focus mainly on *arūbah* penstock mills, as these are most common in the different survey areas. Although a systematic typology has yet to be established for the water mills in the Levant- and this is one of the aims of this study- attempts at creating typologies for certain areas of Jordan have previously been made. An example of this is Gardiner & McQuitty's study of a watermill in the Wādi 'Arab in North Jordan, located in the Irbid region. According to Gardiner and McQuitty[31], three different types of *arūbah* penstock mills can be loosely classified in northern Jordan. These are:

Type X: mills without raised conduits. The penstock adjoins the natural incline in the land so the fall in water can be achieved without a raised tower.

Type Y: single penstock raised tower mills with mill wheel driven by water under pressure. The water flows through the shaft into the wheel chamber below, and its force turns the wheel connected to the millstone in a chamber above by a long rod. The millstone grinds the wheat.

Type Z: twin penstock raised tower mills.

Watermills of types X and Y are more common in northern Jordan than the unusual double penstock tower mills, although several examples of the type Z mills do exist.[32] In Syria, a survey around the Ḥoms area by Shahāda in 1974 revealed several different types of water-driven mills, but no detailed typology was created there either.[33] Typologies for Cyprus are in the process of being created as the Troodos Archaeological and Environmental Survey Project (**TAESP**) continues its research in the Troodos region of Cyprus.[34] Using Gardiner & McQuitty's model described above, the TAESP survey area has so far also only revealed concrete evidence for type Y watermills, although some watermills in the Tembria area may have been of the type X variety.[35] Twin penstock watermills have not been found in the TAESP or Sydney Cyprus Survey Project (**SCSP**) survey areas in Cyprus.[36]

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[31] Gardiner & McQuitty 1987, 31.
[32] Gardiner & McQuitty 1987; Hanbury-Tenison, J. (1984) "The Wādi 'Arab Survey 1983." *ADAJ* 28, 385-423; McQuitty 1995.
[33] Shahāda, K. (1974) *Tarīkh at-ṭāḥūna ka-mu'assasat iqtiṣādiyya, dirāsa wathā'iqiyya, al-qism at-thāni. AA AS* 1974, 109-118.
[34] Given, M., Kassianidou, V., Knapp, A.B., & Noller, J. (2002) "Troodos Archaeological and Environmental Survey Project, Cyprus: Report on the 2001 Season". *Levant* 34, 25-38.
[35] Sevina Zesimou, TAESP architect, pers. comm. 2002
[36] Although the TAESP surveys were intensive over a large area, results in this study are limited to this area and does not preclude the possibility that such mills exist elsewhere in Cyprus; work has also previously been done on watermills in Cyprus by Phroso Igoumenidou, but this has not yet been published.

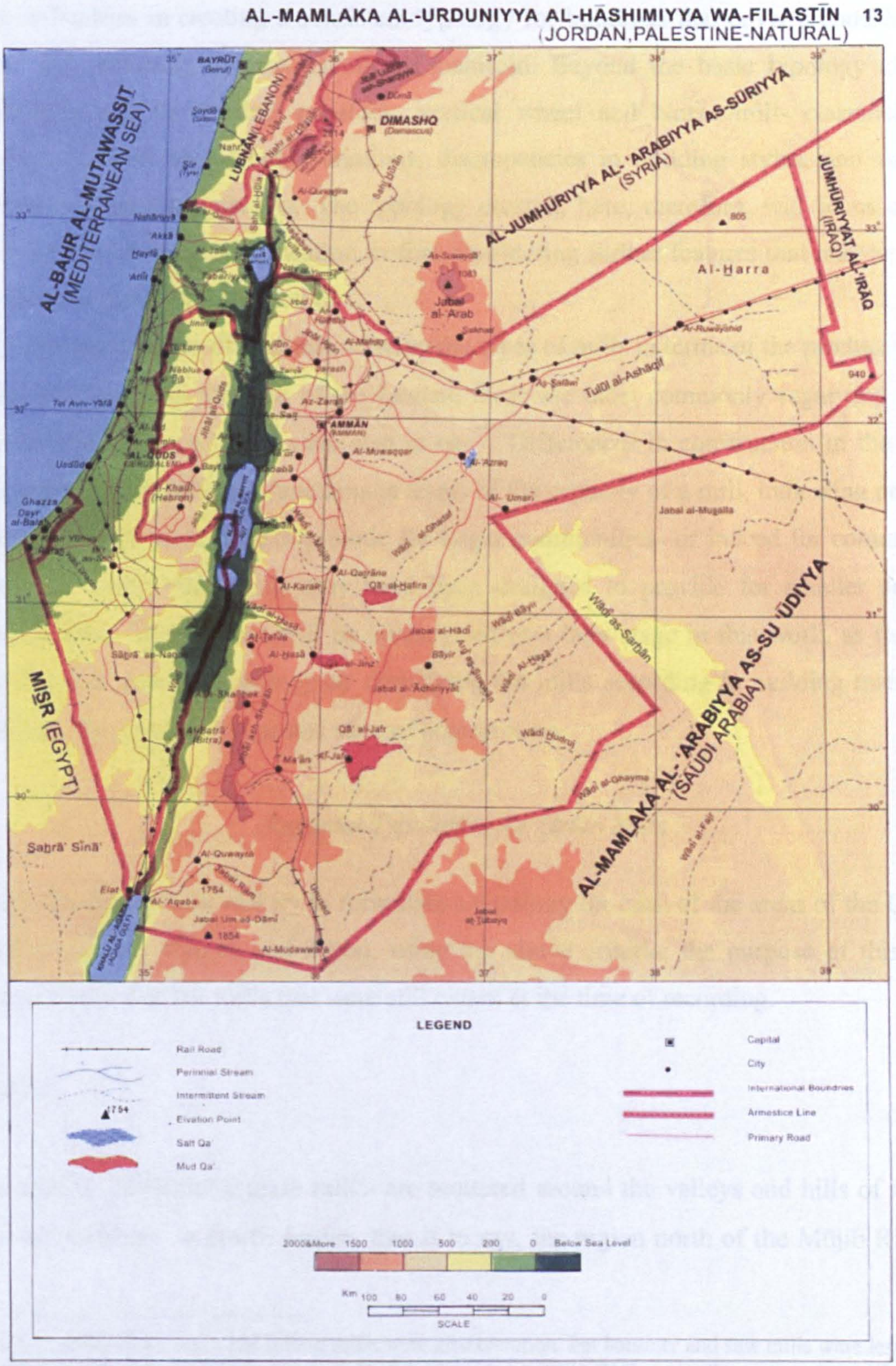

Figure 1. 8. Map of Jordan, with towns and cities mentioned in this study.

The difficulties in creating a consistent typology for buildings that cover a considerably wide and culturally diverse region are manifold. Beyond the basic typology already described- e.g. the *arūbah* penstock, vertical wheel and Norse mill- classifications become difficult as regional variations, discrepancies in building styles, and cultural adaptations become apparent. The typology created, here, therefore, will focus on the main types of a basic classification, before considering further features that may be more common in one area than another.

It is also necessary to distinguish between the types of mills in terms of the product that is being processed; in the case of the Levant, these are most commonly sugar and grain, though other types of mills were also in use[37]. Differences in construction in the water mills may reflect different functions in terms of the capacity of a mill, indicating perhaps that some mills were built to provide for larger communities- or indeed for commercial purposes- while other mills may have been designed to provide for smaller peasant communities. These issues will be investigated at a later stage in this work, as the first priority is to create a typology by classifying the mills according to building materials, location, size, penstock type and state of preservation.

Regional Typologies for Grain Mills

The following section will try to formulate a typology for each of the areas of the Levant studied (Jordan, Cyprus and Syria), using the above criteria; the purpose of this is to design a record of the mills that were still extant at the time of recording.

Jordan

Watermills- particularly grain mills- are scattered around the valleys and hills of Jordan in large numbers. In North Jordan, that is to say, the region north of the Mūjib River, a

[37] Cotton mills, dying mills and fulling mills were also common, but hammer and saw mills were less used during the medieval period; See Mantran, R. & Sauvaget, J. (1951) *Règlements fiscaux ottomans : les provinces syriennes*. Institut français de Damas : Beirut; Pascual, J.-P. (1983) *Damas à la fin du XVIe siècle : d'après trois actes de waqf ottomans*. Institut français de Damas: Damas; Seigne, J. (2002) "A Sixth Century Water-Powered Sawmill at Jarash." *ADAJ* 46, 205-213.

greater number of mills have been studied than the area to the south of the Mūjib. Although no mill is identical, similarities occur, and can be striking, between mills of different areas of North Jordan. Although Gardiner & McQuitty's model of classification of *arūbah* penstock mills can be applied to many of these mills, a more in-depth study of construction techniques and variability within masonry may prove necessary to classify these even further. Grain mills in Jordan can be categorized into several types, using additional categories to Gardiner & McQuitty's model. There are, for example, different construction techniques for single penstock mills:

- Single penstock constructions with a flat, vertical face
- Single penstocks with a stepped face
- Single penstocks with a sloping face

In addition to this, there are double, or even multiple, penstock towers, and very rarely do water mills with no visible penstock occur. For the purposes of this study, I propose to use the following classifications:

• Single penstock mills (general):	Type 1
Single penstock, stepped face:	Type 1a
Single penstock, sloping face:	Type 1b
Double/multi penstock	Type 2 (followed by a superscript of the number of penstocks- e.g. 2^2)
No penstock	Type 3

In addition to this, construction materials will also be considered. Limestone is a frequent resource used as building material due to its natural abundance in Jordan and its ability to retain water, and many mills are therefore built of limestone. Basalt is also a common building material, in all three areas of this study, as is rubble and mortar.[38]In classification of the water mills, the above categories will be used, and in addition, the construction material. The various regions and *widyān*[39] will also have

[38] Abbreviations used for building materials can be found in the Appendix.
[39] (s.) *wādi*, river valley.

abbreviated names, as well as a number corresponding to each separate mill of that region.[40] It may also be beneficial, particularly for future research, to provide information on the degree of preservation of the building. For this study, the following information is proposed:

- I : Ruined
- II: Partially ruined, extant penstock
- III: Extant penstock, remains of mill/wheel chamber, and evidence of mill race
- IV: Extant penstock, mill/wheel house, and mill race

As an example, a simple classification will appear in the following manner:

RAY1a/LMS IV

In addition to this information, each record will also have information on the location of the mill (where available), vegetation, elevation, and information regarding the presence of any related water channel systems. **(Fig. 1.8)**

Syria

The grain mills of Syria have not been studied in any great detail either, and so the different types that exist have also not been classified. The few examples from Syria in this study will be taken mainly from Damascus, but two examples of mills from Misyāf and Aleppo will also be included, as well as a brief discussion on watermills in Ḥoms and Ḥama. **(Fig. 1.9)** This aims to follow an identical classification system to that used in Jordan.

[40] Abbreviations for valley and tow/city names for all regions can be found in the Appendix.

Figure 1. 9. Map of Syria, with areas mentioned in this study.

Cyprus

The mills in Cyprus were studied as a part of **TAESP**, directed by Glasgow University, University of Cyprus and Oregon State University, which took place between 2000 and 2004. The areas studied are the Asinou valley, the Lagoudhera valley and the Karkotis valley. Of these, most examples of watermills are present in the Karkotis valley, as this is the largest and most fertile of the three valleys. The main sites are Evrykhou, Katydhata, Phlasou, Linou, Asinou, Vyzakia and Pano Koutraphas. There are numerous water mills located in these valleys.

There are fewer cases studied here, but an identical method of investigation and description as that for Jordan and Syria is used. However, to avoid complications with catalogue references, the mills will be classified using the catalogue numbering system of the TAESP project. The buildings are listed as **Building Units** (**BU**) followed by their number in the sequence in which they were first located and described. In this study the first letter of the valley in which the mill is located will also be included as a suffix to the number, to serve as a reminder for the reader of which valley the mill belongs to. "K" will be affixed to denote the Karkotis valley, "L" the Lagoudhera valley and "A" for the Asinou valley, e.g. **(K) BU0031a/LMS IV.** **(See Fig. 5.79, p. 181)**

A Typology for Sugar Mills

For the purposes of this study, it seems appropriate to treat the sugar mills in a separate section, particularly as fewer examples remain of these than they do of grain mills. Fortunately, a wealth of documentation exists for these sugar mills, through Crusader charters as well as travellers' accounts. Cyprus has been particularly well documented, as have the sugar producing regions of Tyre (Sūr) in the *bilād al-shām*. They will not be subject to the same typological classification but rather by their name and/or location, and will be discussed after the case studies on grain mills for each area.

CHAPTER TWO

HISTORICAL SOURCES

Introduction

As Chapter One of this work focussed on the aims of this study, and presented the technical and historical background of the water mill, the current chapter hopes to introduce the landscape of the Levant, as seen through historical accounts by geographers, travellers, pilgrims and chroniclers.[1] The time period covered is roughly from the $5^{th}/11^{th}$ century AD until the last century of Ottoman rule. The first section of this chapter deals with the historical landscape of Jordan and Syria, introducing major and minor places of interest to the study of watermills and irrigation; these include places, which pay particular attention to the presence of water-related buildings as mentioned by relevant historical sources. Although specific buildings related to the case studies of each region (Chapter Five) are rarely mentioned, the aim is to provide an overview of the historical landscape, in which the mill and related irrigation works can be placed over time, as well as to ascertain the importance that was placed by contemporary societies on these structures.

The second section of this chapter focuses on Cyprus. Frankish, Venetian and Ottoman period sources, mostly from travellers account, are covered to introduce the historical landscape of the island. A similar approach to the study of the historical landscape of Jordan and Syria will be applied.

Jordan and Syria: Landscapes in Perspective

The landscape of the *bilād al-shām*[2], or Greater Syria, has been described by many Arab geographers, as well as travellers and pilgrims, through the last 1000 years. The early Islamic *bilād al-shām* were divided into military districts, known as *jund* (pl. *ajnād*), of which the *Jund al-Urdunn* was one, but which covered the area from Lake Tiberias

[1] The physical landscape is discussed in Chapter Four.

[2] Literally, the "northern countries". It is a term remaining from the early Arab geographical divisions, encompassing what are today Jordan, Palestine, Syria and Lebanon. It is uncertain whether Cyprus was a part of the *bilād al-shām* during the island's conquest by the Arabs in the early Islamic period, but it has been included in this study.

northwest to Tyre and Acre, and east to al-Lajjūn, Baysān and Adhri'āt. In his work *Aḥsan al-Taqāsim fi Mā'rifat al-Aqālim* (the Best Divisions for Knowledge of the Regions), the 4th/10th century geographer al-Muqaddasī makes one of the earliest references to the existence of mills in northern Jordan; speaking of 'Ammān (in the district of al-Balqa'), he says, "many streams flow through the town, on which are mills which water turns...".[3]

The Ayyūbid, Mamlūk and Crusader periods are also well documented for this part of the *bilād al-shām*, as there is a wealth of historical accounts from both Muslim and Christian historians and travellers during this period.[4] The 15th to the 19th centuries are mostly documented by foreigners travelling in the area, such as pilgrims visiting the Holy Land, a few of who make specific references to the landscape or architecture of what are today Jordan and Syria.[5] The arrival of British administration in Cyprus during the 19th century, and in Palestine and Transjordan during the 20th century, prompted a wave of interest in the topographic and archaeological features of these regions. Horatio Kitchener conducted triangulated surveys of both Cyprus and Palestine in the 1880s, and Conder and Kitchener completed a thorough survey of Western Palestine in the same period.[6] A similar approach was taken by French explorers in Syria during the French Mandate period, among which Dussaud, Deschamps and Sauvaget are well known.[7]

It is hoped that a summary of these sources will provide a picture of the landscapes of the time, and the place of the water mills and irrigation works in the historical Levantine landscape. Although few sources provide information regarding specific mills or related irrigation systems, the references alluding to their existence and use are of importance to

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[3] Al-Muqaddasī 1994, 159.

[4] Ibn Jubayr, Muḥammad Ibn Aḥmad. (1907) *Riḥlāt Ibn Jubayr*. English and Arabic. The Travels of Ibn Jubayr. Ed. William Wright. Brill: Leiden; William of Tyre. (1976) *A History of Deeds Done Beyond the Sea, 2 vols.* Octagon: New York.

[5] Parker, K. (1999) *Tales of Orient: A Critical Anthology*. Routledge: London; Dopp, P.-H. (1958) *Traite D'Emmanuel Piloti Sur le Passage En Terre Sainte (1420).* Publications de l'Universite Lovanium de Leopoldville. Nauwelaerts: Louvain.

[6] Conder, E. & Kitchener, H. (1881-1883) *The survey of western Palestine: Memoirs of the topography, orography, hydrography, and archæology.* Edited with additions by E. H. Palmer, M.A.and Walter Besant, M. A. Palestine Exploration Fund: London.

[7] See Deschamps, P. (1939) *Les Chateaux des Croisés en terre Sainte. II. La défense du royume de Jérusalem. Etude historique, geographique et monumentale.* Paris; Dussaud, R. (1927) *Topographie historique de la Syrie antique et médiévale.* P. Geuthner: Paris.

Sauvaget, J. (1941) *Alep: essai sur le développement d'une grande ville syrienne, des origines au milieu du XIXe siècle.* P. Geuthner: Paris.

this study. Texts referring to specific areas have been targeted to gain relevant information, although the usage of place-names can sometimes be problematic.[8]
The following sources are mainly from Arab historians and geographers -mostly from *al-shām* with some also originating from Muslim Spain. In addition, they include travellers' and pilgrims' accounts of the Holy Land as well as chronicles. Following is a summary of some of the literature available for study today, pertaining to the Ayyūbid, Mamlūk and Crusader periods, covering the 5th/11th to the 9th/15th centuries. These are followed by some relevant sources from the Ottoman-period.

The Landscape in the Eyes of the Arab Geographers

One of the most famous geographers of his time, al-Idrīsī wrote an extensive geography of the world as he saw it in the middle of the 6th/12th century. Apart from his detailed accounts of the geographical properties of al-Andalus (Islamic Spain), described partly in the introduction with the mill network on the Guadalquivir River, he included various places in the Levant among his descriptions. Although he neglects to mention places significant to this study in the area that is today Jordan, he makes some interesting observations on Damascus. Of the *Ghūta*[9] and its channel networks he remarks

"On the other channels from which we come to speak that are also useful is the circulation of water in the streets, in the steps, the houses, the baths and the gardens" [10]

In addition to mentioning the extensive canalisation and sophisticated water system of the city, he says

"Within the city of Damascus there are many mills on the streams, and the wheat ground there is of extremely good quality."[11]

[8] Geographers and travellers during the Ayyūbid and Mamlūk periods varied the names of places quite frequently, so it can sometimes be difficult to find the place one is looking for when reading medieval chronicles. The problem is also that certain places then become completely ignored as they are thought to be unimportant. Another problematic issue is that it can sometimes be difficult to determine whether some of these travellers and historians actually completed the journeys they claim to have undertaken, or whether they simply copied the information from other sources.
[9] The *Ghūta* is the fertile valley surrounding Damascus.
[10] Al-Idrīsī 1975, 367.

In the contemporary world of al-Idrīsī, Ibn 'Asākir[12] wrote a detailed history of Damascus, in which he describes in detail the *qanawāt* and canalisation within the city, as well as mentioning related hydraulic structures. Ibn 'Asākir counts a total of 148 water-distribution channels, 13 of which are *waqf*[13], or pious endowments left by individuals usually in perpetuity; one of the *qanawāt* he mentions is also related to a mill belonging to a particular house, suggesting a *qanāt*- like a watermill- could be publicly as well as privately owned.[14] He also counts eleven watermills (*raḥā* and *ṭāḥūn*) scattered on or outside of the walls of the Old City.[15]

In addition to listing the water mills present in Damascus during the 6th/12th century, Ibn 'Asākir also provides an account of the water system in Damascus by going back to the early Umayyad period, when Yazīd b. Mu'āwiya[16] first began to consider building water channels in the city, as the city and surrounding area was without a ready supply of water and much in need of one. The Yazīd River was used as the source for this venture, and it was thus named after the caliph. In later years, Hishām b. 'Abd al-Malik[17] implemented a system of rationing the water supply by allocating a certain amount from each water source for consumption, as well as by implementing laws regarding the use of water in the city. This was enforced by the time of Hishām b. 'Abd al-Malik's death in 125 AH/745 AD. Such improvements continued throughout the city's history, particularly during the Ayyūbid and Mamlūk periods.[18]

Another famous account is provided by Ibn Jubayr[19], a Muslim traveller from Spain. He completed his itinerary between AH 579/1183 AD and AH 581/1185 AD, a time fraught

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[11] Al-Idrīsi 1975, 366. See also Le Strange, G. (1965) *Palestine under the Moslems. A description of Syria and the Holy Land From AD 650 to 1500.* Khayats: Beirut, 240.

[12] Ibn 'Asākir (AH499/1105AD-AH571/1176AD) (1951) *Tarīkh Madīnat Dimashq.* Vol. 1. Majma' al-Lughah al-'Arabiyah: Dimashq. He completed an eighty volume work on the notable people of Damascus, which included a description of the city. See also N. Elisseeff. (1959) *Description de Damas.* Institut Français de Damas: Damascus.

[13] (pl.) *awqāf.*

[14] The issue of mills as *waqf* property will be discussed in the following chapter.

[15] These are discussed in Chapter Seven.

[16] Umayyad caliph, ruled 60/680 to 64/683. For detailed information regarding Islamic rulers mentioned in this work, see Bosworth, C.B. (2004) *The New Islamic Dynasties : a chronological and genealogical manual.* Edinburgh University Press: Edinburgh.

[17] Ruling Umayyad caliph from 105/724 to 125/743.

[18] Gaube, H. & Wirth, E. (1984) *Aleppo: historische und geographische Beiträge zur baulichen Gestaltung, zur sozialen Organisation und zur wirtschaftlichen Dynamik einer vorderasiatischen Fernhandelsmetropole.* Beihefte zum Tübinger Atlas des Vorderen Orients. Reichert: Wiesbaden, 180-183.

[19] Ibn Jubayr 1907.

in the Levant with religious and political strife as a result of the ongoing Crusader wars. Despite these obstacles, his travels appear to have been extensive, and his reports provide an insight into daily life and ritual of the regions he visited, giving emphasis on the necessities of life such as the availability of water and spiritual fulfilment.

Although he covers the region of what is today Syria and Lebanon, he fails to provide any great detail about life and society in the south-eastern *bilād al-shām*, south of Damascus. Palestine, of course, is important, for Muslims, Jews and Christians alike, but the Eastern banks of the Jordan River, what is today a part of Jordan, are unfortunately given hardly any attention.

Of Aleppo, he says: "it has nought without save a small river (al-Quwayq) that flows from north to south and passes through the suburb that surround the city;.....on this river there are mills contiguous with the town."[20] These mills were no doubt water-driven mills, some of which are still in existence today. (A list of mills is provided in the work of Gaube & Wirth, which will be discussed in Chapter Seven.)[21]

Of Ḥama, Ibn Jubayr mentions the presence of water-wheels on the Orontes ('Āsi) river..."to the east of the city I saw a large river (the Orontes) that in its strong course spreads out and branches, and on its banks observed water-wheels that faced each other....on the bank that borders the suburb of the city is a place of ablution, furnished with many rooms and with water coming to all its parts from one of the water-wheels."[22]Ibn Jubayr fails to specifically mention any watermills or related technology in Damascus; his only remark that hints at the existence of water-wheels and mills is when he talks of strangers inhabiting the city: "the other strangers, who are not in this state (of poverty and need) and who have a trade or craft, are also found divers means of livelihood, such as being a watchman in a garden, supervisor of a bath, or keeper of clothes of the bathers, manager of a mill..... (**أمين الطاحونة, *amīn al-ṭāḥūna* **)."[23]

Yāqūt is another well-known 6th/7th-12th/13th century Arab geographer, and in his encyclopaedic dictionary of places, *Mu'jam al-Buldān,* he provides descriptions of towns covering the entire world as it was seen in the 7th/13th century. Because his work is so

[20] Ibn Jubayr 1907, 263.
[21] Gaube & Wirth 1984, 435-441.
[22] Ibn Jubayr 1907, 265.
[23] Ibn Jubayr 1907, 285; *amīn*: manager, custodian.

monumental, his descriptions and entries lack any great detail. Writing of Ḥama, he describes the river Orontes and how it irrigates the gardens and turns the *nawā'ir*- according to Yāqūt, this was already stated by earlier historians in the year AH 271/893 AD.[24]

Yāqūt's description of 'Ammān and the surrounding area is also limited, although his account of al-Balqa' –the region which 'Ammān is a part of, as are al-Ṣalt and Ḥisbān- is of some interest:

" It (al-Balqa') is a source of cereals and livestock, in which there are a number of rivers and ***arḥiya*** which the water turns..."[25]

The word *arḥiya*[26] is often used to refer to mills in general, although they are commonly used in the names of water mills in Damascus. [27] The area he is describing also includes Ḥisbān, which Abu'l- Fidā a century later witnesses as having several ***arḥiya*** which are turned by the water there, and which can still be seen today.

Ibn al-'Adīm[28] wrote an extensive work on the biography of the notables of Aleppo in the middle of the 7th/13th century, containing in its first volume brief descriptions on the important cities and places in the administrative region of Aleppo. He also describes in some detail the existence of a *qanawāt* system in Aleppo, and its maintenance and improvements by Ayyūbid and Mamlūk rulers in order for the people of Aleppo to be able to have running and drinking water brought to them by the river *Quwayq*.[29] There is no specific mention of any watermills in or around Aleppo, but Ibn al-'Adīm does provide a brief mention of "*ṭawāḥīn*", or "mills", being commonly used as a meeting

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[24] Yāqūt al-Hamawi.(1965) *Mu'jam al-Buldān*. Jacut's Geographische Wörterbuch. Ed. Ferdinand Wüstenfeld: Tehran.
[25] Yāqūt 1965, 151.
[26] See appendix for vocabulary related to mills. In Hans Wehr's dictionary of Arabic, a *ruḥiya* (pl. *arḥiya*) is a hand mill or a quern. It seems unlikely that anyone describing a landscape would pay particular attention to anything as small as a hand mill or quern, as these would have been a part of a household rather than a landscape. It may be assumed then that the author was in fact talking of the numerous water mills that still exist in the landscape today.
[27] Elisseeff, N. (1956) "Corporations de Damas sous Nūr al-Dīn. Matériaux pour une topographie économique de Damas au XIIe siècle." Arabica 3 (1), 61-79. See also Chapter Five and Six in this work.
[28] Ibn al-'Adīm (AH588/1192AD-AH660/1262AD) (1990) *Bughyāt al-ṭalab fī tarīkh ḥalab*, ed. F. Sezgin "Everything desirable about the history of Aleppo". Ed. Fuat Sezgin. Institute for the History of Arabic-Islamic Science: Frankfurt-am-Main.
[29] Ibn al-'Adīm 1990, 58.

place for discussions or negotiations between different families.[30] *Nawā'ir* (water wheels) are mentioned in relation to the outskirts of Aleppo; *dawālib* (water wheels) are also mentioned when he talks of Ḥama, which he claims the people refer to as "the sorrowful" because of the deep, mournful groaning sounds the wheels make as the water turns them. In his various chapters covering Aleppo's environment and that of the surrounding areas, he also gives an account of the River Orontes. This is the river that feeds both Ḥoms and Ḥama, and the people of Ḥama used the water for irrigation and agriculture, by using water wheels (*nawā'ir*). They also irrigate their gardens using the water wheels, and the water also enters their homes by way of the water wheels.[31] Ibn al-'Adīm's account of the Orontes and how it relates to the city of Ḥoms is similar; apparently the *amīr* Shirkūh[32] drew water from the Orontes for the city of Ḥoms, some of it supplying the Friday mosque and the hospital, as well as some of the homes in the city. From there (Ḥoms) the water supplied the city *khandaq* (ditch) and the citadel, and some of the river (water) was used for irrigating the city. [33]

The 7th/13th century geographer Ibn Shaddād's 3-volume work, *Al-'Alāq al-Khaṭīra*[34] covers in detail the topography and history of Damascus, Aleppo and Lebanon, Jordan and Palestine. Along with a brief account of the major rivers, Ibn Shaddād also lists the *qanawāt* of Damascus and its surroundings. Ibn Shaddād claims that the Mamlūks dramatically improved the water supply system of Aleppo in the 7th/13th century, such as the extension of water works by al-Malik al-'Azīz.[35] The complicated and efficient system of improvement of public works, such as water channels, was the handiwork of craftsmen brought from Damascus by the Mamlūk ruler al-Ghāzi[36]. He counts 154 *qanawāt*, fourteen of which are listed as *waqf* (pious endowment) objects. This list, although mainly designed to give a location of the various *qanawāt* within Damascus, is also useful for the related information, which Ibn Shaddād provides for each one. Some

[30] Ibn al-'Adīm 1990, 337.
[31] Ibn al-'Adīm 1990, 390.
[32] A lieutenant of Nūr al-Dīn.
[33] The citadel of Ḥoms is located on a *tall* above the old city, and water would have been brought here via the channel system from the Orontes River.
[34] Ibn Shaddād (d. AH 684/1285 AD) (1956) *Al-'Alāq al-Khaṭīra*. La Description de Damas d'Ibn Shaddād. Arabic Text. Ed. Dominique Sourdel and Sami Dahhan. 3 vols. Institut Français de Damas: Damas.
[35] Ibn Shaddād 1956, 78-79.
[36] Al-Ẓāhir al-Ghāzi, in power from 586/1186 to 616/1216. He was an avid contributor to restoring and restructuring public works in *al-shām*.

of the *qanawāt* often also have related hydraulic structures, such as *sāqiya*[37] and watermills. According to Ibn Shaddād, there were 13 mills in Damascus. 8 of these were *raḥā* and 5 were *ṭawaḥīn*; most of these were connected with mosques.[38] Although Ibn Shaddād mentions the existence of the castles of al-Karak, Shawbak, 'Ajlūn and al-Ṣalt, he does not go into detail about the surroundings or other buildings of importance in the *ajnād* of Urdunn or Filasṭīn; he relates hardly anything on watermills in Palestine, mentioning only a place called *Ṭawaḥīn* near Ramla.[39]

Abu'l-Fidā[40] was born in Damascus in 673/1273, a descendant of Shahinshāh, a brother of Ṣalāḥ al-Dīn[41], and his family were the ruling elite in the city of Ḥama. He completed his geographical work in 721/1321, only 10 years before his death in 731/1331.

The first place of some significance he mentions in the Balqa' region is Ḥisbān, a town which most geographers and travellers of his time neglect to mention, but is a major area of study in this work. Abu'l-Fidā makes no mention of *ṭāwaḥīn* specifically, but he describes the landscape of Wādi Ḥisbān as replete with "trees, gardens, crops and *arḥiya*". Le Strange, in his work *Palestine under the Moslems*[42], also refers to mills in his translation of Abu'l- Fidā's account, although that is a rather vague term. In the accounts of Yāqūt, mentioned previously, *arḥ iya* are referred to as water-driven mills.[43]

Other places he mentions in northern Jordan, where one can today still see a number of mills, are 'Ajlūn (or Jabal 'Awf), and al-Ṣalt; in both towns, large fortifications were built by Ayyūbid *amīrs*. Abu'l-Fidā describes the landscape of this area as a verdant and fertile agricultural area, but makes no mentions of water mills. 'Ajlūn, also known as Ba'ūtha[44], is well-known for its castle, built by 'Izz al-Dīn Usāma, one of Ṣalāḥ al-Dīn's most eminent amīrs. Abu'l-Fidā mentions the many gardens and running water[45], suggesting that the town had a sufficient water-supply system to feed the people and keep the

[37] *Sāqiya* are by definition water wheels, although the term can also be used to describe any device used for irrigation.
[38] Ibn Shaddād 1956, 135-142.
[39] Ibn Shaddād 1956, 125.
[40] Abu'l-Fidā *(AH663/1273AD-AH721/1331AD)* (1840) *Kitāb taqwīm al-buldān*. Reinaud, M. and Le Bon MacGuckin de Slane, M. (eds.) *Geographie d'Abulféda*. E. Thorin: Paris.
[41] Considered the founder of the Ayyūbid Dynasty in Egypt and Syria; ruled from 564/1169 to 589/1193.
[42] Le Strange 1965
[43] Yāqūt 1957, 151.
[44] This is mentioned as a suburb by Ibn Battūta, and may be referred to here as belonging in the wider regional context of 'Ajlūn by Abu'l-Fidā.
[45] Abu'l-Fidā 1840, 245.

gardens and crops irrigated. Al-Ṣalt, situated south of 'Ajlūn, also has a big fortification, and is also complete with running water and a large spring, as well as many gardens. Of al-Karak and Shawbak, situated in Central Jordan, Abu'l-Fidā mainly describes historical events surrounding these towns, but he mentions the *wādi* below al-Karak being full of gardens and also a bathhouse. Al-Shawbak is a town with two big springs running along each side of the foot of the citadel, and also has many fruit gardens.

Further north in the *bilād al-shām*, Abu'l- Fidā comes to talk of places like Bayrūt and Tripoli, which have the usual gardens and rivers, and Bayrūt is blessed with a *qanāt* from which the people drink and get running water. In Tripoli, sugar cane is grown in abundance[46], and in Ḥama, also an ancient city surrounding a castle on a hill, and Abu'l-Fidā's hometown, "there are watermills, and on the outskirts there are water wheels irrigating most of the gardens and the water from the river leaves them (the water wheels) as they rotate. Ḥama is an old city mentioned in the Torah; it and the town of Shayzar (where there is also an Ayyūbid castle)[47] are especially known for their many water wheels, of which there are none in likeness in all of *al-shām*".[48]

Ibn Furāt[49], who lived in the 14th century, drew on many different Arab sources to achieve a thoroughly researched account of the wars of the Crusades. His accounts are almost purely military or political, or a combination of both; rarely does he provide descriptions of people or places. However, it is still possible to glean some relevant information regarding how people lived and what conditions they had to suffer during those times. Ibn Furāt's description of the capture of Antioch, for example, suggests that mills played an important role especially during war:

"the people of Antioch fought fiercely, but the Muslims scaled the walls by the mountain (Mt. Silpius) near the citadel….the citadel had neither enough water nor enough mills to satisfy the needs of the people in it."[50]

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[46] Sugar mills are mentioned here as early as the 6th/12th century.

[47] Shayzar was visited in 2003, and a large aqueduct with an intact water wheel was still located by the river there.

[48] Abu'l-Fidā 1840, 263.

[49] Ibn Furāt (AH735/1334AD-AH807/1405AD) *Tarīkh al-Duwal wa'l-Mulūk*. Lyons , U. & M.C., & Riley-Smith, J.S.G. (1971) *Ayyūbids, Mamlūks and Crusaders.*Vols. 1 & 2. Heffer & Sons: Cambridge.

[50] Ibn Furāt 1971, 122.

The Persian traveller Nāṣir-i-Khusraw made his travels through Syria in the middle of the 11th century, not long before the beginning of the Crusader wars. Again, the major towns relevant to this work are mentioned, if only briefly, but his observations with regards to agriculture and related issues are acute. He notes that the most prominent features along the river in Ḥama are its water wheels.[51] He also makes various references to some of the water systems in major towns and cities, such as Acre, Tyre and Tripoli, indicating the significance of the presence of water works in both rural and urban areas.

Ibn Battūta travelled through the Middle East, Asia and Africa between the years AH721/1325 and AH750/1354 AD. His travels through the Levant were extensive, and it is perhaps for this reason that he has provided little more detail about them than some of the authors mentioned above, like Ibn Jubayr and Abu'l-Fidā. He opts, like most of his contemporary writers, to focus on major cities and places, like Jerusalem and Damascus, amongst others. Travelling through the eastern Mediterranean in the 14th century, he does not make any specific references to the landscape, although he does mention 'Ajlūn and its sweet water.[52] His description of Damascus relates mainly to the major monuments, mostly religious, which are present there during the time of his visit. As Ibn Jubayr, he does, however, mention that there are foreigners in Damascus who find work:

"Those who are manual workers or in domestic service find other means [of livelihood], for example as guardian of an orchard or attendant of a mill (أمانة الطاحونة, **amānat al-ṭāḥūna**)"[53]

This may suggest that during the time of Ibn Battūta, working at a mill, or being its attendant was not considered to be a job of significant social standing, as it would become later, in the late 18th and early 19th century in Damascus.

Less exalted cities also get a mention in his work. When describing Ḥama, he speaks of one of the most elegant cities of Syria and a dignified metropolitan centre, of surpassing beauty. The town "is surrounded by orchards and gardens, supplied by water-wheels

[51] Thackston, W.M. (2001). *Nāsiri Khusraw's Book of Travels*. Mazda: Costa Mesa, 16.
[52] Ibn Battūta. (1964) *Riḥlāt*. Dar Sader and Dar Beirut.: Beirut.
[53] Ibn Battūta 1964,105. *Amānat al-ṭāḥūna:* management of the mill.

(*nawā'ir*) like revolving spheres."[54] Aleppo is of course famous for its citadel, but according to Ibn Battūta, it has within it wells that are fed by a spring, as well as a trench running through it also fed by spring water.[55] Surrounding the city are vast plains of agricultural land.[56]

Frankish Accounts

Pilgrims' and travellers' accounts of the Holy Land rarely contribute any great detail regarding the environment or buildings in the landscape that do not relate to their respective faiths, and thus their accounts offer scarce information related to the agricultural and social landscape during that time. Fortunately, there are occasionally travellers who provide accounts and evidence of a landscape that can be both lush and profitable. Details of agricultural equipment and structures are also sometimes described or mentioned, as are social practices and traditions.

In the "Itinerary of a Certain Englishman", dating to AD1344-1345, the anonymous traveller conducts a journey through the Jordan. He says:

"….and then we descended to the port of Abraham (Fountain of Elisha, Old Jericho), from which runs a stream of pure water to the plains of Jericho, irrigating them, for rarely over this place are open the cataracts of heaven. Around that place are furnaces and mills in which the Saracens prepare sugar."[57]

Another traveller, coming from France, and writing less than one hundred years later, travels to Ḥama, where "is the greatest wheel I ever saw. It is put in motion by the river, and supplies the inhabitants, although numerous, with the necessary quantity of water."[58] William, Archbishop of Tyre (Tyre), writing in the early 12th century, and one of the most famous Crusader chroniclers of the time, provides an eyewitness account of the time of the Crusades in the 12th century, and he also describes the areas he travels through. Of

[54] Ibn Battūta 1964, 66.
[55] Ibn Battūta 1964, 68.
[56] Ibn Battūta 1964, 70
[57] Hoade, E. (1952) ***Western Pilgrims: The Itineraries of Fr. Simon Fitzsimons O.F.M (1322-23), A Certain Englishman (1344-45), and Thomas Brygg (1392).*** Franciscan Press: Jerusalem, 75.
[58] Hoade, E. (1952), 311.

Damascus, he mentions an old water system used to irrigate the landscape through a canal system. Tyre had a prolific sugar growing industry during his time, and sugar-processing facilities are known to have existed, perhaps in the form of sugar mills and presses. He also describes a curious hydraulic structure used to raise and conduct water, and thus irrigate the plains around Tyre as well Tyre itself.[59]

He also describes the country surrounding Jerusalem as being fertile, and tells of how grains, oil and vines grow in abundance near Petra and al-Shawbak.

Some travellers to Syria also make random note of the existence of water mills; a mid-13th century traveller talks of "le molin de Dokes: le chemin devers la cite et la terre de Damas"[60], situated in Acre; another itinerary, dating from around the same period, mentions the "Molin Des Turs (Turcs)" between Arsūf and Jaffa.[61]

A late 15th century treatise by a cleric named Fra Francesco Suriano yields further information on the area of Jericho.

"At the foot of this mountain (The Mount of Quarantine) is the fountain called after Eliseus, which yields so much water that it works the mills and irrigates all the plain of Jericho, in which there are many gardens.[62]

Fra Suriano may here be referring to the same Saracen mills mentioned in the account by an Englishman above, and could suggest that sugar was still being produced here in the late 15th century. Felix Fabri, travelling through the Holy Land in 1483, also refers to a Saracen miller outside of Jericho, whose mill they had to pass through to continue on their pilgrimage.[63]

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59 William of Tyre 1976, II, 5-6.

60 Le Strange 1965, 136. This is probably the mill in Dā'ūq in Palestine; see Chapter Six, p.214.

61 Le Strange 1965, 104.

62 Hoade 1952, 142.

63 Prescott, H.F.M. (1954) *Jerusalem Journey: Pilgrimage to the Holy Land in the 15th Century*. Eyre & Spottiswoode: London.

The Ottoman Empire gained control of Jordan and Syria from the Mamlūks and Ayyūbids in 1517AD, and would last until its collapse in the early 20th century. Modern day Jordan became part of the British Mandate in 1917, and the French created a mandate in Syria in 1922.

Other than general accounts of pilgrims, like those of Pietro Casola and Felix Fabri in the late 15th century, accounts of travellers are few and far between for Jordan and Syria, until the 18th and early 19th centuries, when a revival of interest in Biblical history and archaeology by Western travellers was sparked. Although Glueck[64] and Stanley[65] provide historical and geographical accounts of Jordan, archaeological accounts, such as those offered by Conder and Kitchener in their work *A Survey of Western Palestine* (1881), are more precise. Late 17th, 18th and early 19th century travellers, such as Chelebi (11th/17th century), Maundrell (1736 AD) and Burckhardt (1812 AD), also provide if not specific information, interesting general accounts and observations regarding the history and landscape of Syria and Jordan.

Evliya Çelebi, a Turkish traveller writing in beginning of the 11th/17th century, remarks the following on the situation of mills in Istanbul:

> "The Millers (Deguirmanjian): ninehundred-and-eightyfive horsemills, served by nine thousand eight-hundred men. They had no particular patron in the Prophet's time, when only windmills were in use; watermills are of a later invention, the first having been erected in Egypt in the Caliph Hakem-bi-emrillah's time....Besides the abovementioned horsemills, there are but four water-mills at Constantinople, which, placed on both sides of the street Nejati, grind only in winter time, when the water, carried to the town by the conduit of the Forty Fountains, abounds in such a degree as to drive, by its excess, these mills for the benefit of the owners of these houses, but not for everybody as public mills." [66]

Watermills in this large urban centre were clearly not a common occurrence, and the few that existed were not at the disposal of the general public. Interestingly, Çelebi wrongly

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[64] See Glueck, N. (1951) *Explorations in Eastern Palestine, IV.* American Schools of Oriental Research: New Haven.

[65] Stanley, A.P. (1857) *Sinai and Palestine: in connection with their history.* John Murray: London.

[66] Evliya Efendi. (1968) *Narrative of travels in Europe, Asia, and Africa, in the seventeenth century.* Translated from Turkish by the Ritter Joseph von Hammer. Johnson Reprint Corporation: New York, 124.

attributes the invention of the watermill to the time of the Caliph al-Ḥākim's reign ($10^{th}/11^{th}$ century AD).[67]

Henry Maundrell, writing in 1696 AD, travelled from Aleppo to Jerusalem and provided detailed accounts of his visits to various places along his route. In his travels, he makes continuous remarks about the availability of water in and around places he travels through, as well as what this water is used for. Passing through Ḥama, he comments on the "great wheels, made for lifting up water...".[68] Maundrell later makes very interesting observations regarding the irrigation system at the Palace Garden in Bayrūt, where there are stone channels with outlets that release the water at intervals, usually next to trees.[69] This appears similar to the channel system at Ḥisbān, where there are also outlets for the water, set at intervals to irrigate the crops.

Maundrell also passed by Solomon's cisterns, outside Tyre (Ṣūr), a complex water storage system which was still in use by the Turks at the time of his travels.

> "The whole vessel contains a vast body of excellent water; and is so well supplied from its fountain that though there issues from it a stream like a brook, driving four mills between this place and the sea, yet it is always brim full. On the east side of this cistern was the ancient outlet of the water, by an aqueduct raised about six yards from the ground, and containing a channel one yard wide. But this is now stopped up, and dry; the Turks having broke an outlet on the other side driving thence a stream for grinding their corn." [70]

Tyre was well known for its production of sugar during the period of the Crusades, of which Maundrell makes no mention here; it possible that the mills he mentions above were once sugar mills which, when production of sugar cane ceased in the 16^{th} century, could have been converted to grain mills. This would be one of several examples of an Ottoman initiative to take advantage of existing water supply structures and adapting them for their own needs. Grain was commonly grown across this part of the Levant, as he observes when speaking of Palestine, where "nothing can be more fruitful, whether for the production of corn or cattle".[71]

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[67] Fāṭimid *imām* and ruler of Egypt, 396/996-421/1021.
[68] Maundrell, H. (1731). *A journey from Aleppo to Jerusalem at Easter A.D. 1697.* By Hen. Maundrell M.A. late Fellow of Exeter Coll. and Chaplain to the Factory at Aleppo. Printed at the Theater: Oxford, 4.
[69] Maundrell 1731, 40.
[70] Maundrell 1731, 51.
[71] Maundrell 1731, 65-66.

One of the most interesting accounts of travellers east of the Jordan River in the early 19th century is given by John Lewis Burckhardt, who travelled through Syria and the Holy Land in 1812. Although he provides a good general overview of the people and the landscape of the region, more specific accounts of some places are particularly relevant to this study. When travelling to al-Karak, for example, he observes the following:

"In the valley, on the west and north sides, are several copious springs, on the borders of which the inhabitants cultivate some vegetables, and considerable plantations of olive trees. The principal of these sources are 'Ayn Sāra (عين سارة), which issues from the rock in a very romantic spot, where a mosque has been built, now in ruins; this rivulet turns three mills....."[72]

These are interesting observations, as 'Ayn Sāra is the site of four water mills that are still extant today; three of these are situated in close proximity to each other, and may well be the mills that Burckhardt refers to above.[73] Burckhardt also makes additional remarks about the tax situation at the time, and states that the tribes in this area were exempt from taxes, as the Ottoman *wazīr* of the time did not have power over the Bedouin *shaykhs.*[74] Burckhardt also mentions the "ancient city" of *Ṭawaḥīn al-Sukkar*, the name of several sugar mill sites in Jordan and Palestine, but does not mention the mills specifically; his reference to it as a city may indicate it significance as a place known for its watermills in the past.

Although historical sources of the early to middle Ottoman period are fewer in number for Jordan and Syria, the accounts that do exist provide useful information regarding the rural and urban landscapes of this part of the Levant. In particular, as with the accounts provided during the Crusader period, emphasis is often on the availability of water, and the use of land. The picture provided suggests that water and agricultural prosperity were of utmost importance, even if this was not always an achievable goal. The information provided in these accounts is also reflected in the administrative issues regarding agriculture and water use, which will be discussed in the following chapter.

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72 Burckhardt, J.L. (1822) *Travels in Syria and the Holy Land.* Published by the Association for Promoting the Discovery of the Interior Parts of Africa, J. Murray: London, 379.

73 This also indicates that the mills were built some time in the late 12th/18th century, at the latest.

74 Burckhardt 1822, 383.

The Historical Landscape of Cyprus

The landscape and history of Cyprus have been well documented since medieval times. In its economic heyday- the 13th to the 15th centuries- Cyprus was a rich country, owing mainly to the Frankish and Venetian abilities to exploit the island's rich natural resources, which in turn became the basis for their vast commercial, industrial and trade ventures. Numerous records of this commercial activity exist in Venetian archives, along with a wealth of historical accounts provided by travellers and historians who lived in that time. Following is a brief description of the island of Cyprus as seen through these sources.

Frankish and Venetian Sources

Apart from the well-known water-driven sugar mill at Kolossi Castle, chronicles of the Crusader period report the existence of a number of mills in Cyprus. Alberic (14th century) writes of "the Royal mills of Kythrea" which were owned by Alice, Queen of Cyprus in the 13th century.[75] The Cartulary of the Cathedral of Santa Sophia of Nicosia mentions a mill located in Nicosia in the year 1391.[76] References to irrigation and water-supply methods during the mid-14th century are also made to the city of Famagusta, where "there are gardens and plots irrigated from fountains on the spot by water artificially raised and poured straight into stone troughs, and from which it is carried by canals to all the plantations in the gardens when they need irrigation."[77]

In 1458, the traveller Capodilista writes of the "many fields of sugar cane.....watered by running streams" in Episcopi.[78] A similar account is provided by Fra Suriano in 1480.[79]

Earlier references to some villages included in the TAESP survey do exist where watermills are still extant today, suggesting they were of economic and political

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[75] Roberts, L. (2000) *Latin Texts from the First Century B.C. to the Seventeenth Century A.D.* In Wallace, P.W. & Orphanides, A.G. (eds.) Sources for the History of Cyprus Vol. VIII. University of Albany, State University of New York. Altamont: Greece and Cyprus.

[76] Roberts 2000.

[77] Hoade 1952, 60.

[78] Cobham , C.D. (1908) *Excerpta Cypria. Materials for a History of Cyprus.* Translated and transcribed by C.D. Cobham. Cambridge, 35.

[79] Frescobaldi, L. (1948) *Visit to the holy places of Egypt, Sinai, Palestine, and Syria in 1384.* Translated from the Italian by Theophilus Bellorini and Eugene Hoade ; with a pref. and notes by Bellarmino Bagatti. Franciscan Press: Jerusalem.

significance during Crusader Cyprus. In Dawkins' translation of the chronicle of George Bustronios (1456-1489) both the town of Vyzakia and estate of Athassi are mentioned:

"74. And on the fifteenth of April 1461 the king went to Kerynia to lay an embuscade, and Nicholas Morabit also was there......As soon as the king reached Lefkosia he granted Morabit three estates, Vyzakia, Cafcalo, and Athasi and two vineyards..." [80]

There is a mention of the mill at Lapithos, but here it is not referred to as a sugar mill, but as being used for grinding corn.[81]

There are also a few references to do with the irrigation systems in Cyprus in the later medieval period. Le Saige (1518) provides the following account of Nicosia:

"Near the convent is a great space of garden ground watered from a well. A horse turns a big wheel, and many earthen pots are bound on this wheel which pour out a wonderful quantity of water, and there are many small pipes in the garden by which the water is distributed." [82]

Grain is also "greatly abounds" on the island, and this is also confirmed by other travellers to the island during that period.[83] In addition to the wealth of agriculture attested to by Possot[84], writing in 1532, he provides a similar account of water systems as Le Saige:

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[80] Dawkins, R.M. (1964) *The chronicle of George Boustronios, 1456-1489.* Distributed by University Bookroom, University of Melbourne: Parkville, Vic., Australia, 27-28. See Chapter Seven for a discussion on the archaeology of the study areas.

[81] Dawkins 1964, 25. In addition to chronicles and travellers' accounts, some maps, which date to the Venetian period, still remain in existence today. One of the maps was drawn by a Venetian cartographer called Giacomo Franco; it dates from 1573 AD, and is perhaps the most famous of the island of that period. The original exists in the British Library, and is interesting because it depicts the names of some villages which still exist today in the Troodos area, and which are also in the TAESP survey area. These villages are also listed in Venetian records of the early 14th and 15th centuries noted in de Mas Latrie's work, listing the names of the *casale* of each region. De Mas Latrie, M.L. (1970) *Histoire de l'isle de Chypre: sous le règne des princes de la maison de Lusignan.* Les Editions l'Oiseau: Famagouste, Stylianou, A. & J. (1971) *An Important Venetian Map of Cyprus in the Map-Room of the British Museum, London.* Zeno: London. These are discussed briefly in Chapter Seven. It is interesting to note that water mills and related irrigation structures have been discovered during surveys in or near all of these villages, many of which are assumed to date from the Ottoman period but could quite feasibly have been built during the Frankish or Venetian periods.

[82] Cobham 1908, 47.

[83] Cobham 1908, 61.

[84] Cobham 1908, 63.

"There was a great spring, abounding in water, like a deep cistern of four fathoms, long and narrow, built of cut stones, in which was a large wheel, and ropes thirty fathoms long, on which thirty large stout pots were fastened by chains. And when the said wheel turned with its chains of ropes all the pots below filled themselves with water, and when they came up and went down again they poured their water into a large trough, which spread this water over the adjoining fields on whichever side they wanted it to run, guided by channels and drains. This wheel is turned by another wheel which they cause to be moved by a horse or ass which has its eyes blindfolded; and in an hour they draw enough to water copiously two acres of land."[85]

Similar irrigation methods were present in Egypt at the time, where through the use of a *sāqiya* crops along the banks of the Nile River were watered. These are also akin to the *nawā'ir* of Ḥama, the main difference being that the *sāqiya* was animal-driven, while the *nā'ūra* was driven by the current of the river.[86]There is as of yet no evidence of the existence of *nawā'ir* in Cyprus.

A German traveller named Fürer, writing in 1566, only five years before the conquest of the island by the Ottoman army, also makes an interesting comparison between Cyprus and Egypt when writing of the irrigation practices of Larnaca:

"As in Egypt, the natives draw the water with which they irrigate the land, and which supplies the daily wants of the city, by the joint use of oxen and wheels." [87]

The Ottoman Period

Early Ottoman period sources allude to the production of sugar on the island, but not always as the main commercial product. Paleme, travelling around the island in 1581, talks of the "abundance of grains"[88], and in 1596, Fynes Morrison relates:

"This island yieldeth to no place in fruitfulness or pleasure, being enriched with corne, oile, cheese....; canes or reedes of sugar (which they beat in mils, drawing out a water which they seeth to make sugar)..."[89]

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[85] Cobham 1908, 65.

[86] Rabie, H. (1981) "Some Technical Aspects of Agriculture in Medieval Egypt," in Udovitch, A.L. (ed.) *The Islamic Middle East, 700-1900*. Studies in Economic and Social History. Darwin: Princeton, 59-91.

[87] Cobham 1907, 77.

[88] Cobham 1907, 299.

[89] Cobham 1907, 185.

A few years later, a German traveller called Cotovicus provides a lengthy commentary on the state of the island's agriculture, and the neglect forced by the Turks. However, he mentions the well-watered grain and sugar cane crops of Kouklia, and those of Lapithos.[90] Although he has a relatively negative opinion regarding the lack of enterprise by the Turks with regards to agriculture, he admits to their care and maintenance of irrigation works:

"One could hardly exaggerate the richness of the soil, but it must not want water through the long summer heat, but be diligently irrigated. On this matter they spare neither money nor labour, for when the rivers or torrents fail they have deep and wide wells from which, by means of large wheels driven by horses, they draw up in earthen vessels abundance of water for the use of their fields."[91]

In 1604, Henry de Beauvau said Cyprus was "very fertile in all kinds of grains"[92], and less than a century later, Danish traveller Cornelius van Bruyn makes no mention of sugar being produced at Episcopi and Kouklia, but makes note of the good agriculture and the abundance of wheat and cotton plantations there[93]. John Heyman, who visited Cyprus between 1700 and 1709, mentions the corn being ground by water-mills, remarking that "in a time of drought there is not only want of water, but also of bread...."[94] He remarks further on the sugar production during the Venetian period, and its commercial value, but that the Greeks had by the time of his travels become "entirely ignorant of the process".[95] In the 17th century, the travelling monk Basil Barsky refers to several mills and irrigation works.[96] These appear mostly to be related to the monasteries and churches he visits during his travels through the island.

Although there seems to be a general opinion that the Turkish occupation of the island had caused it to fall into economic and social ruin quite rapidly, there are intermittent reports of enterprising governors who were committed to the upkeep of public works.

[90] Cobham 1907, 193-194
[91] Cobham 1908, 193,199.
[92] Cobham 1908, 209.
[93] Cobham 1908, 241.
[94] Cobham 1908, 247.
[95] Cobham 1908.
[96] Barsky, B. (1996) *A Pilgrim's Account of Cyprus: Bars'kyj's Travels in Cyprus*. Essay, Translation and Commentaries by Alexander D. Grishin. Sources for the History of Cyprus, Vol. III. Altamont: Greece and Cyprus Research Centre, 44.

Alexander Drummond, the consul of Aleppo, visited Cyprus in 1750 AD, and noted the "public spirit" of Bekir Pasha, the then governor of Cyprus.

"....In the year 1747, he formed the noble design of bringing water from the river of Apera....to supply the people of Larnica, Salines and the shipping...accordingly, he set down sumpts, or pits, and carried drifts from one to another to lead the water through the high grounds, and conveyed it in aqueducts over the hollows: the first of which from Arpera, is an arcade, of fifty arches...and he has planted silk gardens, with a vineyard, and built a mill, in which grain is ground by the fall of water...." [97]

In addition, Drummond makes note of the people of Solia (the Solea valley in the North Troodos area) taking advantage of the spring water, which they gather in reservoirs, before they are distributed to crops in the valley below, indicating the existence of a sophisticated irrigation method.[98] Another traveller of the same time also remarked upon Bekir Pasha's "great reputation" because of his efforts to build the water supply to Larnaca.[99] In addition, that writer mentions the existence of 32 watermills in Cithrea (Kythrea) for grinding corn.[100] These same grain mills were to play an important role in the Greek and Turkish revolts against Chil Osman in 1764 AD, when water was diverted from them to stop grain milling in the capital, Nicosia.[101]

The Egyptian traveller Ali Bey, who visited Cyprus in 1806 AD, also remarked upon "the remains of aqueducts which are found everywhere, even in the driest parts..." and goes on to suggest that that is indicative of a system of irrigation existing in the past.[102] Some accounts also provide information on properties belonging to religious institutions, such as churches and monasteries. The English traveller William Turner relates the following whilst travelling through the mountains of Cyprus:

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[97] Cobham 1908, 288.
[98] Cobham 1908, 298.
[99] Cobham 1908, 369.
[100] Cobham 1908, 373.
[101] Given, M. (2000) "Agriculture, Settlement and Landscape in Ottoman Cyprus." *Levant* 32, 215-236, 227; Mariti, G. (1971) *Travels in the Island of Cyprus*, translated from the Italian of Giovanni Mariti by Claude Delaval Cobham; with contemporary accounts of the sieges of Nicosia and Famagusta. Zeno Booksellers: London, 98-99.
[102] Mariti 1971, 410.

"At half past twelve we descended into a beautiful part of the valley, through which ran a crystal stream...here we found a small farm belonging to Kikkos, inhabited by six or seven priests, provided with a good corn-mill turned by the mountain stream..."[103]

Later travellers, such as Giovanni Mariti (1760), also attest to the existence of various hydrological features on the island, which have been made reference to in earlier medieval times. On Kythrea, for example, which is mentioned in Crusader charters as far back as 1220 AD[104], Mariti states:

"Citerea (Kythrea)....is especially rich in silk and cotton, and its fields are abundantly watered by a spring in the north of the village, called Cetalofriso, or well-head, in which are three large jets, which throw out so much water that a few paces only from the source it turns a mill. There are many more mills below which grind grain for the neighbourhood, and for the city of Nicosia, eight miles away. In old times this water was carried as far as Salamis by aqueduct, of which some remains are still visible."[105]

More than forty water mills can still be seen around the village of Kythrea today[106], and as suggested previously, many of these almost certainly date back to the Crusader period, at least in their foundations.

In addition to travellers' accounts, geographical and archaeological surveys were often also undertaken in the Levant, particularly with the onset of British rule. The island of Cyprus became a Colony of the British Empire, after the Ottoman secession in 1878 AD. To establish an accurate idea of the topography of the island, the first fully triangulated survey of Cyprus was undertaken by Lieutenant Horatio Kitchener, completed in 1884.[107] During the 5-year period in which he mapped and surveyed the island, he recorded a number of water mills, particularly in the region of the Troodos mountain range, where TAESP conducted several survey seasons between 2000 and 2004. This area of Cyprus had previously not been studied to a great extent. An intensive survey conducted by the Sydney Cyprus Survey Project (SCSP) over a large area was also conducted in an area to

[103] Mariti 1971, 439.
[104] La Monte, J.L. (1932) *Feudal monarchy in the Latin Kingdom of Jerusalem 1100 to 1291.* Mediaeval Academy of America: Cambridge (Mass.), 449.
[105] Mariti 1971, 61.
[106] Zesimou pers.comm, Troodos Archaeological Survey Project, 2004.
[107] Shirley, R. (2001) *Kitchener's Survey of Cyprus, 1878-1883. The First Fully Triangulated Survey and Mapping of the Island.* Cyprus Cartography Lectures No.5. The Andreas Hadjipaschalis Memorial Lecture. The Bank of Cyprus Cultural Foundation: Nicosia.

the east of the TAESP survey area during the 1990s, where a number of watermills were discovered.[108]

Kitchener's map has provided interesting information as he made an attempt to record not just the topography of the entire island, but also to mark buildings, which he perceived as relevant to the landscape. Fortunately, these buildings included water mills and wells, some of which are still in existence today. His maps are particularly interesting as they were produced very shortly after the island's takeover by the British Government in 1878.

Both early and later travellers' accounts have revealed to varying degrees the important nature of agriculture on the island of Cyprus through the last millennium. Travellers have provided physical descriptions of the island and its dependence on agriculture for survival, which help to explain the importance it played in a predominantly rural society dependant on productive agriculture for economic stability. The impression gained from this brief survey of literature available suggests that the island was at its height in prosperity during the Venetian and early Ottoman period, but its economy suffered as a result of drought, poor crop management and civil unrest in the later years.

Conclusion

This chapter aimed to provide a portrait of the Levantine landscape as seen through the eyes of a variety of sources from the $5^{th}/11^{th}$ to the $13^{th}/19^{th}$ centuries. The information provided in the accounts of geographers and travellers, although varied, suggests that use and availability of water were always regarded with extreme importance. While individual accounts may focus more on the monumental architecture of certain places, importance is also placed on references to the availability of water and its uses, such as for irrigation and powering mills. This importance is also emphasised in relationship between Crusaders and Muslims, where the conquest and reconquest of land was not only of political importance, but also of economic and social importance.

The historical accounts summarized here suggest that watermills, water wheels and other hydrological installations were frequently encountered within the Levantine landscape.

[108] Given 2000, 225-227.

This indicates a social understanding of the value of water, both for the survival of physical life, as well as its use for power. For Jordan and Syria, it is apparent that watermills and irrigation systems were an integral part of both rural and urban societies during medieval and Ottoman times, and that particular care and consideration was taken to maintain these. In addition, the sources reveal a technological ingenuity with regards to irrigation in particular, such as the construction of aqueducts in Cyprus, or the large *nawāʿīr* of Ḥama.

The impression of Cyprus through these sources is of a similar nature; the locations of specific mills are rarely mentioned, but the numerous references throughout the medieval and Ottoman periods to the presence of water-related structures suggest that these were of primary importance within rural and urban communities. Even through the generally perceived declining Ottoman period, irrigation works and watermills were still being constructed, as attested to Drummond's account of Bekir Pasha and the construction of the aqueduct and watermill in Larnaca. There are also frequent descriptions of watermills being part of religious institutions in Cyprus, such as the corn mill near the famous Kykkos Monastery in the Troodos mountain region, or Barskiy's accounts of watermills belonging to churches and monasteries.

The production of sugar cane is also mentioned, until its apparently widespread disappearance from the Levant by the 17th century, and sugar mills and factories are frequently mentioned both in Cyprus as well as in Jordan and Syria. These are usually described as being located in the coastal plains, such as Tyre in modern-day Lebanon (as described by William of Tyre), or the mills of Kolossi and Episcopi, as described in the Crusade charters. The historical sources thus give the general impression that sugar mills were located along the coast in low-lying areas, while the grain mills appear to be located in the hillier regions, with the exception of Damascus and Ḥama, where the presence of a strong river current could provide enough power for mills in low-lying areas.

Although the Ottoman periods is generally thought of as a period of steady decline, at least since the 17th century, the fact that many watermills mentioned in the historical texts still remain today indicate that the political decline did not always induce a local economic decline.[109] This is discussed in the the following chapter, where some legal and

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[109] This will be discussed further in Chapter Eight.

administrative issues regarding water, mills and irrigation within the proposed study area are discussed, drawing on archival resources- such as treaties and charters- and historical manuals to determine the place and importance of the mill in an administrative context.

CHAPTER THREE

OFFICIAL DOCUMENTS ON WATER MILLS & IRRIGATION

Introduction

Water has been an important issue to consider within the laws of governments since the beginning of civilisation. This is certainly also the case in medieval and Ottoman times, when various administrative and legal procedures, which dealt with water, watermills and irrigation, were in existence. These underwent some changes over the years, depending on the nature of the rule in each area, before the Ottomans introduced their own legal ideas to these agricultural practices using the Islamic *sharī'a* law as a basis for these new regulations. Various documents related to law and the administration of *waqf* properties, or pious endowments, exist which shed light on the at times complicated nature of legal and administrative arrangements regarding irrigation and watermills. Included in other existing documents are also Crusade charters and treaties between Crusaders and Muslims, as well as legal texts, *waqf* documents and manuals on administration of agriculture.

For later periods, the Ottoman *Kanūn-name,* or state administrative laws, and *Mejelle,* or civil code, provide some legal information on the watermill and irrigation. The *defter-i-mufaṣṣal*, or Ottoman tax registers, also offer information on the financial issues related to watermills and irrigation in the form of fiscal surveys. The situation of watermills and irrigation in Islamic Spain will also be discussed, as there is a wealth of detailed information from this area of the Muslim world, where a greater number of surviving documents have been studied than in the Levant. Following are brief descriptions of these texts, starting with a summary of the legal aspects regarding water-related issues in Islamic law, followed by treaties and charters, manuals on agriculture and concluding with Ottoman administrative policies regarding irrigation and mills. The aim of this chapter is to give a background of the administrative issues related to watermills and irrigation practice, and in combining these texts with the information supplied by historians and travellers in Chapter Two, to provide a historical setting for the case studies which follow in Chapter Five.

The Prophet Muḥammad said "mankind are co-owners in three things: water, fire and pasture".[1] There are many aspects concerning water in Islamic law, and most fall under the category of land law in *sharī'a*. The following paragraphs will explain briefly some laws concerning land and water, followed by a summary of *ḥisba* regulations (market law) and the role of the *muḥtasib* (market inspector) with regards to watermills and water-related issues.

Sharī'a, Land and Water

Laws regulating water in Islam are almost unanimously associated with laws related to land and landownership[2]. Al-Māwardi[3], a 5th/11th century writer on the laws of government, classifies water under three headings: river water, well water, and spring water. Of these, river water is most relevant to this study, as this is where the water for irrigation is drawn from, and to where the water from the mills is returned.

River water encompasses the water that flows in large natural rivers made by God, small rivers, and artificial man-made rivers. The water from large rivers is enough to feed everyone, and no quarrels should arise as a result. As for smaller rivers, if the river is large enough to feed the people who live near it, there is no problem; if it is insufficient, then the people need to build dykes and sluices to control the flow so they can take turns in using it. As for man-made rivers, they are by law held by all those who built them, and the distribution between them is determined according to the volume of water. If the volume is large enough, then everyone in the community is entitled to some of it; if there

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[1] Wilkinson, J.C. (1977) *Water and tribal settlement in South-east Arabia : a study of the aflaj of Oman.* Clarendon Press: Oxford, 16.

[2] Legal rights to water are thus concerned mostly with *mawāt* land. *Mawāt* is literally dead land, which is not used or owned by anyone. Although there are slightly different arrangements in the different schools of Islamic Law, fundamentally it is seen as important that this dead land should be revived. The *iḥyā al-mawāt*- the revival of dead land- is therefore encouraged, and so the law says that the person who develops the *mawāt* and restores it to life becomes the legal owner of that land. In most cases, permission had to be obtained previous to claiming the *mawāt* land and developing it; this was usually granted by the *imām*, or in the case of Oman as late as 1957, by the Ṣulṭān. Wilkinson 1977, 12.

[3] Al-Māwardi, 'Ali Ibn Muḥammad. (1960) *Al-Aḥkām al-ṣulṭānyah wa-al-wilāyāt al-dīniyah.* Cairo; (d. 458/1058), a constitutional theorist of Baghdād, most famous for writing the political treatise *Al-Aḥkām al-Ṣulṭāniya* (The Laws of Islamic Governance). This deals with the laws of government, but he also described the various offices that existed within government.

is not enough water, it is owned jointly by those who dug the canals, and only they are entitled to it. The division of water rights between the owners is determined according to how much work was put in by each owner, so the one who invests most into the digging is entitled to the greatest rights.

In addition to the laws governing the use of water mentioned in the previous section, al-Māwardi also provides guidance on additional rules regarding water supply and the reclamation of land. It is particularly interesting to note that the land that has been reclaimed and revived by an individual also grants that individual the right of ownership to the utilities and buildings that are present on that land; these include, among other things, canals and drains, and although there is no mention of this, would no doubt include watermills if they were present.[4] Al-Māwardi further explains that

> "rivers dug by humans to serve the land they reclaim.....belong to those who dig it to the exclusion of all others for both irrigation and drainage. Nor may any of the users build a bridge across it, raise its water level, or turn a mill by it without consulting all the others, because they all share in that which may not be usurped for personal use..."[5]

In addition, there are regulations on who may draw water from this man-made canal, and when; this can either be done by rotation every few days in case of a small population, and every few hours in case of a larger population. If there arises any dispute regarding this, lots may be drawn to decide the order. Alternatively, a wooden panel extending across the river may divide the water according to each owner's share, taken in turn. The last method of distributing the water involves the building of separate irrigation canals, which can hold the amount of water allotted to each member, but the owners have to take care not to exceed their share.[6]

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[4] Al-Māwardi 1960, 196.
[5] Al-Māwardi 1960, 198.
[6] Al-Māwardi 1960, 198.

In addition to the laws of water, there were also regulations- although not so clearly defined- in which water played a role; these are to do with *ḥisba*, or market inspection. The *muḥtasib* was mainly responsible for overseeing the goings-on of the market day, such as making sure that vendors were not overcharging their customers, or selling where or when they were not supposed to be open. This was particularly important in terms of overseeing the activities of the grain merchants and millers, as the *muḥtasib* had to make sure they were not overcharging for their goods, as was frequently the case in Mamlūk Egypt, for example.[7] He did not assume, as far as can be interpreted from the *ḥisba* manuals, any official duties with regards to regulating the distribution of water, or maintenance of water canals and mills, as was the case in medieval Valencia, which will be discussed later.

Various works have been written on the duties of the market inspector and the role of *ḥisba* in society. In addition to al-Māwardi's *Al-Aḥkām al-Ṣulṭāniyya*, two of the most renowned handbooks were those of Ibn Taymiyya[8] and al-Sunāmi[9], both writers from the 7th/13th and 8th/14th centuries. Al-Sunāmi explores some issues regarding water and mills, such as disputes between neighbours and the building of mills on one's own property, which reflect the role of the *muḥtasib* as a kind of "supervisor of moral behaviour". For example, according to this handbook, a mill could not be installed in a residential property as it could damage the houses of the neighbours as it turned to grind the wheat.[10] This would have restricted the construction of mills in urban areas in particular to open places, away from residential areas.

[7] Lapidus, I. (1969) "The Grain Economy of Mamlūk Egypt." *JESHO* 12, 1-15.

[8] Born in Harrān in 663/1263, he flourished in Damascus and based his studies and writings on a strict adherence to the writings of the Qur'ān. He died in 728/1328.

[9] His work, *Kitāb Nisāb al-Iḥtisāb*, explores all issues related to *ḥisba*.

[10] Izzi Dien, M. (1997) *The theory and the practice of market law in medieval Islam : a study of Kitāb Niṣāb al-Iḥtisāb of 'Umar b. Muḥammad al-Sunami (fl. 7th-8th/13th-14th century)*. E. J. W. Gibb memorial Trust: Warminster, 84.

Ibn Taymiyya, on the other hand, provides slightly more specific detail regarding the role of the *muḥtasib* and the supervision of public services.[11] Here, the office of the *muḥtasib* is described as one that encompasses most public services, rather than the few mentioned by al-Sunāmi.

"Third, the muhtasib paid special heed to various municipal services, especially hygienic conditions in the town. Perhaps the muhtasib was the only municipal officer in the Muslim society. He would look into the entire municipal administration such as street lighting, removal of garbage, architectural design of buildings, water supply and antipollution sanctions."[12]

These duties provide the *muḥtasib* with a purpose other than moral supervision, and it appears indeed, as Kurshid states, that he was a municipal officer appointed to deal with the public services, in a similar manner that Glick describes the office of the *sequier* existing in medieval Valencia.[13]

There were also rules regarding the building of certain public services; it seems that the government itself was not always responsible to provide these services, and many of them indeed resulted because of *awqāf* left by individuals. Water canals and sewage drains came under particular scrutiny as they were seen as being potentially harmful if they were located in areas frequented by many people, such as roads and markets.[14]In other matters, al-Māwardi states that it was not permitted to install flourmills or tanneries in residential areas because of the pollution they caused to the environment[15], again implying that mills could only be built in certain areas of cities, perhaps not by law, but certainly by moral obligation.

The office of *muḥtasib* also existed in Cyprus, even before the arrival of the Ottomans; during the Lusignan period, the *mahtessep* was in charge of market inspection as well as

[11] Ibn Taymiyya, Aḥmad Ibn ʿAbd al-Halīm. (1982) *Al-Ḥisba fi'l Islām. Public duties in Islam: the institution of the Hisba.* Translated from the Arabic by Muhtar Holland; introduction and editorial notes by Khurshid Ahmad.

[12] Ibn Taymiyya 1982, 141.

[13] Glick, T.F. (1970) *Irrigation and Society in Medieval Valencia.* Belknap/Harvard University Press: Cambridge.

[14] Al-Māwardi 1960, 361.

[15] Al-Māwardi 1960.

providing a moral police function.[16] He was allowed to arrest offenders, but punishment was distributed by the viscount. The *mahtessep* became the *mathiesep* of the Venetian period in Cyprus, where his duties remained unchanged.[17] The equivalent of the *muḥtasib* in Latin Jerusalem was *justiciar*, and it is interesting that the arabicised version of the office was adopted in Cyprus, rather than the Latin version, but is indicative of the cross-cultural adaptation and transfer of knowledge that ocurred during the period of the Crusades. The office continued in the Ottoman period, where the *muhtesib* was in charge of regulating market prices, but in particular also of ensuring that the weights and measures of merchants were legal. Here, the *muhtesib* also acted as a kind of police man, but whether this included supervising the correct use of canals and mills is uncertain.[18]

Manuals and Technological Treatises on Agriculture

Official documents are few in number for the period preceding the Crusades, especially for the area east of the Levant. However, a document concerning irrigation in Iraq at the beginning of the 11th century, the "*Kitāb al-hawi li'l-'amāl as-ṣulṭāniya wa rusum al-ḥiṣāb ad-diwāniya*" (Book of Government works and records of the Accounts of the Treasury) kept in the Bibliothèque Nationale in Paris, is a work on the technical aspects of irrigation during Buyid Iraq and considers the economic and administrative aspects of irrigation.[19] It is divided into three sections, the first of which describes the machinery involved in irrigation. The subsequent sections discuss instruments and developments in the field, and the problems that occur during planning and execution of irrigation works. It is an interesting treatise because it describes machinery which is very similar to that described and found in the Levant, as well as in Muslim Spain and Iran. It is interesting also because it is an official "handbook" describing an important public service both for social and economic purposes; official references to the construction and maintenance of

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[16] Glick, T.F. (1971) "Muhtasib and Mustasaf: A Case Study of Institutional Diffusion." *Viator* 2, 59-81; 80.

[17] Glick 1971.

[18] Jennings, R.C. (1993) *Christians and Muslims in Ottoman Cyprus and the Mediterranean World, 1571-1640.* New York University Studies in Near Eastern Civilization XVIII. New York University Press: New York and London, 121.

[19] Cahen, C. (1951) "Service d'Irrigation dans l'Iraq." *BEO XIII 1949-1951*. Institut Français de Damas, 149-173. The Buyids (or Buwayhids) ruled parts of modern-day Iraq and Iran from 334/934 to 455/1055.

irrigation systems and water mills and wheels are relatively few, although the involvement of the government in these issues is known to have existed already from early Islamic times.[20]

Treatises and other literature pertaining to technology are comparatively few, particularly those originating from the *bilād al-shām*. Apart from al-Jazāri's work, "The Book of Ingenious Devices"[21], little has been written during the same time period regarding the subject of hydraulics or agriculture. Manuals on agriculture focussing on Egypt were also written during the Ayyūbid and Mamlūk periods; Ibn Mammāti (d. AH606/AD1209) wrote a treatise on the ordinances of government offices (*Kitāb al-Qawanīn al-Dawawīn*), in which he includes descriptions of various government offices and officials[22]. A century later, another Egyptian author, al-Nuwayrī (d.AH732/AD1335), also provides similar information, although in greater detail than Ibn Mammāti, in his work *Niḥāyat al-Arab fi Funūn al-Adab* (The Ultimate Goal in the Art of Culture).[23] In general, these treatises deal with several subjects related to agriculture, such as soil types and properties, plant types, as well as providing information on tools related to agriculture, such as means of irrigation and use of water mills for processing foods, such as wheat and sugar.

The Egyptian writer Ibn Mammāti provides information on Ayyūbid offices of government in place during that time; these include the *amīn*, among whose duties it was to assist the *nā'ib*[24] with issues such as inspecting water works. Ibn Mammāti also mentions the cleaning of canals[25], suggesting that there was an official program of maintaining water works in the Ayyūbid administration, as it existed in the *bilād al-shām* during the same period. Ayyūbid and Mamlūk administration thus does not appear to have been specific to local areas, but rather a general "imperial" policy, which may have extended beyond irrigation to the construction and use of watermills.

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[20] See p.28; also, al-Azri 1967; Lassner 1970.

[21] Jazari, Ismail b. al-Razzaz. (1974) *The book of knowledge of ingenious mechanical devices = (Kitāb fi ma'rifat al-hiyāl al-handasiyya)* translated [from the Arabic] and annotated by Donald R. Hill. Dordrecht ; Reidel: Boston.

[22] Ibn Mammāti 1943, 453.

[23] Al-Nuwayrī. (1960) *Niḥāyat al-Arab fi Funūn al-Adab* (The Ultimate Goal in the Art of Culture). 12 vols. Dār al-Kutub: Cairo.

[24] The *nā'ib* is in this case a judicial deputy, appointed to the government.

[25] Ibn Mammāti 1943, 453.

Al-Nuwayrī's *Nihāyāt al-Arab*- a handbook on the offices of the government- contains a brief section on the processing of sugar cane, as well as regulations regarding irrigation. When describing the sugar manufacturing process, he describes how the press crushes the cane using heavy millstones to squeeze out the juice, a process that is repeated several times so that the maximum amount of syrup can be extracted. Al-Nuwayrī discusses the types of irrigation for the sugar cane, and goes into detail about the process involved in pressing and clarifying the syrup, and the areas within a sugar factory, which are used in the distillation and squeezing process.

The description rendered by al-Nuwayrī regarding the sugar pressing process appears to differ from how the process occurred in Cyprus and Jordan; indeed, a section at the end of this description claims that it was done differently in *al-shām*. This is also corroborated by the contemporary writer from Palestine, al-Nābulsī.[26] Al-Nuwayrī does not mention the use of a *ṭāḥūna* (mill) which is used for squeezing the sugar, but a press (*ma'āsir*). In Egypt, this press involved the use of animals for grinding, as well as water for purification. Water is mentioned frequently, but usually concerning the purifying process, although a *qadūs* (waterwheel bucket) and a specified amount of water lifted in it, is mentioned in connection with irrigating the sugar cane. As a source of direct water power for the press there is no direct reference; as the presses were doubtless located near the banks of the Nile river to facilitate crop irrigation, one can assume that a traditional Egyptian method using a *sāqiya* (which was used, but not common anywhere else in the Levant) was employed, but water-driven sugar mills do not appear to have existed as they did in Cyprus and Jordan. Rather, they were driven by animal power.[27]

Having reviewed some of the manuals on agriculture in the eastern Islamic world, it is interesting to compare the situation as it was in the Levant and Egypt to the system of medieval Spain.[28] Medieval Spain has a wealth of documentation regarding the use and operation of water mills and irrigation works. However, it is fortunate that Arab writers from al-Andalus were providing detailed works on these subjects, and although it cannot

[26] Al-Nābulsī, 'Uthmān Ibn Ibrahīm. (1958-60) "*Kitāb luma' al-qawanīn al-mudiyya fi dawanīn al-diyār al-misriyya (Book of Egyptian Laws)*". Ed. C. Becker and C. Cahen. *BEO* XVI, 3-78 (Arabic); 119-134 (French), 53.

[27] al-Nuwayrī (VIII)1960, 268.

[28] Watermills and irrigation in medieval Spain are discussed at the end of this chapter, as a comparative study area.

be automatically assumed that the technology originated entirely from the *bilād al-shām*, climatic and geographic conditions were similar in al-Andalus to those of Jordan and Syria, and thus it can be argued that the technology also bears some similarities. There are in particular two authors from al-Andalus who provide detailed information on watermills, *nawā'ir* and agriculture in general. There is Ibn Awwām's *Treatise on Agriculture*, written in the 6th/12th century AD, and the well known work by Ibn Baṣṣāl, the *Libro de Agricultura*. Both are said to have had their main reference work based on an earlier work on Nabatean agriculture by Ibn al-Waḥshiyya, written in the early 4th/10th century.[29]

Ibn Baṣṣāl's treatise on agriculture[30] deals with the tools used in agriculture, primarily the water wheels and their uses and maintenance. Ibn Baṣṣāl suggested that an elevated place, preferably near the entrance to the field needing irrigation, was the most suitable place for a *nā'ūra*. This way the water can descend more rapidly, and turn the wheel more quickly, providing a greater rate of irrigation flow. If the land was close to a river, the *nā'ūra* should be built close to it so the water from the river could turn the wheel with the current of the river flow. The wheel would keep turning as the level of water in the river would be constant. There are various different types of water wheels, in particular in size and in distance to the water. These differences occur especially when two *nawā'ir* are close to one another and the water sources is a superficial one, which flows over the surface of the land, and is absorbed between the rocks. That is why the water channels are under the surface of the earth until they come up; this is perhaps similar to the *qanāt* system in Iran[31]. Similarly, it is necessary to find a solution to the problem of multiple *nawā'ir* at one source of water. This is the cause of much dispute, as Thomas Glick has suggested in his work on irrigation in medieval Valencia.[32] Ibn Baṣṣāl explains that "if there is one *nā'ūra*, with sufficient water to feed it, and another person opens another *nā'ūra* next to the first one, the result is that there will not be enough water to feed both

[29] Ibn al-Waḥshiyya (fl. ca. 300/900) an 'Abbāsid writer living in Baghdād, who wrote a work entitled *al-Filāḥa al-Nabātiyya* (Nabatean Agriculture). Other than his writings on agriculture, little is known of his life.
[30] Ibn Baṣṣāl, d.AH 499/1105AD. (1995) *Kitāb al-Filāḥa/ Libro de Agricultura*. ed. & transl. José María Millás Vallicrosa & Mohamed Aziman. Instituto Muley El-Hasan: Tetuán,
[31] See Chapter 7.
[32] Glick 1970.

nawā'ir. However, this can be resolved by increasing the water supply. Legally, the court has to be involved if the owner of the second *nā'ūra* uses water that was allocated for the first *nā'ūra*. This is especially important if, through a system of testing the water quality, it is found that the owner of the second mill has had the advantage of having the water filtered through the first *nā'ūra*. If the water happens to be of different quality and type, then there is no problem between the owners, as it means that the second owner has obtained his water from a different source, and has not "stolen" water from the first owner.[33]

Ibn Awwām's treatise[34] was also based on the treatise by Ibn al-Waḥshiyya. He explains how to open the irrigation wheels in the gardens and the houses and provides information regarding the building and positioning of the ***nawā'ir*** (or ***biyār*** here) for the purposes of successful irrigation. Up to four wheels can be constructed, opposite each other and connected with a communication channel through which the water can flow between them. He proceeds to describe what kind of flow of water is good for which type of irrigation, and when to deepen the trench to increase water flow to the wheel, which is best done in September or October after the rains. The *nawā'ir* appear to be mentioned merely as an irrigation device, and not as a device for processing grain, and he does not mention horizontal wheeled watermills similar to those found in the Levant, although they are known to exist in Spain even today.[35] Unfortunately, both Ibn Baṣṣal and Ibn Awwām make few references to the role of watermills, although they frequently allude to them being connected to *nawā'ir*.[36]

Treaties, Charters and other Official Documents

Official documents often provide an insight into the legal and administrative procedures and rules regarding the use of water mills in the specific areas of focus in this study . The

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[33] Ibn Baṣṣāl 1995, 228.

[34] Ibn al-Awwām. (1988) *Libro de agricultura / Kitāb al-Filāḥa*. Translated and annotated by Abu Zacaria Iahia and Josef Antonio Banqueri. Ministerio de Agricultura Pesca y Alimentation: Madrid. He was a 7th/13th century agronomist from Seville, best known for this treatise on medieval agriculture, for which he was also renowned in the western world.

[35] Ibn al-Awwām 1988; Cressier, P. (1998). *El Resbalón de Sitán: Observaciones sobre el molino hidráulico en el-Andalus y Marruecos*. Tomás Quesada Quesada: Homenaje. Granada, 152-171.

[36] Ibn Baṣṣal 1955, 228.

Mamlūks were, like the Ottomans, very eager to keep official records of any important events and agreements, although few of these- other than treaties and ***waqf*** documents- survive today, or have been accessible to the medieval scholar. There are a number of treaties drawn up between the Mamlūks and various Crusader Orders, relating to the use of agricultural land, water rights, and mill ownership. Crusader charters, or cartularies, have also given light to new evidence surrounding the importance of mills in several *casalia,* as indicated by Jonathan Riley-Smith in his work.[37] P.M Holt's work *Early Mamlūk Diplomacy* contains several treaties between the Mamlūks and their Crusader counterparts regarding disputed sugar mills, or mills present on disputed land.[38]

A treaty of 667/1267 specifically refers to a mill at Kurdāna (also mentioned by Denys Pringle in his work on secular buildings in Palestine)[39]. It was destroyed by Baybars in that year and subsequently rebuilt. The land attached to these buildings was also of some considerable importance; in clause 11 of the above-mentioned treaty, it says:

"Al-Laynufer shall be a condominium: half of it to al-Malik al-Ẓāhir and half to the Order of the Hospital. And it is confirmed that the new mill, recognised as having been set up by the Order of the Hospital, in which the fighting occurred, and the orchard there, also recognised as having been set up by the Order of the Hospital, shall be a condominium. They shall be under the jurisdiction of a representative on behalf of the Ṣulṭān's representatives, and a representative on behalf of the Order of the Hospital. They shall have jurisdiction over both, administering them and taking their revenue. And it is confirmed that whatever new mills, buildings and so forth are constructed by the Order of the Hospital on the water which turns the mill and irrigates the orchard, shall be a condominium of al-Malik al-Ẓāhir and the Order of the Hospital."[40]

This territory seems to mainly involve rich agricultural land and useful agricultural buildings with the ability to process the products of this land, particularly sugar and grain. *Condominia* [41]were a common solution, and appear to have been a kind of compromise or sign of good will between the Mamlūks and the Crusaders. This is interesting also

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[37] Riley-Smith, J. (1973) *The Feudal Nobility and the Latin Kingdom of Jerusalem, 1174-1277.* Archon Books: London. *Casalia,* (s.) *casal:* villages or estates.

[38] Holt, P.M. (1995) *Early Mamluk diplomacy, 1260-1290: treaties of Baybars and Qalāwūn with Christian rulers.* E.J. Brill: Leiden; New York.

[39] This is a restored sugar mill, located between Haifa and Acre; see Chapter Six.

[40] Holt 1995, 36.

[41] ***Condominium*** (pl. *condominia*): Joint rule or sovereignty; frequently the outcome in treaties between Muslims and Crusaders.

because the Crusaders themselves often had difficulties keeping the peace amongst themselves with regards to water rights and the use of mills, as Jonathan Riley-Smith pointed out in his work.[42] Similar differences have also occurred in Spain, where Thomas Glick has conducted studies regarding water-driven mills and the pertaining rights; struggles and between two or more parties as to ownership of the water and the buildings often resulted in bloody disputes, and even death. This was sometimes the case in Christian Valencia.[43] Treaties were as often a political formality as they were practiced in reality; this is evident in accounts of daily life, such as observed by Ibn Jubayr in the 6th/12th century.

Treaties between al-Manṣūr Qalawūn[44] and the Crusaders also existed after the death of al-Malik al-Ẓāhir. In AH 681/1282 AD a truce was established in the territories of Ḥisn al-Akrād; everything, including arable land, pastures, towers and mills were to be included in this truce, leaving them entirely in the hands of the Templars. A similar treaty was devised two years later between al-Manṣūr and the Latin Kingdom, leaving them "Acre, its orchards, lands, mills, its property of vineyards, dues belonging to it in the vicinity, and settlements as confirmed to it in the truce…".[45] The treaty also mentions specific mills at Da'ūq and Kurdāna, mentioned previously, and the provinces of al-Karak and Shawbak (Crusader Montréal) and its districts, as well as the rarely mentioned towns of al-Ṣalt and 'Ajlūn are referred to, although only in passing.[46]

A treaty of AH 684/1285 AD between al-Manṣūr and the Lady Margaret of Tyre[47] had similar stipulations to the 1282 AD treaty, where land was conceded to the Crusader lordship, in addition to the existence of a condominium between Lady Margaret and al-Manṣūr. Approximately eighty villages are listed in this treaty as being part of the truce. Revenues generated from these villages, such as ground rents, land taxes, fines, and

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[42] Riley-Smith 1973.
[43] Glick 1970.
[44] Successor of al-'Ādil (d. 678/1280). He ruled Egypt and Syria from 678/1280 to 689/1290.
[45] Holt 1995, 78.
[46] The regions of both al-Ṣalt and 'Ajlūn are still today dotted with numerous water mills, thought to date from the Mamlūk to period, but probably renovated during the Ottoman period. Rogan, E. (1995) "Reconstructing Water Mills in Late Ottoman Transjordan." *SHAJ* V: Art and Technology throughout the Ages. Department of Antiquities: 'Ammān, 753-757; Greene, J.A. (1995) "The Watermills of the 'Ajlūn-Kufranja Valley: The Relationship of Technology, Society and Settlement." *SHAJ* V. Department of Antiquities: 'Ammān, 757-767.
[47] Wife of John of Montfort, Lord of Tyre; she died in 1312 AD.

inheritances were divided equally, as were the cultivable lands, mills, rivers, orchards and their revenues.[48]

As mentioned earlier, some charters concern the planting and growing of sugar cane and the region around Tyre (in modern-day Lebanon) was especially well known for this crop. Sugar was considered not only a valuable economic commodity, but also a necessary daily food staple; sugar cane plantations and their related processing presses and mills were therefore often the subject of dispute between Crusader parties, as well as Crusaders and their Muslim counterparts. This was particularly the case when it came to the watering of the sugar cane plantations, as well as supplying water to the mills for power. The sugar mill at Kurdāna in Palestine is an excellent example of this; when it was built by the Hospitallers, it was constructed as a fortification including features such as arrow slits and buttresses, clearly for defensive purposes. [49]

William of Tyre also provides information on agreements between Venetians and the princes of the Kingdom of Jerusalem. In a treaty concerning the siege of Tyre, stipulations regarding the division of the town and the appropriation of property and rights are put forth as follows:

> "In the square at Jerusalem, however, they [the Venetians] shall have for their own only as much as the King is want to have. But if the Venetians desire to set up at Acre, in their own quarter, an oven, a mill, a bath, scales, measures and bottles for measuring wine, oil, and honey, it shall be permitted freely to each person dwelling there without contradiction to cook, mill, or bathe just as freely as it is permitted on the King's property. "[50]

Similar treaties and ordinances were in use in Cyprus. Royal charters of the Crusader period refer occasionally to the existence of water mills, particularly if there is some dispute over it, or if it is being sold. Issues concerning water distribution also appear in charters, an interesting example dating from 1413 AD involving the distribution of water to the mill of Tongoupou from the spring of Paleokythro; here the office of *neroforo* was already employed to assess the situation and solve any problems concerning water

[48] Holt 1995, 113-114.
[49] See section on fortified mills, in Chapter Five, pp.158-160.
[50] William of Tyre 1976 (I), 553-554.

distribution.[51] Kythrea was well known for its springs and abundance of water, and there are, as mentioned previously, a number of watermills in Kythrea still extant today. This is not surprising, as the area was also frequently referred to as the granary of Cyprus. The water resources there were thus highly sought after, both as a means of energy to drive the mills as well as for irrigating the cereal crops; disputes involving these were thus frequent and required the intervention of an appointed official, as it did in the case cited above.

Crusader charters are also a reliable source of information when studying social relationships of that period. Records were kept by the Crusaders, regarding everything concerned with private property, agricultural land and related buildings. Although importance was often emphasised on the product with which the mill was concerned- in these cases, almost always sugar- the need for water to supply both plantations and power to the mill was clearly undeniable, as is often reflected in the number of disputes which the treaties and charters examine. Indirectly, these documents allude to the significance of water as a means to promote agricultural growth, which yielded economically lucrative crops such as sugar and grain. The watermill thus played a part in an early developing industry, which was recognised as an asset by both sides, and this is reflected in the charters and treaties of the time. In addition to this, the mill was recognised as a necessary tool for food processing in disputed territory, and was often shared as a result by Muslims and Crusaders through the implementation of *condominia.*

The Ottoman Period

The Ottoman period was also a time of precise record keeping in the Muslim world; fortunately, more records have survived from this period than from previous periods. In their eagerness to preserve the vast bureaucratic and administrative status of the government in order to maintain control over their far-reaching empire, the Ottomans drew up various civil codes and laws related to all aspects of daily life. Following are brief summaries of these laws and regulations, mainly relating to water and watermills.

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[51] De Mas Latrie 1970, 504. *Neroforo*: official supervisor of water distribution in towns and villages.

*The **Kanūn-nāme** and the **Mejelle***

There are two official administrative documents from the Ottoman period, other than the existence of *waqf* documents. These are the *Mejelle*, or the Civil Law, and the Ottoman administrative laws, known as the *Kanūn-nāme*. The land laws (incorporated in the *Mejelle*) were reformed during the middle of the 19th century, but some documents from the late 18th century relating to the official administrative arrangements of the Ottomans still exist.[52] Not much information is provided regarding the administration of water mills, but general laws and regulations do apply as to their use and ownership. These laws are not very different from the *sharī 'a* law described earlier, although the *Kanūn-nāme* offers more detail of financial issues concerning the administration of various departments. For example, a watermill was charged a tax of 60 *aspres*[53] for running the whole year, and half that amount for running six months, while olive presses were charged a flat rate of 10 *aspres*[54]; maintenance of a watermill was probably less expensive than an animal-driven olive mill, and the tax charged may reflect this. As another comparison, windmills were charged 15 *aspres*[55], perhaps for similar reasons.

The *Mejelle,* the Ottoman land code, has more detailed regulations as to the administration of water channels, landownership, and related matters. Various articles in the *Mejelle* concern themselves with the rights to water, maintenance of water channels, the building of mills and irrigation. Among these regulations are similar codes to those stipulated in the *ḥisba* manuals discussed earlier in this chapter:

"1200. Excessive damage in whatever way it may be caused is to be removed.... For example, when a forge or mill is made touching a house, a weakness is cause to the building of the house by...the turning of the mill...they can be put a stop to in any way which is possible. Again, if someone, on a building site touching the house of another, makes a new water channel, and weakens the wall of the house by the taking of the water to his mill......the owner of the wall can cause the damage to be removed."[56]

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[52] Von Hammer, J. (1963) *Des Osmanischen Reichs Staatsverfassung und Staatsverwaltung.* Georg Olms: Hildesheim.
[53] *Aspre*: As of yet, it is uncertain what currency this was, but it seems to be interchangeable with the Ottoman *akçe*. For more information on currencies, see Pamuk, S. (2000) *A monetary history of the Ottoman Empire.* Cambridge University Press: Cambridge.
[54] Von Hammer 1963, 277.
[55] Von Hammer 1963, 408.
[56] Von Hammer 1963, 180.

The similarities to the *ḥisba* continue, with the Mejelle stipulating these conditions for the upkeep of irrigation channels:

1321. Of a river which is not owned as property, the cleansing and repair, that is to say, the up-keep is on the Beit ul-Mal. And if the Beit ul-Mal has not the ability to do it, the people are compelled to keep it up.[57]

The *Mejelle* and the *Kanūn-nāme* were both employed in daily legal issues, but while the *Kanūn-nāme* was the basis of the Ottoman legal system, the *Mejelle* was more specifically referred to for issues dealing with land and landed property. Both of these legal documents are originally based on *sharī'a*, hence the similarities between these and some of the earlier Islamic laws and regulations regarding land and water that were discussed earlier. This reflects a continuity of the Islamic legal system over a long period of time, which can also be seen in the stipulations offered in available *waqf* documents, which will be discussed in the following sections.

Waqf Documents

In addition to the information provided in the laws and statutes discussed briefly in the previous sections, a wealth of information is also provided in *waqf* documents of the Ottoman period, often in greater detail and more specific to the endowments of specific individuals. Various *waqf* documents exist with regards to irrigation and water mills during the Ottoman period for what are today Jordan, Palestine and Syria. Mantran and Sauvaget conducted a study of *waqf* documents related to the Syrian provinces of the 16th century.[58] These documents provide information on the costs and administration of various types of mills in different regions. For the *liwā'* (administrative district) of Jerusalem, for example, 2 *aspres* were levied each week on each mill "since time immemorial".[59] This is considerably more expensive than in the *liwā'* of Tripoli, where each mill was charged 60 *aspres* per year.[60] This seems to have been a standard annual

[57] Von Hammer 1963, 201.
[58] Mantran & Sauvaget 1951.
[59] Von Hammer 1963, 38.
[60] Von Hammer 1963, 76.

levy for watermills, as suggested in the *Kanūn-nāme* .[61] On the other end of the financial scale, mills in the *liwā'* of Jable were only charged 30 *aspres* per annum.[62]
The following document pertains to a pious endowment concerning, amongst other items, water mills and *nawā'ir* in the Ḥoms region. The *waqf* document, dating from the time of Selim II (AH 978/1570 AD), has provided some clues about the functions and significance of *nawā'ir* and watermills in Syria during the early years of Ottoman rule. The main cities of Syria during that time- Damascus, Aleppo, Ḥama and Ḥoms- are discussed as well as pertinent places surrounding them.

"In Ḥama, there are numerous mills, one of which is close to the Bāb an-Nahr (Gate of the River), attributed to the *qādi* Badr al-Dīn. There is a *nā'ūra* next to this mill, consisting of a wheel, the "piece triangulaire"[63] and the channel, equipped to irrigate the surrounding gardens. Near the village of Kazu, there are a total of five mills turning along the Orontes River, belonging to the *qadā* (administrative district) of Ḥama. There are also two *nawā'ir* located in the village of Gur, of the same *qadā*. Three mills are located there, and a *nā'ūra* adjoins these mills."[64]

In Ḥimriyya, a little place southwest of Damascus, a *khān* with incorporated marketplaces as well as a flourmill was supposedly built by the endower, a man named Murād Čelebi Efendi of the imperial court. A list of endowments includes numerous *nawā'ir* and water mills. Two gardens close to the Bāb an-Naḥr in Ḥama, have one mill attributed to one Badr al-Dīn. It is referred to as the mill of the *qādi,* who is assumed to be Badr al-Dīn, also mentioned in the text of Mantran & Sauvaget. Further watermills for processing grains, and *nawā'ir* to power them, are mentioned in various districts of Ḥama and Ḥoms. The text also describes how the endowment provides for the maintenance and upkeep of these *nawā'ir* and mills, and how much the keepers are paid to do this. There is also an allotment of moneys for necessities, such as oil for lamps and feed for working animals.[65]

[61] Von Hammer 1963.
[62] Mantran & Sauvaget 1951, 93.
[63] Pièce triangulaire: the triangular wooden "stand" which supports the wheel of a *na'ūra.*
[64] Sauvan, Y. (1977) "Une liste de foundations pieuses (*waqfiyya*) au temps de Selim II." *BEO* 28, 231-258; 233.
[65] Sauvan 1977.

Pascual's translation and analysis of three 16th century Ottoman *waqf* documents provides further insight into the regulations and laws regarding water mills in Damascus during this time. He draws specific attention to how the tax of the mill was determined:

> "In the Ottoman empire, the laws regarding the mills were according to "[mill]stones", meaning "turning"; in the case of the mills which did not work for six months of the year (by high tide, like for example in the Hawran) the law was not pursued for "half of a stone". [66]

Clearly, the tax was calculated according to the amount of wheat that could be ground, so the more millstones a mill had, the higher the tax would be. The tax thus appears to have no direct relationship with the amount of water that was needed to power the mill.

The 16th century *waqf* documents translated by Pascual do mention numerous water mills existing in Palestine, for various purposes; predominantly these are fulling mills and grain mills. Further mills were located near Jisr Ya'qūb, also on the River Jordan; another grain mill was located near Manwāt. The document also mentions a mill in Kardāna, comprising four millstones; Pascual believes this to be the village of Kafr Dāna in 'Akka, but it is possible that the mill in question is actually in Kurdāna, the location of the fortified sugar mill.

While earlier sources regarding agriculture and related topics in Jordan and Syria provide general descriptions as well as information through treaties and charters, information from later periods appears more frequently through *waqf* documents or government manuals, particularly with reference to taxes. The sources provided in the previous section is not exhaustive, and only a few have been selected for this study to demonstrate the importance that was placed on issues related to water, watermills and agriculture by the various political regimes through the specified time periods.

Waqf Documents in Cyprus

In addition to travellers' accounts of the Ottoman period in Cyprus, there are a few documents related to religious endowments, which concern the use of water mills. The

[66] Pascual 1983, 50 n.[3].

Kanakaria monastery, located in the Karpasian Mountains in North Cyprus, has a wealth of archival material related to the history of the early to mid-Ottoman period in Cyprus. One relevant document explains the procedures for possession of water; here, possession of water came jointly with the land it was found on. This was a typical rule which the Ottoman military classes in particular availed themselves of; and it was an example taken from the Venetians and Franks by "occupying fertile areas which had good perennial water supply". [67] Irrigation became important to the Ottomans, as proper crop maintenance and watering provided them with a rich, steady income, both for the state treasury as well as for the individual rural landowners. Legislation regarding water was therefore planned with care and method, as is reflected both in the *Mejelle* as well as the *Kanūn-nāme*.

According to this work, the laws governing water and its distribution came from Iraq where "big rivers...were and are not private property and small water courses and canals are the joint property of the owners of the adjoining land".[68] However, because of pre-existing laws and traditional legal customs, these laws were adapted; in Cyprus, ownership of water did not result from the property's proximity to water, but water distribution occurred on an hour system, as it did in most areas of the Levant and Central Asia. (Interestingly, this changed in the late 19th century, when it became legal in Cyprus to sell water separately from land.[69])

Other documents reveal that there was a system of mill-sharing, which involved having shares in a mill as well as in the water that powered the mill. In Cyprus, this was not just the case in the Karpass, but it also occurred in other areas, particularly with regards to flourmills.[70] A particular document also explains the ownership of a streamlet called ***οςαλυ*** (Ozalos) by a group of villagers who had purchased it from the Kanakaria Monastery.

"As for the mill, it was known as ***όμύλος τού οςάλου*** (*mylos tou ozalou*- the mill of ozalou), because it was depending for the moving power on the water of this rivulet....since mills were essential parts of (both

[67] Kyrres, C.P. (1987) *The Kanakaria documents, 1666-1850: sale and donation deeds*. Texts and studies of the history of Cyprus 14. Cyprus Research Centre: Nicosia.
[68] Kyrres 1987, 83.
[69] Kyrres 1987, 84.
[70] Kyrres 1987, 143.

Byzantine estates and) Ottoman *hasses*...it is possible that both the mill and the water in question were restricted within a *hass*....flour-mills, like oileries or oil-presses, formed part of closed rural economic entities in Ottoman Cyprus, which were maintained from the Latin period...."[71]

A further document makes references to mills as *mulk* and *waqf* property (taxable although it was a pious foundation), belonging to the Kanakaria Monastery. Because it was church property, the mill was the equivalent to a *waqf* property, and flourmills usually fell into the category of *waqf* property.[72] Interestingly, references to taxes for Syrian mills located in Ḥoms are made for comparison- the tax here was set at 60 *aspres* per year as an industrial tax which was decided depending on the number of months each mill was in use.[73] Again, this appears to have been the rule during the Ottoman period in all areas studied.[74]

Between East and West: Water Mills and Administration in al-Andalus

Spain is an interesting example to use for comparison with the eastern Muslim world, as it was between Christendom and Islam from the 8th to the 15th century, and provides invaluable information regarding the cultural interchange on the laws related to water, irrigation and the running of watermills. Although the following section does not include any primary historical accounts, the information has been collected by a study of historical accounts, and there is a wealth of detailed information from this area of the Muslim world, where a greater number of studied documents exist than in the Levant. One of the main contributors to research on irrigation and agriculture in medieval Spain is Thomas Glick, and in his comprehensive work *Irrigation and Society in Medieval Valencia* he provides a detailed picture of agricultural life, law and custom of this part of Spain in the late medieval period, focussing mostly on documentary evidence but also on

[71]Kyrres 1987, 154.
[72]Kyrres 1987.
[73]Kyrres 1987, 153.
[74] Von Hammer 1963; Hütteroth, W.-D. & Abdelfattah. K. (1977) *Historical geography of Palestine, Transjordan and Southern Syria in the late 16th [sixteenth] century.* Erlanger Geographische Arbeiten Sonderband 5. Fränkische Geographische Gesellschaft/Palm und Enke: Erlangen.

material remains, though there are few of those existing today.[75] Although Glick does not go into great detail on the architectural features of medieval water mills, his research into the laws concerning their use, and the regulations regarding irrigation and land partitioning prove to be very useful for comparison with the *bilād al-shām*. There is a general assumption, based on documentary evidence, that al-Andalus water and irrigation system had Islamic origins; this in itself is interesting, as there is also a general assumption that the irrigation systems throughout the Middle East had origins from Classical times, particularly Roman times. Much of the hydraulic architecture that belongs to these irrigation systems is also assumed to date back to Ancient Rome. The existence of a Tribunal of Water (*Diwān al-Mā'*) in medieval Valencia suggests a complicated administrative network involving the use, distribution and building works related to water, a system that is unfortunately not so clearly defined for the Levant.[76]

Robert Burns' work on medieval colonialism in Christian Valencia also offers information regarding the partitioning of land and administrative procedures on the use of water and canals. Watermills were a common feature in Medieval Valencia, and they ranged from simple single-wheel constructions to "multi-wheeled monsters", around which large settlements would grow.[77]Mills were not only used for processing grain, but also for producing henna dye, processing paper and materials used for cloth (presumably silk). A type of *na'ūra*, as found in Ḥama, could also be found, which was designed to lift up water for irrigation purposes, or to a higher canal to convey water elsewhere. Most mills however were used to grind wheat, or to carry water to homes and gardens.[78] The idea that mills were used to carry water to houses or gardens has not been considered as a possibility for the Levant, where they are generally thought of as solely serving the purpose of grinding either grain or sugar. However, it is probable that the extensive

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[75] For further reading on watermills and water administration in Spain, see Chabas, R. (1998) *Distribución de las aguas en 1244 y donaciones del término de Gandía por D. Jaime I.* Valencia; Palencia, A.G. (1945) "Notas sobre el régimen de agues en la región de Venuela en los siglos XII y XIII." *Al-Andalus* 10, 79-88; Bazzana, A. & Guichard, P. (1981) "Irrigation et Societe dans l'Espagne orientale au moyen age," in J. Metral and P. Sanlaville, (eds.), *L'Homme et l'eau en Mediterranee et au Proche Orient* 115-140.

[76] The administration of water may have come under the administration of a general government department, as suggested by Ibn Mammāti for the Ayyūbid period. In the Mamlūk period, this may have come under the *Diwān al-Jaysh*, for example. (van Steenbergen pers.comm., 2004)

[77] Burns, R. (1975) *Medieval colonialism : postcrusade exploitation of Islamic Valencia.* Princeton University Press: Princeton/London, 53.

[78]Burns 1975.

irrigation canals usually seen connecting mills both in Jordan and in Cyprus also served to bring water to small settlements for domestic use.

Mills bore such importance, economically and financially, that King James I[79] reserved all mills (as well as bakeries or ovens) for himself, while other industrial buildings were given to towns and cities during the *reconquista* of Spain. The king also appointed civil servants as special collectors for mills to gather taxes and revenues from the use of these mills. In addition to this, he also carefully considered the building of new mills, as was also the custom in the Crusader held kingdoms of *al-Shām*:

"he distributed them to concessionaries with frugal care, and allowed new constructions only by explicit privilege"[80]

It is further acknowledged, although King James I was a generous regent, that he kept the rights to the mills (including the charges levied upon them for using the canal water) when he donated the Moncada canal to the city of Valencia in 1268 AD.

The construction of mills was also heavily controlled; apart from the careful consideration of whether to allow any new mills, there were also rules on how many wheels a new mill was to be allowed. In 1239 AD, for example, the Dominicans were granted only one wheel for their mill on a canal, which led past a five-wheeled mill and could only "raise it so high as is required to draw one full measure of water day and night continually.[81] The *Repartimiento de Valencia* also describes Islamic mills as having from three to six water wheels, and one even possessing fourteen wheels. [82] The acknowledgement of an "Islamic" mill is interesting, particularly as no references seem to be made to Christian mills specifically. This is perhaps because there was an overwhelming presence of "Islamic" mills in Valencia, which had been taken over by the Christian conquerors and maintained as they had been in the time when the Muslims still ruled the region. There is a note in the *Libre dels Feyts*, referred to in Burns' work, where King James destroyed canals belonging to Muslims around Jativa "to cut off the water

[79] King James I of Aragon (Jaime I, the Conqueror); conquered Valencia in 1232 AD, and ruled until 1276 AD.
[80] Burns 1975, 64.
[81] Burns 1975, 55.
[82] Burns 1975.

used for irrigating and for grinding at the mills".[83] These regulations were in accordance with Islamic law, such as stated by al-Māwardi previously:

> "In Islamic law, irrigation canals are the communal property of the individuals who contributed to their establishment. The commons alone have the right to use the water of their canal for irrigation and they rule the affairs of the canal. The co-irrigators set the laws, and no one of them may erect a mill or even build a bridge over the canal without the agreement of all."[84]

This appears to be in accordance with the Code of Cuenca, where there had to be communal agreement on new constructions, and their intended use.[85]

Taxes were determined in several ways; depending on the capacity of the mill, anything from one third to two thirds of the profit were claimed as a form of rent, or a fixed sum of money, or measure of wheat, could be offered as rent as an alternative to the above, as they were in Ayyūbid and Mamlūk Egypt.[86] Mills in Valencia were, as previously mentioned, still in operation by Muslims after the *reconquista*, particularly in rural areas where the Muslim farmers were much greater in number than the recently settled Christians. All that had changed was the tax system, as the Christians were now in receipt of the revenues.[87]

Water Tax in Medieval Spain

As in *sharī'a*, Valencian laws deemed all rivers, waterways, waterfronts and water free to the public, although maintenance repairs, particularly of canals, may have fallen to the farmer whose land the damaged canal was on, depending on the circumstance.[88] This monetary charge was known as *sequiatge*, literally "canal-age", or the maintenance tax. Burns points out that Glick, in his work on irrigation in medieval Valencia, claims the *sequiatge* always to have been a maintenance charge determined for members of an

[83] Burns 1975, 55.
[84] Glick 1970, 206.
[85] Powers, J.F. (2000) *Municipal Law on the 12th Century Castilian Frontier.* Ed. And Transl. University of Pennsylvania Press: Philadelphia, 61-63.
[86] Sato 1997.
[87] Burns 1975, 57.
[88] Burns 1975, 125.

irrigation community[89] by the community itself, or by a town on individual irrigators, for upkeep and cleansing of the canals.[90]

The laws regarding the distribution and use of water for irrigation, as well as other purposes, were manifold and sometimes not very clear. Municipal officials, known as *sequier*, were in charge of maintaining an overall irrigation system, indicating the existence of a local, not imperially controlled, water economy; *sequiers* "had to repair breaks within one week or in wither two weeks, to oversee proper distribution by proportioning the available volume of water to the current extent of cultivated land."[91] In addition, regulations on how long the water was "kept" were also in existence; farmers who did not return the water after irrigating their fields within a certain time were fined by the *sequier*.[92] There were some unusual, and perhaps surprising, exceptions; mosque waters and their waterways were exempt from the water tax, adhering strangely enough to a principle which holds religious institutions to be free from such charges, which can be applied to Islam, despite the area's Christian rule. This appears to have been a common law in the Mediterranean as well as the Levant. In medieval Milan, for example, similar laws regarding irrigation and the use of mills as those of Spain were in place, but they were not always clearly defined, and depended heavily on the patronage of the wealthy.[93]

Almost identical procedures regarding irrigation and taxation were in place in the Ayyūbid and Mamlūk period Egypt, where irrigation communities were controlled by a local governor employed by the *amīr* who owned a particular feudal domain[94]. Additionally, Muslims were allowed to hold on to their own tradition with regards to the use of water:

[89] In Mamlūk administration in Egypt a similar system was in place, where a community of irrigators was collectively charged a fixed tax for the privilege of irrigation; see Sato 1997, and Chapter Eight in this work.
[90] Glick 1970, 294-295.
[91] Burns 1975, 130.
[92] Burns 1975.
[93] Boucheron, P. (2001) "Water and Power in Milan, c. 1200-1500." *Urban History 28/2, 180-193.*
[94] Sato 1997.

"we concede to all you present and future Saracens of Aldaye, a hamlet of Cuart, that you may provide a canal check in the canal that flows through Alacuas, for irrigating those four fields that you hold, according as was done of old in the time of the Saracens."[95]

Other documents reveal a similar leniency toward Muslims and their use of water; a document from 1282 AD reveals that Saracens were not expected to pay *alfarda*[96] because they were already charged a fixed sum every year per household as a charge for the water.[97]

T.F. Glick's work on these issues is equally informative. He theorises about a "*ṣāḥib al-sāqiya* " for medieval Valencia, an office similar to that of the *sequiers* mentioned above. The *sequier* was the inspector of the canals, but in addition there was a *mustasaf*, who was inspector of mills and general economic activity. Glick continues to put forth the hypothesis that although there is no documentary evidence of a specific office of the *ṣāḥib al-sāqiya*, he was probably "an urban officer in charge of water distribution, and carrying out basic Koranic precepts concerning the public nature of water and the duty to share it equally and keep it clean and pure ".[98] This appears to be a similar office as that of the *neroforo* in Cyprus, which continued from the period of the Crusades through the Ottoman period.

Another office to be held concerning water was the *amīn al-mā'*, but this was a purely administrative official who had no police power, unlike the *sequier* or *mustasaf*; the *amīn al-mā'* was more concerned with the distribution of water and the direction of turns for the water used for irrigation. This may roughly correspond to the *amīn* mentioned by Ibn Mammāti in his work[99], who is an official responsible, among other things, for inspecting irrigation works. The Arabic terminology used within the administrative organisation in medieval Spain indicate that the rules and regulations pertaining to watermills and irrigation were of Islamic origin, or at least heavily influenced by *sharī'a* law. It may well be that the Muslims took with them a highly effective tradition of irrigation and mill technology to Spain, where this replaced older, less efficient methods. This would

[95] Burns 1975, 131, from Arch. Crown, James I, Reg, Canc.15
[96] This was a maintenance tax, similar to the *sequiatge*.
[97] Burns 1975, 135.
[98] Glick 1970, 202.
[99] Ibn Mammāti 1943.

account for the similarities in laws and administration regarding mills in the Levant and Spain.

Conclusion

The relationship between the documentary evidence related to water mills and irrigation does not always directly apply to the case studies, which will be discussed in Chapter Five; however, administrative texts provide a connection between the landscape and society, if not always immediately apparent. For example, this can be seen in one of al-Māwardi's points regarding the law of water, where those who have dug a canal must ask each other for permission to build a mill on it, or a bridge across it. The Code of Cuenca stipulates similar regulations for Spain, indicating that these regulations were heavily influenced by Islamic law.[100] The regulations regarding higher and lower mills also indicate that in an area such as 'Ajlūn in Jordan- where the mills are situated consecutively at decreasing altitudes- there would have had to be a supervisor present, or an agreement between mill owners, unless the mills were owned by a single individual, or the state.[101] The Islamic legal code was clearly employed across the Muslim world from medieval to early modern times.

The overall interpretation of the material at hand suggests that the laws and administrative aspects regarding water, irrigation networks and watermills did not change a great deal over a time-period of more than 500 years, but underwent subtle transformations. In addition, there appears to have been a system of "reuse and adaption" in terms of administration and laws related to water across the Mediterranean region and the Near East. This is not only the case for Jordan and Syria from the Mamlūk to the Ottoman periods, but also for Cyprus, where the transfer of rule from Venetian to Ottoman hands signified the adaptation of older laws and customs into the laws of a new regime. Conversely, this change is also reflected in the transition from Muslim rule to

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[100] Powers, J.F. (2000) *The Code of Cuenca: Municipal Law on the 12th Century Castilian Frontier.* Ed. and Transl. University of Pennsylvania Press: Philadelphia.

[101] The question of ownership is discussed in greater detail in Chapter Eight.

Christian rule in medieval Valencia, where Muslim laws and customs regarding water, irrigation and watermills were also adopted- and adapted- by the new rulers.

The following chapter will examine the watermill in the physical landscape, and how the environment affected the construction and use of the mill over time; water harnessing techniques and hydraulic technologies will also be discussed to further provide a picture of the Levantine agricultural landscape, and the obstacles and benefits it has provided for settlements and technological advancement in this kind of environment.

CHAPTER FOUR

AGRICULTURAL INNOVATION IN THE LANDSCAPE

Introduction

The physical landscape and the ready availability of natural resources determine the nature of buildings as much as they influence the pattern of human settlements; the shape of the landscape, as well as the availability of natural resources such as water and fuel, are fundamental in shaping any society, be it rural or urban. Successful agriculture relies on water, and making use of this water to its optimum is paramount to its agricultural productivity and survival; naturally semi-arid regions, such as Jordan, can be transformed into fertile and agriculturally productive areas by properly harnessing water through the use of different technologies for water catchment, storage, distribution, and energy. Watermills- although primarily a means of processing grain and sugar products- combined with water wheels and irrigation channels can help to transform dry and agriculturally bare areas into areas that can sustain agriculture and human settlement. Thus, settlements do not need to arise in the immediate vicinity of a body of water if an efficient channelling system is implemented, such as for example the *qanawāt* system of Iran and Syria.

The following section aims to provide an insight into how the environment influenced man's movements throughout the Levant, with particular references given to water resources, how these were exploited and what effect this may have had on the medieval and early modern societies. Issues such as settlements and the presence of the watermills and irrigation systems in relation to these will be analysed.

Physical Landscapes and Human Interactions

Jordan and Syria contain a part of the desert margins of the Levant. These consist of three different zones: the *bādiya*, the *ḥamād* and the *ḥarra*. The *bādiya* is the dry steppe reaching from the bend of the Euphrates river in Syria toward the south, where the *ḥamād*- or the stony steppe and desert- is located. The *ḥarra* are a series of hills and low plateaus in southern Syria and northern Jordan, reaching down toward the 'Ajlūn area.

These different landscapes and environments have had a long history of settlement and land use which is still reflected in the environment today; the early Neolithic saw settlements cluster near plateau edges, followed by a movement down into river valleys. Bronze Age settlement saw a shift from favouring the lower valley terrains to return to higher plateau areas, and this trend appears to have lasted and then continued through the Ayyūbid and Mamlūk period, where the majority of settlements were located near the Karak plateau and Madaba Plains.[1] Nomadic pastoralism was high in many areas of Jordan, but there appears to have been fewer nomads in Palestine, where the margins of permanent settlements coincided with the 250mm isohyets, or highest line of precipitation. Thus, the levels and regions of precipitation appear to have strongly influenced the locations of permanent settlements.[2] Generally speaking, settlement here in the Ottoman period was sporadic, with main clusters present to the West of the Jordan River, and nomadic peoples roaming the area of Transjordan.[3]

Wilkinson suggests that the earlier Graeco-Roman period settlement was formed by a blend of sedentary villages, hamlets and farms with nomadic agropastoralists, indicating major cycles of landscape growth or abandonment for areas such as Ḥisbān, Karak and the southern *Ghawr* in the southern Levant.[4] As pointed out in Wilkinson's work, the "complex limes frontier system defines the outer limits of the settled zone, incorporating various local communities which were part of a long tradition of locally administered villages belonging to the Semitic East".[5] Although the start of this transition took place long before the arrival of the Muslim armies in the 1st/7th century, there is no doubt that the continuing changes of settlement growth and abandonment influenced the development of the landscape in a significant way.[6] This, in turn, affected the growth of the agricultural landscape, as well as influencing the nature of the buildings that were

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[1] Ibach, R.D. (1987) *Archaeological Survey of the Hesban Region: Catalogue of Sites and Characterization of Periods*. Institute of Archaeology, Andrews University Press: Berrien Springs; Jacobs, L.K. (1983) "A Survey of Wādi Isāl." *ADAJ* XXVII, 244-261.
[2] Hütteroth & Abdelfatteh 1977, 45-54.
[3] Ibach *et al* 1987; Jacobs 1983; Kareem, J. (2000). *The Settlement Patterns in the Jordan Valley in the Mid- to Late Islamic Period. British Archaeological Reports S0877.* Archaeopress: Oxford.
[4] Wilkinson, T.J. (2003) *Archaeological Landscapes of the Near East.* University of Arizona Press: Tucson, 141. The *Ghawr* are the Jordan Valley depressions.
[5] Ball, in Wilkinson 2003, 141.
[6] Wilkinson 2003, 141.

Figure 4. 1. Water channels surrounded by crops and terraced hills, Wādi Ḥisbān, Jordan.

necessary to process foods, such as watermills, in order for the settlements to survive. Thus, horizontally wheeled mills would gain power through the aid of water channels and mill ponds, which also served as irrigation devices, while vertical water wheels and mills were powered directly by the strength of the river. Around both these agricultural tools, settlements would grow and become abandoned with the onset of wars, the change in climate and the occurrence of natural disasters such as earthquakes. **(Fig. 4.1)**

It is not surprising, then, as suggested by Wilkinson, that irrigation networks formed ultimately transitory landscapes; although he speaks mainly of the Mesopotamian region, Wilkinson refers to the inevitable changes that factors such as irrigation overflow or marsh drainage have had on the landscape, as well as on the hydrogeology of the region:

"Although it is not possible to equate precisely the extension of settlement on both uplands and lowlands with downstream transition in hydrogeology and sedimentation, it is clear that large-scale human landscaping projects, both on the uplands and within the valley floors, must have had a significant influence on hydrogeology and sedimentary regimes."[7]

[7] Wilkinson 2003, 147.

The location of settlements being to a greater or lesser degree naturally dependent on the availability of water, the environment perhaps unquestionably influenced the people as much as the people influenced change in the landscape. Terraced fields and irrigation canals, as are frequently found in the vicinity of watermills, were- and still are- a major and highly visible factor in this change in the landscape, and in many areas ancient water management systems for agriculture continue to form the basis of later irrigation works.[8] The use of run-off agriculture, which involves taking advantage of natural or man-made slopes to harvest rainwater that can be used for crop cultivation and irrigation, was the most common means to irrigate crops from Nabatean to early Islamic times[9], and is still common in the arid and semi-arid climates of the Mediterranean and Near East today. However, due to its ephemeral nature the remains of this system have become difficult to identify in the northern Fertile Crescent. Kennedy observes that the terraced *widyān* of northern Jordan may have been used to harness water in a similar manner as they watered crops, as appears to have been the case in Ottoman Cyprus according Drummond's account of the Solea Valley.[10] This may be applied to water harnessed for watermills, as the majority of mills located in highland areas, such as 'Ajlūn and al-Ṣalt in Jordan, or the Karkotis Valley in Cyprus, were built against steep terraced hills that made use of their position to catch precipitation and run-off. Furthermore, because of the nature of the climate of the desert margins, many different ways of collecting water were brought into use during that period of time; the desert margins thus "saw increased cultivation and soil fertility depending on the success of the particular water-gathering techniques."[11]

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[8] For example the Bronze Age water and field systems in Wādi Faynān in Southern Jordan, which continued to be developed into the Byzantine and Islamic Periods, and even now form the basis for Bedouin farming activity. See for example Levy, T.E., Adams, R.B. & Shafiq, R. (1999) "The Jabal Hamrat Fidan Project: Excavations at the Wadi Fidan 40 Cemetary, Jordan (1997)." *Levant* XXXI, 293-308.
[9] Wilkinson 2003; Watson, A. (1981) "A Medieval Green Revolution", in A.L. Udovitch, ed. *The Islamic Middle East, 700-1900. Studies in Economic and Social History*. Darwin: Princeton, 29-59; Watson, A. (1983) *Agricultural Innovation in the Early Islamic World. The Diffusion of Crops and Farming Techniques, 700-1100*. Cambridge University Press: Cambridge; Beaumont, P., Blake, G.H. & Wagstaff, J.M. (1976) *The Middle East : a geographical study*. Wiley: London; Wagstaff, J.M.(1987) *The evolution of Middle Eastern landscapes : an outline to AD 1840*. Croom Helm: London.
[10] Kennedy, D. (1995) "Water supply and use in the Southern Hauran, Jordan." *JFA* 22.3, 75-90; for Drummond's account, see Chapter Two, p. 46.
[11] Wilkinson 2003, 139.

Qanawāt (Open and Covered Channels)

In Iran and Oman, for example, *qanawāt* and *fallāj* are common devices within the landscape. Both these are underground channels that tap natural reservoirs, and are known as *qanawāt* in Iran and *fallāj* in Oman.[12] The importance of these devices is reflected in the ancient tradition of maintenance of *qanawāt* along with the technology, where the *muqanni* [13] (*qanāt* supervisor) is appointed to look after the reparations and maintenance of these underground channels. These hydraulic inventions serve to provide water for a number of settlements over relatively long distances, and as Wilkinson points out, they influence these settlements in a number of significant ways:

"In a typical *qanawāt*, water is collected from an alluvial fan or from river gravels and transported via underground tunnels linked by vertical ventilation and access shafts so that the rate of descent of the main channel is less than that of the ground surface. Because these tap ground water, flow is continuous, with the result that its distribution can entail time-shares that run throughout night and day (Dutton 1989; Beaumont 1989). *Qanawāt* can determine the structure both of the neighbouring rural landscape and the villages and towns that receive its water. For example, in Iran the main street often follows the *qanāt* channel (Roaf 1989), and many social activities become focussed upon the point where the water emerges at the surface (i.e. the *mazhar*). The place of water withdrawal is frequently located in the main village square around which some of the more prominent inhabitants have their houses (Honeri 1989:65). According to Bonine, there is often a striking correspondence between the field systems and settlement form so that the shape and orientation of courtyard houses follows and develops along the pattern of field systems (Bonine 1989). This field pattern is, in turn, established by the pattern of distribution canals, which follow a roughly rectilinear grid (Bonine 1989:49)."[14]

The *qanawāt* system serves several purposes within rural communities, including supplying water for domestic use as well as for agricultural purposes, and also the supply of water for power to watermills.[15] The allotment of water through a time-share system is also common in other areas of the Levant, such as Jordan, Syria and Cyprus, and depends on the availability of water and the size of the population. In the past, when water was

[12] For further reading on these types of irrigation methods, see Beaumont *et al*; Wilkinson 2003; Beazley & Harverson 1982.
[13] Wessels, J. pers.comm.. Lecture given at the University of Damascus in 2001.
[14] Wilkinson 2003, 155.
[15] Beazley & Harverson 1982.

commonly used as a source of energy, there was an additional need, although the harvesting of precious water meant that any water needed for power also needed to be returned to the community either as irrigation water, or be conducted back to the source it came from, to maximise its use and to reduce waste of a valuable resource. This is often reflected in the relationship between mills and water channels; the water used to power mills did not usually just pour out onto the soil the mill was built on, but was either led away through channels, where it was used to irrigate crops further away, or poured directly back into the river if it was situated on the banks of a stream.

In Iran, a significant path of the *qanāt* is through the town or village, where it passes through the mosque to provide water for ritual cleansing. As Wilkinson states, "the building of a mosque is often related to the construction of a new water channel (Costa 2001), and in this way the religious landscape becomes tied in to the broader landscape....".[16] This is a pattern that can be distinguished in other Levantine landscapes such as that of Cyprus, for mosques, churches and monasteries, and although the religious landscape may take many shapes within the wider landscape, the demand for water remains equally significant for physical as well as spiritual survival, be it for drinking, washing, irrigation or for water power for food processing.

The example above from Iran is interesting, as it shows the inevitable interaction between man and nature; water is essential for the survival of any living being, and it is apparent in the structure of village and town life and the construction of homes, places of worship and the location of crops that life in an arid or semi-arid environment revolves wholly around the presence and availability of water, or the technology to make it available.

Cyprus has similar ways of harnessing water to other parts of the Near and Middle East. The Troodos mountain range in Cyprus, stretching north of Larnaca, has valleys rich in vegetation, with well-watered mountains, making valley sides ideal for terracing and cultivation, as well as for the construction of watermills that could exploit the natural water power of the rivers. Other than increased deforestation, and the "Little Ice Age" which occurred in the 17th century[17], the natural and climatic conditions of Cyprus do not appear to have changed in any drastic measure since the Middle Ages. Historical

[16] Wilkinson 2003, 156.

[17] Deckers, K. (2005) Post-Roman history of river systems in Western Cyprus: causes and archaeological implications. *Journal of Mediterranean Archaeology* 18, 155-181.

documentation has alluded to the use of an animal-powered waterwheel, similar to the *sāqiya* found in Egypt; this use of the waterwheel seems to have been the most common form of irrigation until recent times. A census taken in Cyprus in 1946 showed that 42% of the land irrigated mechanically was done so by the waterwheel; 4830 such wheels existed at that time on the island of Cyprus.[18] Today, these wheels are no longer used, and it is not known whether any of these still exist. As suggested by historical documentation dating back to the late Venetian period, this form of irrigation carried on as a tradition at least until the middle of the 20th century.

The *qanāt* form of water supply is more commonly found in Iran and Syria, but similar patterns of tradition related to settlements occur in Jordan and Cyprus. In Cyprus, for example, most villages in the mountains were –and still are- supplied by open or semi-covered channels, which tend to run along the main village road, with feeder channels into each village house. **(Fig. 4.2)** Here, also, the channels tend to follow the line of main or secondary roads, as is the case with the *qanawāt* in Iran. The main channels also fed, or helped to feed, existing watermills as well as providing the main supply for crop irrigation. In some instances, where settlements are very small and scattered, the nearest river provides the water supply for crops, where it is diverted into a number of channels that irrigate nearby fields. In Jordan, the system is similar; water is supplied via underground channels, similar to *qanawāt* in Syria and Iran, as well as open irrigation channels that used to feed water to mills and now irrigate crops, and to supply rural domestic buildings. Channels feeding mills are almost always open, and may allude to an older system of supplying water for irrigation, to power mills and to feed settlements. In addition, like the *qanawāt* around which many remote Iranian and Syrian villages centre their existence, the watermill in the Levant has an equal place in the rural countryside; it may belong to a mosque or a church, or as a part of a *waqf*, symbolising not only man's innovative capabilities in a potentially harsh climate, but also his understanding of the interaction between people, nature and religion.

[18] Christodolou, D. (1959) *The Evolution of the Rural Land Use Pattern in Cyprus*. The World Land Use Survey Regional Monograph No.2. Geographical Publications Limited: Bude, 121.

Figure 4. 2. Open water channel connected to BU0044, Katydhata, Cyprus. The millrace can be seen in the centre of the photograph.

The Nā'ūra

As mentioned previously, one of the most effective ways of harnessing water was the waterwheel, or *nā'ūra*. The most famous region for water wheels in the Levant is Ḥama, although they are also abundant along the Euphrates and its tributaries in eastern Syria.[19] Around Ḥama, numerous *nawā'ir* are scattered along the banks of the Orontes river, inside and outside the city, in various shapes and sizes. Many of these are in remarkably good condition, considering that they date back as far as the Ayyūbid period. These giant wheels are a witness to the great achievements of hydro-technology in the Levant: moved by the force of the Orontes River, they gather its waters as they turn, irrigating the land surrounding them by the use of aqueducts and irrigation channel. In the three regions

[19] Berthier, S. ed. (2001) *Peuplement rural et aménagements hydroagricoles dans la moyenne vallée de l'Euphrate, fin VIIe-XIXe siècle: region de Deir ez-Zor-Abu Kemāl (Syrie)*. Institut Français de Damas: Damas.

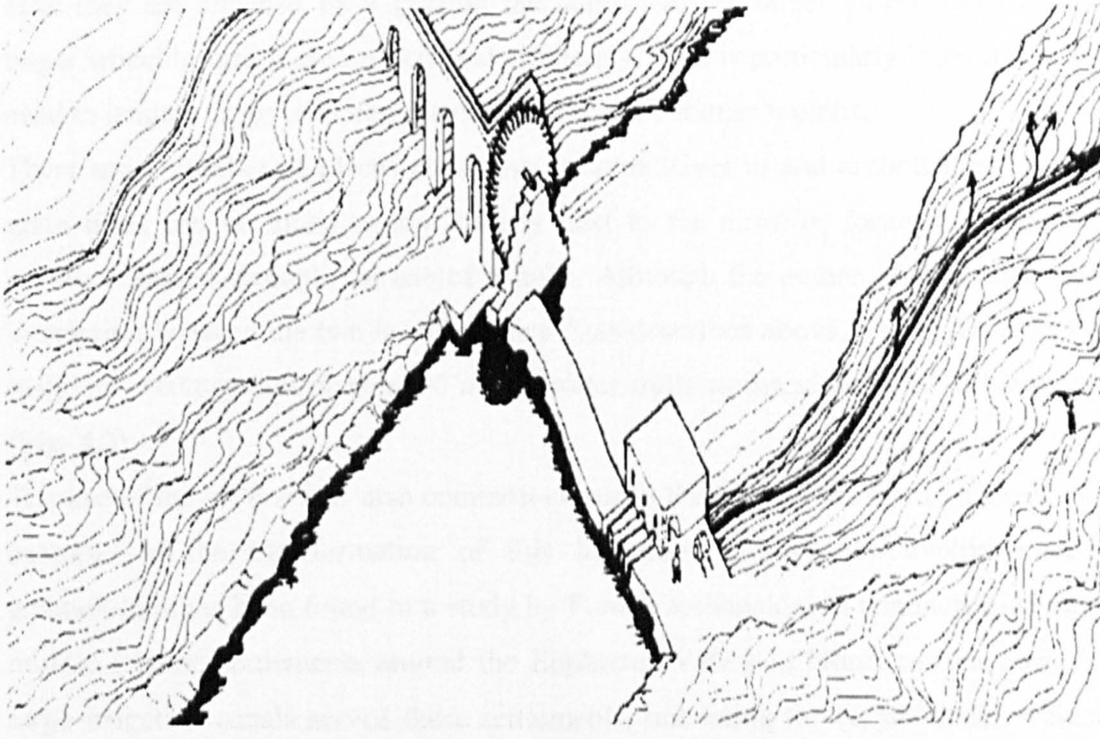

Figure 4. 3. *Nā'ūra* and mill, connected by a dyke. The dyke serves to increase the water pressure running up to the *nā'ūra*, probably increasing the rotation of the wheel and thus intensifying irrigation. The dyke may serve the same purpose for the mill, increasing the rate of rotation for the mill wheel, and grinding the grain at a faster pace. (From Delpech *et al* 1997)

being studied in this paper, Syria remains the only place where these water wheels can be found in a large number.

Nawā'ir, due to their heavy machinery, need a strong, predictable current of water for the wheels to rotate efficiently. The volume of water in the Orontes River is ideal for this purpose. The lack of comparable river-currents in both Jordan and Cyprus may be a reason for the lack of a similarly abundant existence of vertical water wheels in these areas.[20] *Nawā'ir* in this part of the Levant are not usually used to grind wheat, although smaller versions similar to the Vitruvian water wheel are used to grind grain in Iran. Although many of the larger *nawā'ir* are able to function on their own, some of the medium and smaller sized types can be found in groups of two or three. The smaller wheels serve the larger wheel by being able to turn more easily and rapidly due to their

[20] The existence of a vertical water wheel complex has been recorded by Parker in the Wādi Lejjun in Jordan. It was apparently used in WWI. See McQuitty 2004.

size; they are attached by a gearing mechanism to the larger wheel, thus helping the larger wheel to turn more quickly and efficiently. This is particularly important when the need to irrigate crops is more urgent, as it is in the summer months.

There are a number of places along the Orontes River in and around Ḥama where the grain mills can be found nearly directly next to the *nawāʿir*, forming a kind of *mill-nāʿūra* complex through the use of a dyke. Although the nature of the actual physical interaction between the two is still unclear[21], as described above, a *waqf* document of the early 16th century describes *nawāʿir* and water mills as interdependent in many cases.[22] **(Fig. 4.3)**

The use of the *nāʿūra* was also common closer to the edge of the Syrian Desert. A good example of the transformation of this landscape through the evolution of these technologies has been found in a study by French archaeologists conducted on early and middle Islamic settlements around the Euphrates Valley in North eastern Syria.[23] Two large irrigation canals served these settlements, one being the Naḥr Dawīn, which took water from the Khabūr River to the north. From the canal, water flowed into gravity-fed channels to irrigate the fields below the terraces.[24] This posed a problem, as there was no control over the flow of water. However, the invention of the *nāʿūra* solved this dilemma. The settlements within the flood plain on the west bank of the Euphrates were fed by the Naḥr Saʿīd irrigation canal through the use of a number of *nawāʿir* along the Khabūr River which provided control over the flow of water.[25] Although settlement was abandoned here by the 8th/14th century[26], the successful agricultural regime of the previous seven centuries in an environment that was both difficult to manage and impossible to control suggests that the *nāʿūra* was a prime factor in this success. It is not surprising then that in regions less difficult to manage, such as Damascus and the peripheral countryside of Transjordan, agricultural innovation played a key role in the survival of settlements during the same period. Within this, the watermill- along with its extensive channel networks- provided the tools necessary to sustain even marginal

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21 Delpech *et al* 1997.
22 Sauvan 1977.
23 Berthier *et al* 2001.
24 Berthier *et al* 2001 , 355.
25 Berthier *et al* 2001, 355.
26 Berthier et al 2001, 437.

agricultural communities, as well as ensuring continuity of settlement in arid and semi-arid climates.

Grain and Sugar: Landscapes of Food Production and Processing

It has already been noted that sugar and grain mills functioned using similar principles of water power and basic technology with slight variation in function, but their situation in the physical landscape can be rather different. In Jordan, for example, the grain mills that have been studied are located in *widyān* in the hilly parts of the country, while sugar mills tend to be located at a lower altitude, closer to- or even in- the Jordan Valley. The change in climate between these altitudes, which can range between 200m below sea level to above 1000m - is therefore profound, and vegetation and agricultural activity changes considerably. Some climate studies have suggested that there has been no dramatic climatic change in the last 1000 years in Jordan[27], although considerable deforestation of the northern Jordanian hills took place during the late Ottoman period, but these appear to have only caused slight changes in climate and precipitation. The difference in situation between the grain mills and the sugar mills is not likely to be attributed to this phenomenon and in any case, both types of mills would have functioned contemporaneously.

The use of channels and aqueducts to feed mills is a common feature in both the hilly regions and the Jordan Valley regions; sugar mills, being more like factories than mills, required a heavier flow of water to power the larger grinding stones, and hence are more frequently connected to long aqueducts. Fairly long millraces do exist for grain mills in the mountain regions, but they rarely continue for any great length –usually no more than 25-30m- and are normally connected to a water channel further along which normally follow the contours of the physical landscape. Despite the presence of natural rivers and wells, the semi-arid nature of the *Ghawr* in Jordan, particularly during summer when there is little or no rain, would not seem suitable for the production of sugarcane, which

[27] See for example Issar and N. Brown eds. (1998): *Water, Environment and Society in Times of Climatic Change*. Water, Science and Technology Library, vol 31.Kluwer Academic Publishers : Dordrecht; Brice, W., ed. (1978): *The Environmental History of the Near and Middle East Since the Last Ice Age*. Academic Press: London; D. Stamp, ed. (1961): *A History of Land Use in Arid Regions*, UNESCO: Paris.

requires constant irrigation, and it is intriguing that the Jordan Valley is relatively abundant in sugar mills, counting not only *Ṭawaḥīn al-Sukkar* and *Tell el-Ṭaḥūna*, but also the 13th century travellers accounts claiming the existence of Saracen sugar mills in the plains of Jericho.[28]

Today, the Jordan Valley grows oranges and bananas with the aid of both natural and artificial irrigation, and perhaps the climate played a part in the disappearance of the sugar cane, as it also may have done on the coasts of Cyprus as well as Lebanon. This implies that a need for proper irrigation systems throughout the year, across the Levant- particularly for sugar cane, which needs more water than grain, was not met after a certain point in time. Grain, on the other hand, is easily grown at higher altitudes, where fertile soils and irrigation through the aid of terracing contribute to this growth. The presence of the majority of grain mills in these areas is therefore not surprising, despite the seasonality of water resources here. Although there are differences in the position of the grain mills within this landscape- some being positioned against steep slopes, while others are situated in wider valleys closer to the river bed- their function, and efficiency, does not appear to have differed in any major way. For Syria, this does tend to vary, as there are several kinds of mills depending on the type of water supplied to the mills; hence, vertical mills are driven by the river in the same manner that *nawā'ir* are, while horizontal penstock mills are sited in similar landscapes as Jordan.

A similar pattern of construction, influenced by the environment as water mills are in Jordan, was detected in Cyprus. The grain mills tend to be located up in the mountains, while the sugar mills are located along the southern and western coastal plains. Crop growth has a similar pattern; wheat is grown mostly in the mountains or plains, while sugar was grown at a lower altitude along the coast. The difficulty in maintaining the sugar cane plantations were compounded by the fact that sugar cane could not be sustained in a crop rotation system, as wheat and barley can, as it required a long cultivation and harvesting process, despite the fact that it was not able to grow in the same place repeatedly. Such a high-maintenance crop therefore required not only a sophisticated system of irrigation, but also widely available land. It is not surprising,

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[28] Hoade 1952; see also Chapter Six for a list of mills in Palestine.

therefore, that in addition to the problems encountered with irrigation, sugar cane cultivation and factories were abandoned for more economically viable crops such as cotton in later times.[29]

Considering the TAESP landscape, there appeared to be no geomorphological constraint in terms of location for building mills; they could be built against bedrock high up in a valley, or resting on alluvium lower down in a valley. Studying local hydrology suggested it would seem logical that density and flow direction of streams would play a part in determining the size and location of a mill, but in reality that was not the case. In addition, the irrigation paths around the mills were not always controlled by the natural

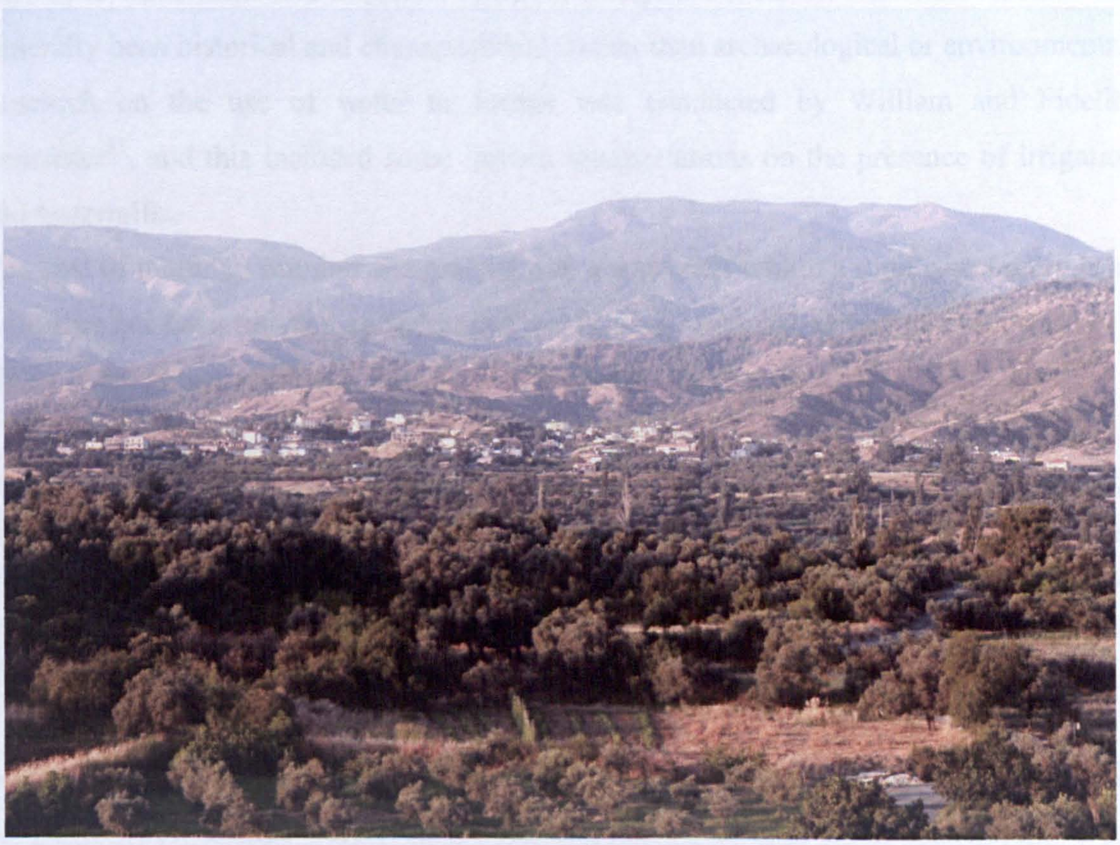

Figure 4. 4. View of part of the Karkotis Valley, Troodos area, Cyprus.

[29] Historical sources allude to a change in agricultural productivity with the arrival of the Ottoman administration, but also that it was a time of innovation with the construction of aqueducts, mills and irrigation systems; see Chapter Two. This has made it difficult to determine to what degree this decline occurred, but as suggested by Wagstaff in the previous chapter, a playing factor in this may have been widespread corruption by government officials.

hydrology and geomorphology of the area. An interesting point to note was that the outflow of water from the mill did not always lead immediately into the river; in the Linou mills, the water flowed back into channels in order to irrigate the landscape, but did not return back into the river. Modern irrigation channels were built over older channel systems, suggesting a reasonably long history of irrigation paths, and the mills were always associated with old and new irrigated terraced agriculture.[30] **(Fig. 4.4)**

Watermills, Irrigation and Agriculture

Some anthropological and ethnographic research has been undertaken in Jordan with regards to water mills and irrigation systems, though the focus on watermill research has generally been historical and ethnographical, rather than archaeological or environmental. Research on the use of water in Jordan was conducted by William and Fidelity Lancaster[31], and this included some limited interpretations on the presence of irrigation and watermills.

The cost of building, running and maintaining a watermill within a rural community is an issue that has been touched upon briefly, and it is unanimously agreed that this was not a cheap undertaking. However, Lancaster & Lancaster claim that:

> "Rogan (1995), working from Late Ottoman land registers for al-Ṣalt and legal documents, finds an increased investment in mills from the 1870s on by wealthy merchants and tribal sheikhs, and considers that, due to the expense of even restoring a mill which took three years' rent to recoup the outlay, the initial investment in mills and associated infrastructure of canals was almost certainly from the Burji Mamlūk state. This is not wholly convincing. Local people see no great costs in constructing water channels."[32]

Narrow earthen channels are often used for irrigation within crops and orchards in Jordan; several of these were seen surrounding the 'Ajlūn area or the Linou mills in the TAESP area, and these are not difficult to maintain, or expensive to create. However, it is difficult to believe, when looking at the extensive and sometimes complex water channel

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[30] Robbins pers comm., 2004.This would also appear to be the case in Jordan, although a thorough geomorphological and environmental study concerning the watermills there has yet to be conducted.
[31] Lancaster, W. & F. (1999) *People, Land and Water in the Arab Middle East. Environments and Landscapes in the Bilād al-Shām.* Studies in Environmental Anthropology. Harwood Academic Publishers: Amsterdam.
[32] Lancaster & Lancaster 1999, 277.

network around the Wādi Kufranja or the Karkotis Valley, for example, that such an infrastructure would be inexpensive both to build and to maintain; digging long stretches of trenches alone is both time consuming and laborious. On top of that comes the plastering of the earthen channels, some of which may first have been lined with stone. Sluices and dams are also a part of this infrastructure, and neither of these inexpensive to build or maintain. Stone lined channels, rather than the earthen kind, are necessary to supply water to watermills, as the momentum of the water needs to be retained; in addition, using earthen channels would mean losing water through seepage back into the ground. A similar idea could be applied to the expense in the construction and maintenance of watermills, which as suggested by Rogan was by no means negligible. This also appears to be the case in Cyprus, where the sometimes maze-like organisation of channels feeding village houses was supervised by the *neroforo*, who was employed by the government, indicating that it was a relatively costly endeavour.

Considering the expense of creating and maintaining water channels and mills, it is not surprising, therefore, that medieval regulations regarding the maintenance of water channels stipulated that the Treasury would pay for these if it had sufficient funds, and failing that, the richer families of the town or village would be called upon to contribute financially. In addition, canals were frequently dug by several individuals who shared the expense and ownership, suggesting that the construction of irrigation channels was time- and labour intensive, as well as an expensive undertaking.[33] Hence, it seems unlikely that the expense of creating and maintaining irrigation channels was as negligible as Lancaster & Lancaster have suggested, and may suggest that the channels were constructed by state-supervised offices such as they often were in Ayyūbid and Mamlūk Egypt and Syria.[34] Again, a similar idea could be applied to watermills for this period, in particular considering the organisation of feudal domains and the system of collecting revenues from the peasants, in Cyprus as well as the *bilād al-shām* throughout the medieval and Ottoman periods.[35]

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[33] Al-Māwardi 1960.
[34] Ibn Mammāti 1943.
[35] Sato 1997; the possibility of a state initiative is also furthered in some of the available *waqf* documents discussed in Chapter Three, as well as Walker's recent study on Ḥisbān (Walker 2003). See also Chapter Eight.

Irrigation of crops is, as it always has been, of the utmost importance, and Lancaster & Lancaster provide the following account of the irrigation channel system employed in the Wādi Ibn Ḥammād, as well as other areas around Karak:

"Water is taken out of a *sayl* (flood water), or from a spring, by a channel constructed along the contour line; from this main feeder channel, subsidiary channels are taken off at an angle to lead water to parcels of land; here smaller channels carry water to each garden, which are sometimes levelled. The water cannot be sold away from the land; the garden, its channels and its rights to water are inseparable. The amount of water each parcel of land receives is determined by the group of people, the *jama'a*, using the land off the main channel; over time, these amounts become more or less fixed, so that each parcel gets so many hours of water a day, and the amount of water a parcel gets determines what crops can be grown....Disputes over water allocation are sorted out with the *jama'a*, who collectively own the water rights because they own and work the land."[36]

As the rights to the water tended to become complicated once someone wanted to use water coming from someone else's land the owners of water channels were often the owners of mills which were fed by the channels, and a similar system was probably in place in the Karak region; this was sometimes also a collective or consortium of owners which could share costs, as indicated by Rogan on his study of watermills in al-Ṣalt. Despite increased agricultural modernisation in Jordan and Cyprus, the legal status of water and its related infrastructures appear to remain close to ancient custom governed by Islamic law.

Conclusion

Despite the varying landscapes of Cyprus, Jordan and Syria- both regional and local- as well as the degrees of availability of the most precious natural resource, water, there was a unanimous recognition of water as a source not just for power, but also for survival in a dry and sometimes harsh climate. Thus, how it was harnessed was of the utmost importance in agricultural societies of the time. This is clearly recognized in the medieval and early modern works of geographers, chroniclers and travelers, where emphasis is often placed on the importance of water, mills and irrigation methods through the frequent- if somewhat general- references to water and related technology in the

[36] Lancaster & Lancaster 1999, 149.

historical sources. The changing nature of the physical environment also reflects this, and has revealed that there was a continuous pattern of agricultural activity, the importance of which is apparent in both cities and villages; the role of the grain and sugar mills in that landscape shows that industry, agricultural and rural enterprise went hand in hand with each other, and relied upon man's innovative ideas to function efficiently and cost-effectively.

The next chapter consists of a catalogue of watermills studied for this work. The aim of the catalogue is mainly to maintain a record of extant watermills, as these are disappearing rapidly across the Levant due to urban infringement on the countryside and their perceived lack of value as historical monuments. A general classification, as set out in Chapter One, will be used, and the location, architectural features, and relevant references, as well as other necessary information, will be applied to each building. Where ever available, a photograph will also be provided.[37]

[37] A CD with further photographs for the case studies is provided in the Appendix; for Cyprus, these are mostly located in the TAESP archive in Glasgow University.

PART TWO

Catalogue

CHAPTER FIVE
CATALOGUE OF WATERMILLS

JORDAN

Grain Mills

'Ajlūn

The landscape surrounding 'Ajlūn, and the Kufranja basin, is agriculturally very rich as well as diverse. Verdant hills surround the castle and the town almost year-round; crops of various types are grown throughout the year. 'Ajlūn, or *Qal'at al-Rabaḍ*, is flanked by three major *widyān*; these are Wādi al-Yābis (Wādi Rayyān) to the north of the town, and Wādi Kufranja and Wādi Rājib to the south, in that order.
The Wādi Kufranja, running parallel to the Wādi al-Rayyān, is the main water source which feeds this valley, with the Wādi 'Ajlūn to the northeast and the Wādi Ḥijla to the southwest as main affluents. This mountainous landscape varies in altitude from 1100 m above sea level, at the *wādi* head on the western side of Jabal 'Ajlūn, to 100 m below sea level at the *wādi* outlet in the eastern *Ghawr* (the depression that is the Jordan Valley) along the Dead Sea. This region is an ideal setting for watermills, as the natural vegetation and soils are conducive to agricultural activity and crop cultivation, and the presence of natural water sources is abundant. In a survey conducted in this region in an area to the southwest of 'Ajlūn in 1986 more than 20 watermills were recorded.[1] Their state of repair ranged from ruined to reasonably intact during the time of the survey, but modern development in this area has caused the disappearance of many of these mills in the last few years.

Wādi Kufranja

Altogether, 18 watermills have been studied so far in all three areas, although Greene states in his report of 1995 that there were 21 watermills in the Kufranja area alone.

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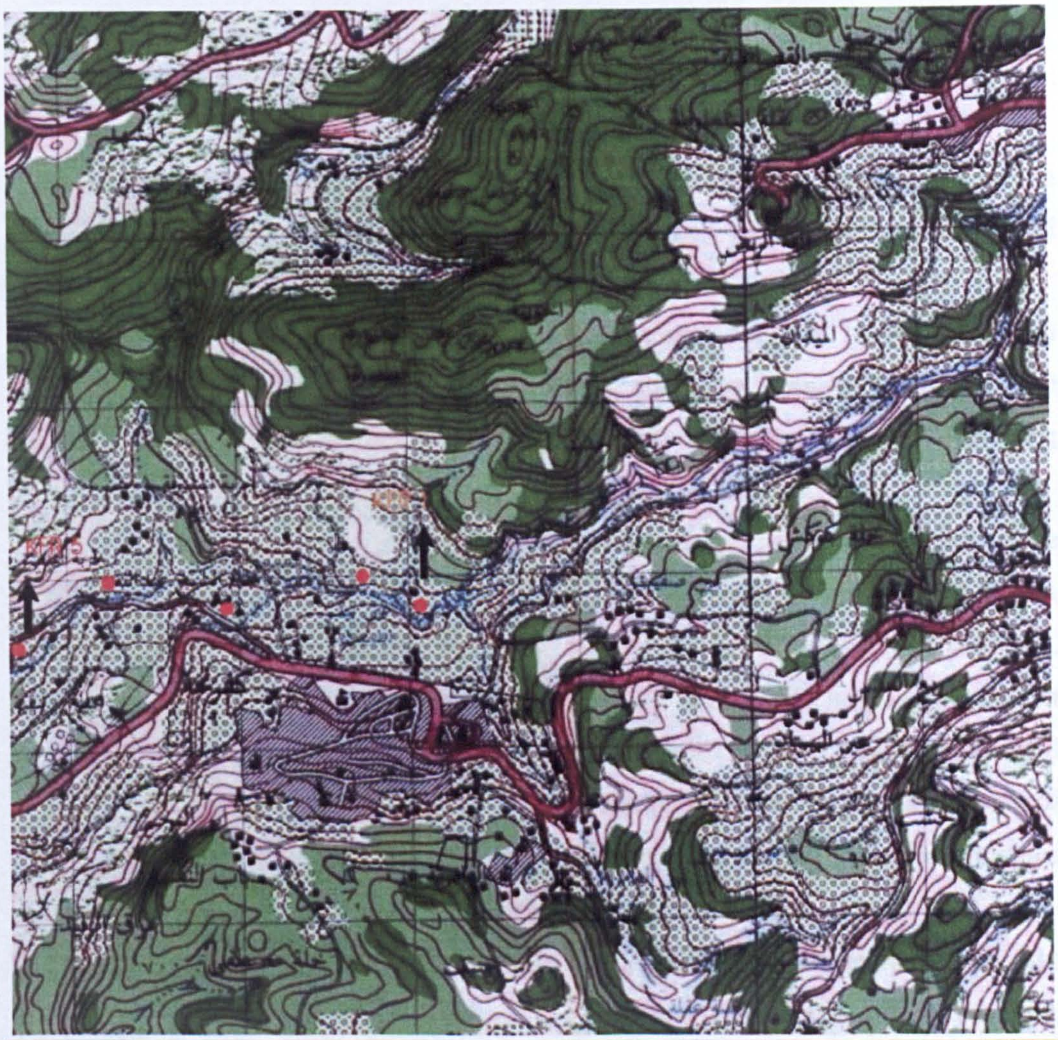
[1] Greene 1995.



N ↑ **Scale 1:50 000 Jordan Topographic Map Series (Arabic)**

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Figure 5. 1. Map of Wādi Kufranja with approximate location of watermills **marked in red.**

Modern road expansions have no doubt destroyed many of the watermills that he recorded, as has crop expansion and general decay over time. Brief, sporadic surveys of the mills and their irrigation networks in the 'Ajlūn area, including the Wādi al-Rayyān and the Wādi al-Rājib were conducted between 2001 and 2004, during both summer and winter months, in order to assess the mills and irrigation channels within the landscapes of both seasons. Following are brief descriptions of the mills that were surveyed and photographed, highlighting particular features of interest.

Building No.: KFR 1 ***Type:***KFR1a/LMS III

GPS Coordinates: E 36S 0758133, N 3579323 ***Elevation:*** 697m a.s.l.

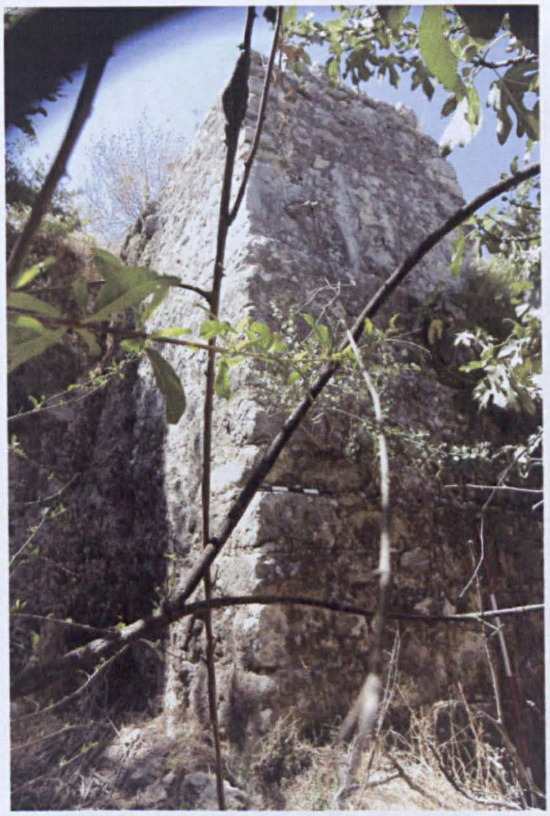

Figure 5. 2. KFR1, penstock. (Photo: Denis Genequand)

Location: This mill was located on the main road between 'Anjāra and Kufranja.

Landscape: Situated low in the *wādi* bed, about 5m from the location of the present stream, and terracing surrounded all sites.

Architecture: An arch springer once supporting a vaulted ceiling was clearly visible on the corner of the penstock. The SW facing mill house wall- ca. 6m in length showed some masoned stonework covered with the remains of plaster. There were no visible remains of a wheel chamber.

The north face of the penstock also showed severe signs of weathering, probably suggesting either heavy use over a shorter period of time, or degradation by environmental factors over a longer period of time. The penstock was built against a sheer ridge slightly higher than the penstock itself, and as it was impossible to climb this face, it was not possible to see the penstock chute or millrace, or exactly where the water that fed the mill was brought from. **(Fig. 5.2)**

Associated Structures: Possibly KFR2 and KFR3.

References: 16th c. tax registers include the towns of 'Ajlūn, Kufranja, 'Anjāra and 'Ayn Jenna. Merrill also mentions that "at least a dozen flour-mills" in 'Ajlūn were working during his visit between 1875 and 1877.[2]

[2] Hütteroth & Abdelfatteh 1977; Hütteroth, W.D. (1978) *Palästina und Transjordanien im 16. Jahrhundert : Wirtschaftsstruktur ländl. Siedlungen nach osmanischen Steuerregistern. Reichert: Wiesbaden* ; Merrill, S. (1986) *East of the Jordan : a record of travel and observation in the countries of Moab, Gilead and Bashan.* Darf: London, 374.

Building No.: KFR 2 ***Type:*** KFR1a/LMS, RM III

GPS Coordinates: E 36S 0758002 N 3578999 ***Elevation:*** 670m a.s.l.

Location: Located about 500m southwest along the *wādi* from KFR1.

Figure 5. 3. Penstock and collapsed mill house, KFR2. (Photo: Denis Genequand)

Landscape: it was situated higher up on the *wādi* bank among a variety of crops and orchards. Remains of terracing were seen in the hills across the road, but none were visible near this part of the *wādi* anymore.

Architecture: The architectural remains consisted of a millrace and penstock with a partially intact mill house; the mill house had clearly been rebuilt very roughly, using loose masonry blocks piled upon each other. The three-tiered penstock stood at a height of approximately 5.5m, and the millrace was between 12 and 15m long. An arch supported the millrace wall, which was ca. 3m wide by 1.5m high, and 1.2 m deep. The circular opening of the chute was approximately 60cm in diameter.

Associated Structures: This mill most likely received its water supply from the same source as KFR1; unfortunately, it was unclear where this source was located. However, it may have been that the run off from KFR1 fed this mill, which is located about 30m lower than the first mill, and therefore able to receive any water from higher above. The presence of the channel running perpendicular to this mill may also be a factor in feeding the next mill further down the *wādi*. A bridge of similar construction was located below the mill, and may be an indication of a communication network around the mills existing before the construction of the recent modern road. **(Fig. 5.3)**

References: As previous entry.

Building No.: KFR 3 ***Type:*** KFR1a/LMS, RM III

GPS Coordinates: E 36S 0757507, N 3578760 ***Elevation:*** 652m a.s.l.

Location: Located about 200m downstream from KFR2; across the stream about 5m above the water on a gentle incline leading to a steep ridge.

Landscape: Set against a steep slope, and terracing was scattered along this same slope, on both sides of the mill.

Architecture: The penstock was well preserved, and approximately 6m high, with four tiers; its width was approximately 4m. Below the penstock, ca. 5m above the river bed, was the intact wheelhouse, with about 1m of the mill house walls still extant at the foot of the penstock. The masonry blocks of the mill house remains were smaller and coarser, perhaps an indication that the mill house was destroyed and rebuilt in later times. The wheel chamber also seemed to be architecturally different from the penstock; it is ca. 3-3.5 m deep, and has a roughly masoned, uneven arched opening ca 1.2m wide and 80cm high. The view from the top of the penstock revealed the irregular shape of the mill house and thus the wheel chamber. **(Fig. 5.4)**

Figure 5. 4. View of penstock and remains of wheel chamber, KFR.

Associated Structures: Probably KFR1 and KFR2. About 6m of the millrace were extant, but again it was difficult to determine where the water was coming from to feed the mill.

Reference: As previous entry.

Building No.: KFR 4 ***Type:***KFR1a/LMS, BAS II

GPS Coordinates: E 36S 0757399, N 3578621 ***Elevation:*** 642m a.s.l.

Location: Approximately 100m downstream from KFR3.

Landscape: Low by *wādi* bank, surrounded by woodland, against steep incline.

Architecture: The penstock was in good condition, at a height of about 4.5m, but the masonry on the upper layers appeared to have fallen off, as there was a substantial amount of building debris near the mill. Some blocks were of basalt masonry.

Associated Structures: The construction of the concrete and stone water channel running past the mill would have destroyed any structure, such as a wheel chamber or mill house. A stone slab jutting out at the bend may be a sluice to regulate water flow, or it may be a channel divider, which would indicate that the mill received water as well as playing a part in conducting it to the next mill, as perhaps did KFR2. The

Figure 5. 5. Penstock and remains of millrace, KFR4. (Photo: Denis Genequand)

channel winds its way around from KFR3 and past KFR4 further down into the *wādi*. It is possible that it is connected with the channel running perpendicular to KFR2, suggesting a channel network. It would seem appropriate that this mill gained its water supply from the same source as the previous mill; they stand only at 10m difference in altitude. **(Fig. 5.5)**

References: As previous entry.

Building No.: KFR 5 ***Type:*** KFR1a/LMS, RM III

GPS Coordinates: E 36S 0757239, N 3578529 ***Elevations:*** 647m

Location: About 100m down the *wādi* from KFR4.

Landscape: Nestled in the hills among grapevines and orchards; heavily overgrown with grapevines.

Architecture: Blocks of limestone ashlar masonry and rubble and mortar, approximately 50cm wide by 35cm. The chute in the penstock was stone lined, and the penstock itself was of a rather unusual design. It was rounded at the edges, rather than being rectangular, as in the previous mills; it had multiple tiers, which narrowed at the top where it formed a shallow parapet around the chute.

The room adjacent to the penstock base was approximately 4m wide and 2m high, at an angle to the penstock. The masonry of this room was also unusual- the arch was much wider than expected, there was a floor made of limestone blocks, and the ceiling showed small river boulder-type stones rather than masoned or cut blocks of stone. There were various openings in the floor of this room suggesting there was another room below, indicating this was the mill room. **(Fig. 5.6)**

Figure 5. 6. View of penstock, KFR5. (Photo: Denis Genequand)

Associated Structures: The millrace channel width is approximately 50cm, and man-made earthen channels existed where the leat had collapsed. A recently built bridge now connects the road with the mill.

References: As previous entry.

Building No.: KFR 6 ***Type:*** KFR1/LMS IV

GPS Coordinates: 36S 0755936, N 3578088 ***Elevation:*** 576m a.s.l.

Location: About 250m down the *wādi* from KFR5.

Landscape: Located on the other side of a full stream. It was situated on a steep ridge on one side, and across from heavily cultivated land on the other side, and was thus inaccessible.

Architecture: Architecturally, it had all the characteristics of KFR 1-4; the limestone masonry was cut in similar dimensions, its height was approximately 6m, and it was built against a steep ridge. There was an extant mill house and wheel chamber, which appeared very similar in construction to KFR3. **(Fig. 5.7)**

Associated Structures: Possibly KFR1-4.

References: As previous entries.

Figure 5. 7. Penstock and mill house, KFR6.; the opening to the wheel chamber can be seen directly below the arched window of the mill house.

Building No.: KFR7 ***Type:*** KFR1a/LMS II

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: KFR7 could only be seen from the road although it was quite a distance away.

Landscape: It was located almost right on the river, with its millrace running along, rather than upward, parallel to the surrounding terracing.

Architecture: Similar to KFR1-4 (photo not available).

Channels: The millrace extended about 20m south.

Associated Structures: It was located near a bridge that did not appear to be contemporary.

References: As previous entry.

Building No.: KFR8 ***Type:*** KFR1/LMS, BAS III

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: In a valley off main road to Kufranja, between village and KFR7.

Landscape: A similar predicament was encountered with the KFR8; no immediately accessible road was found that led to it, but it appeared to fit the similar characteristics of the majority of the Kufranja mills surveyed in this survey.

Architecture: It had similar architectural features to the other mills, although it appeared to be larger in size; its position in relation to the other mills, as well as its size, may suggest a later date of construction for this particular mill. A mill house was partially extant.

Associated Structures: Its millrace ran along the gentle incline of the terracing, as in the previous mill. Orchards and cultivated fields, rather than rough terrain, surrounded this last mill. Various hamlets were scattered around it, and the village of Kufranja lay on the other side of the stream from it.

References: As previous entry.

Wādi al-Rayyān

Wādi al-Rayyān is located north of the Wādi Kufranja, and is a part of the 'Ajlūn-Kufranja drainage basin. The mills studied in the Wādi al-Rayyān are still in relatively good repair with intact penstock towers of the *arūbah* type, although no wheels or grinding stones remain. All of these mills are located in close proximity to the river bank, ca. 500 m apart, near the village of 'Irjān just north of Ba'ūn, with one mill located further along a smaller road continuing to the east of the main road. **(Fig. 5.8)**

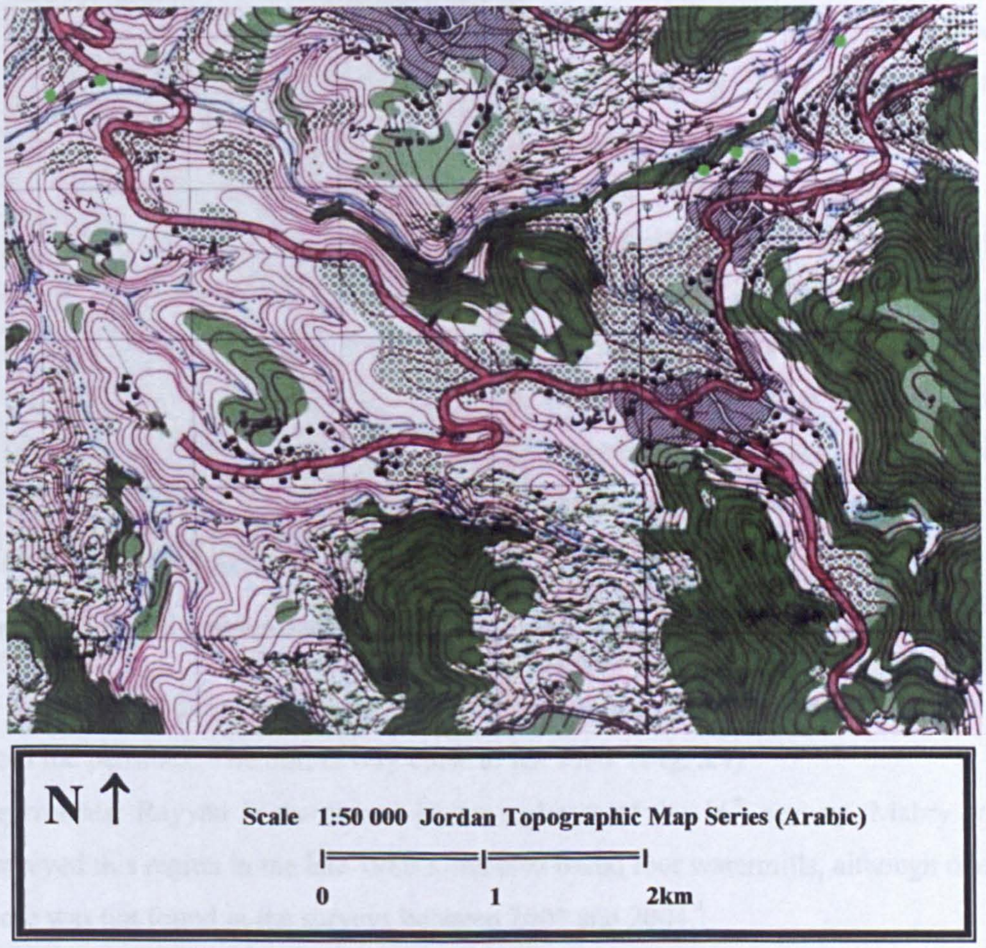

Figure 5. 8. Map of Wādi Rayyān, with approximate locations of mills marked in green.

***Building No.*:** RAY 1 ***Type*:** RAY1/LMS, RM III

GPS Coordinates: E 36S 0757772, N 3588740 ***Elevation:*** 608m a.s.l.

Location: Off main 'Ajlūn road toward Irjān.

***Landscape*:** A dried out river bed was located about 15 meters to the east of the mill house.

Figure 5. 9. RAY1, penstock and remains of mill house.

Architecture: Its construction was of ashlar masonry with rubble and mortar, apparently from locally quarried stone. The penstock was well built, although the construction itself lacked the neatness of the other mills in this area; the tower was approximately 3.5m in height; the remains of buttresses protruded at regular intervals along the leat[3]. A modern steel frame was located in the collapsed mill house, which may have been used for holding the millstones in place as well as supporting the hopper during the mill's life, indicating that this mill was in use in recent years.

Associated Structures: Well preserved leat, 20m long and parallel to a small road going back toward 'Ajlūn, after making a sharp left turn about 15m from the penstock. The mill is very close to RAY2-4. **(Fig. 5.9)**

References: Rayyān is mentioned in tax registers of the 16th century. Mabry *et al* surveyed this region in the late 1980's and also found four watermills, although one of these was not found in the surveys between 2001 and 2004.[4]

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[3] Buttressed walls are also uncommon in Jordanian mills; the only other clear example- where the buttresses are clearly added as separate structures- is Sayl al-Karak. See pp. 144-147.

[4] Hütteroth 1978, 23; Mabry, J., Palumbo, G. & Kuijt, I. (1988) "The 1987 Wādi el-Yābis Survey." *ADAJ* 32, *275-305.* The mills in the Wādi al-Yābis survey were labeled as "Ottoman" by Mabry *et al.*

Building No.: RAY 2 ***Type:*** RAY1a/ LMS II

GPS Coordinates: E 36S 757457, N 3588436 ***Elevation:*** 586m a.s.l.

Location: Approximately 150m from RAY1, at the road junction.

Landscape: It was situated immediately adjoining the road, and thus any water channel had been destroyed, and all that remained was the penstock.

Architecture: The penstock was different to any so far found in Northern Jordan; rather than being built with a sheer face, it was of a stepped design; and rather than being constructed at right angles, it twisted almost like a winding staircase. The stepped layers were also rounded at the edges. Although the penstock itself had been blocked with rubbish and dirt, it was of a circular nature, approximately 1m in diameter, so slightly larger than the average 75cm chute openings found in the Kufranja mills. The masonry was of finely cut limestone blocks, approximately 20x30cm on average in dimension, and lacked the visible rubble and mortar fill of RAY1. **(Fig. 5.10)**

Figure 5. 10. Stepped and twisting penstock, RAY2.

Associated Structures: Possibly RAY2 and 3.

References: As previous entry.

Building No.: RAY 3 ***Type:*** RAY1/LMS, RM II

GPS Coordinates: E 36S 757322, N 3588329 ***Elevation:*** 576m a.s.l.

Location: About 200 meters further downstream from RAY2.

Landscape: Abuts steep hill, with dense forest below around the river bed.

Architecture: The penstock remained intact, at a height of approximately 4m; the nature of the environment proved it difficult to reach the bottom of the penstock tower, due to a steep decline toward the stream. The mill house appeared to be completely destroyed, but shrubbery and trees at the bottom of the escarpment may be hiding any building remains. Masonry in the leat had been replaced with coarse masonry and plaster on the upper layers, giving it a rather sloppy appearance. The chute was round, approximately 60 cm in diameter. The masonry blocks were of cut limestone with approximately the same dimensions as RAY2, and a noticeable feature that linked them to other mills in this region was that the penstock tower widened at the end of the leat, giving almost the appearance of being buttressed.

Associated Structures: The water channel was probably destroyed when the road was built. A modern concrete water channel ran perpendicular to the mill leat. An inaccessible mill is located cross the river to the east of RAY3. **(Fig. 5.11)**

References: As previous entry.

Figure 5. 11. RAY3, view of penstock from above; the modern concrete channel runs perpendicular to it.

***Building No.*: RAY 4** ***Type*: RAY1/LMS, RM III**

GPS Coordinates: E 36S 757213, N 3588247 ***Elevation:*** 559m a.s.l.

Location: A further 150m downstream from RAY3.

Landscape: Situated low in *wādi* bed, abutting the road, and surrounded by dense shrubbery.

Architecture: The mill house was almost completely destroyed and appeared to be used as a sheep or goat pen. Remains of the outer walls of the mill house were still present which helped to give an idea of the plan of the building. The masonry blocks were finely cut and neatly assembled, showing no rubble or mortar fill, and the penstock, also standing at a height of approximately 4m, widened at the end of the leat running to the chute in a similar manner as the previous mill. The penstock was approximately 15 meters from the stream. **(Fig. 5.12)**

Associated Structures: Probably RAY2. Other than partial millrace, no other channels visible.

References: As previously.

Figure 5. 12. Penstock, RAY4.

Building No.: RAY 5 ***Type:*** RAY1/LMS, RM II

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: Adjoins the main road from Dayr Abu Saʿīd to ʿAjlūn and Jarash.

Landscape: Set near olive orchards and fig plantations.

Architecture: It is well preserved, with an intact leat and penstock tower, but the mill house has been nearly totally destroyed. The masonry was of cut limestone blocks neatly assembled. The penstock tower was approximately 4m in height, with ruins of the mill house covering about 3m x 6m at its foot. On the front face of the east side of the mill house ruins an arch could be identified, indicating that this was perhaps an entrance into the milling room of the water mill. **(Fig. 5.13)**

Associated Structures: RAY6 and irrigation channels. The leat continued about 15m from the penstock tower before it was cut off by the main road; a modern concrete channel was built on top of the old masonry blocks, which lead all the way to the penstock tower and the chute, where it had been lined with plaster.

Figure 5. 13. View of RAY5, with RAY6 in the background.

References: The town of Judayta is mentioned in 16th century tax registers. Banning's surveys of the region around Dayr Abu Saʿīd have also discovered some watermills, mainly in the Wādi Ziqlāb.[5]

[5] Hütteroth 1978, 23; Carla Parslow, pers. comm., ʿAmmān, 2001.

Building No.: RAY6 Type: RAY1/LMS, RM III

GPS Coordinates: Not available *Elevation:* Not available

Location: About 20m from RAY5.

Architecture: was not as well preserved as the first, but a substantial part of the penstock still remained. It stood at approximately the same height as RAY5, with similar masonry, although the limestone blocks appeared more weathered. The masonry blocks at the top of the penstock tower, around the chute, had fallen away to reveal a circular penstock with a view into the finely masoned chute. It had not been lined with plaster, and the polished limestone blocks were still in good condition. The leat edges had also mostly crumbled away, as had the blocks supporting the water channel, but the length of the leat was estimated at approximately the same as the first

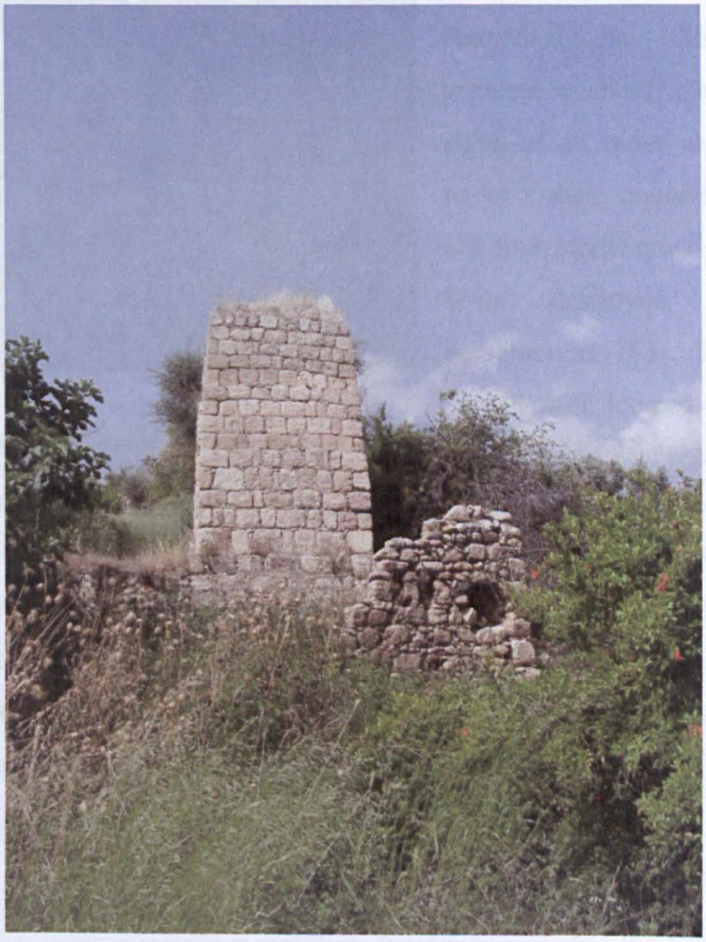


Figure 5. 14. Penstock and remains of mill house, RAY6.

mill. The mill house was in roughly the same condition as that of RAY5, although there was no archway to indicate an entrance to the mill house. Rubble masonry had

Figure 5. 15. Restored penstock and remains of mill house, Wādi Rayyān. Courtesy of Dr. Rami Daher, Jordan University of Science and Technology.

been piled up in awkward heaps in an apparent attempt to reconstruct a building, making it more difficult to see the precise layout of the mill house.

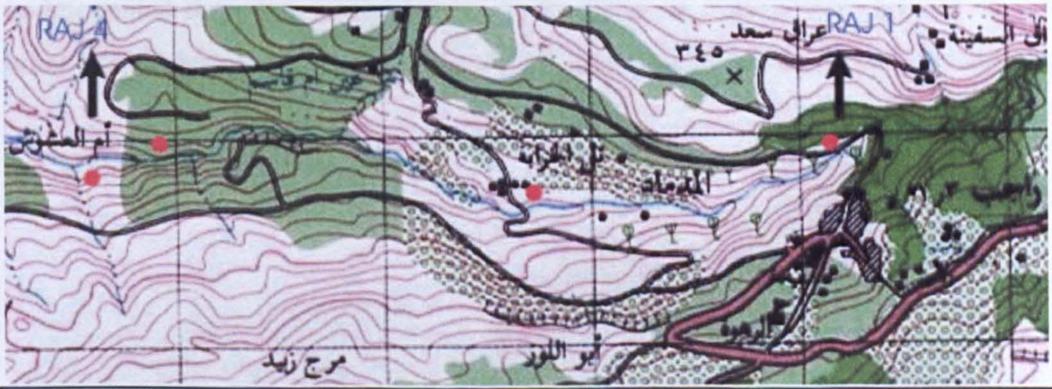
Associated Structures: A concrete water channel was running between the mills, splitting into a y-shape in both directions. The interesting feature was the concrete channel built on top of the leat of the first mill, as it seemed to be connected to this y-shaped, separate channel. There were no signs of an older channel system under the concrete channels, although that could easily have been destroyed during its construction. **(Fig. 5.14)** Another water mill, located near the town of Judayta, was recently restored by architects from the Jordan University of Science and Technology. **Fig. 5.15** reveals the fully restored penstock, and the partially ruined mill house and wheel chamber; the mill was not restored to its functional purposes.

References: As previous entries; information on this mill was provided by Dr. Rami Daher of Jordan University of Science and Technology.

Wādi Rājib

To the south of 'Ajlūn, parallel to the Wādi Kufranja and the Wādi al-Rayyān, lies the Wādi Rājib. The landscape is hilly, with an abundance of agricultural activity; the Rājib River is very full in early spring, after the winter rains and the snow has melted. Although this area is little known archaeologically and historically, the rich agricultural landscape and environment alone must have provided some incentive for settlement in the past.

In 2003, there were five water mills along a 2km stretch of the Rājib River, two of which were in reasonably good condition, although one of these was completely inaccessible as it was located at the bottom of a steep escarpment across the Rājib



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Scale 1:50 000 Jordan Topographic Map Series (Arabic)

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Figure 5. 16. Map of Wādi Rājib, with approximate location of mills marked in red.

River. The landscape here, as around 'Ajlūn and Yābis, is lush and suitable for growing basic subsistence crops, and the water supply appears to be fairly consistent throughout the year.

Building No.: RJB 1 ***Type:*** RJB1a/LMS III

GPS Coordinates: Not available ***Elevation:*** Not available

Location: Near the top end of the river, close to the spring of the Rājib River and at the edge of a small village. It was situated very close to the main road leading from 'Ajlūn to Rājib.

Architecture: The mill was much smaller than any other mill so far studied in the 'Ajlūn area, and a column head or lintel of Classical style was found near the bottom of the penstock remains. Neatly cut limestone blocks formed the penstock, which stood at a height of about 2m; the mill house was not located in front of the penstock, but at its side. It was about 3m by 2m in dimensions.

Associated Structures: The remains of an abandoned village of as of yet undetermined date- but most likely from the Ottoman period- were located on the other side of the ride, on a small hillock. A Classical style lintel was present near the

Figure 5. 17. Remains of penstock and mill house, RJB1.

mill. **(Fig. 5.17)**

References: Rājib is also mentioned in the tax registers of 16th century Ottoman Jordan.[6]

[6] Hütteroth 1978, 23.

Building No.: **RJB 2** ***Type:*** **RJB1a/LMS, BAS III**

GPS Coordinates: Not Available ***Elevation:*** Not Available

Location: Further down the same road, at a distance of about 1km, another mill was located.

Figure 5. 18. Penstock and view of entry to wheel chamber, RJB2.

Landscape: Surrounding the mill were numerous orchards and crops, as well as abundant terracing.

Architecture: RJB2 was situated near a small bridge crossing the river, and had an intact penstock with leat, as well as visible remains of the wheelhouse. The penstock was approximately 4.5 meters high, and had a slightly sloping façade; the masonry was of cut limestone blocks arranged in even courses producing the similar "stepped" effect as those in the Wādi Kufranja. The arched entrance to the wheelhouse was barely visible above the edge of the riverbank; it had been filled with a deep layer of mud and sediment over the years and was impossible to enter. **(Fig. 5.18)**

Associated Structures: The water channel leading to the penstock chute was quite well preserved and showed no signs of recent reconstruction; about 10m in length remained. The bridge nearby was probably of a late Ottoman date and may again suggest the importance of a road network to make the mills more accessible, as in KFR2 in Wādi Kufranja.

References: As previous entry.

Building No.: RJB 3 ***Type:*** RJB1b/LMS, BAS II

GPS Coordinates: Not available ***Elevation:*** Not available

Location: Two further mills were located approximately 500m away from RJB2.

Landscape: Set in a narrow *wādi* bed, with steep hills on both sides.

Architecture: RJB3 was very well preserved, with a standing penstock and extant water. The remains of an enclosure at the foot of the penstock may indicate the previous existence of a mill house. The façade of the penstock, made of limestone blocks, had fallen away, but still revealed the same stepped and sloping pattern as the previous mills in the Rājib area.

Associated Structures: The millrace was positioned at an angle to the water channel, causing the channel to curve, as it does in RAY1. This may have caused the momentum of the water as it coursed down the channel to decrease, thus decreasing the power at which the mill wheel was turned, causing the grinding stones to grind at

Figure 5. 19. Remains of penstock and possible mill house, RJB3.

a slower pace. The water channel was of rubble masonry, but has probably been rebuilt a number of times. Blocks of masonry, stones and rubble had been piled up to form a mock enclosure, possibly for sheep and goats. Its position relative to the penstock suggested that its foundations belonged to the mill house. **(Fig. 5.19)**

References: As previous entry.

Building No.: RJB 4 ***Type:*** RJB1b/BAS, RM I

GPS Coordinates: Not available ***Elevation:*** Not available

Location: Located about 150m downstream from RJB3.

Landscape: Against a steep slope, only 2-3m from the river.

Architecture: The penstock was reasonably intact, although there was no sign of a water channel, nor do there appear to be any remains of a mill house. It was located very near the river, and the meandering course of the river over the years may have destroyed much of this mill. Unfortunately, the mill was located across the river, and due to the volume of water, it was impossible to cross it to have a closer look at it. However, the penstock was of similar construction to RJB3, in the same stepped and sloping fashion, although the masonry appeared to consist mostly of basalt blocks of a smaller dimension than the previous and of so. There was thick shrubbery covering the façade of the penstock, which made studying it all the more difficult, but it may have concealed the possible remains of the wheel chamber, or the grinding room. **(Fig. 5.20)**

Figure 5. 20. Remains of penstock, RJB4.

Associated Structures: Possibly RJB3.

References: As above.

Wādi Shu'ayb

Wādi Shu'ayb is located about 15km northwest of 'Ammān, and leads down into the northern most part of the Dead Sea; the main town at the top of the *wādi* is al-Ṣalt. There are three mills located near the town of al-Ṣalt, situated about 250m apart from each other. All three mills are built against steep ridges, and only one of the water mills has a partially intact wheel chamber. No mill houses survive. They were located at an altitude of between 670m and 750m, probably the highest watermills located in the north of Jordan. **(Fig. 5.21)**

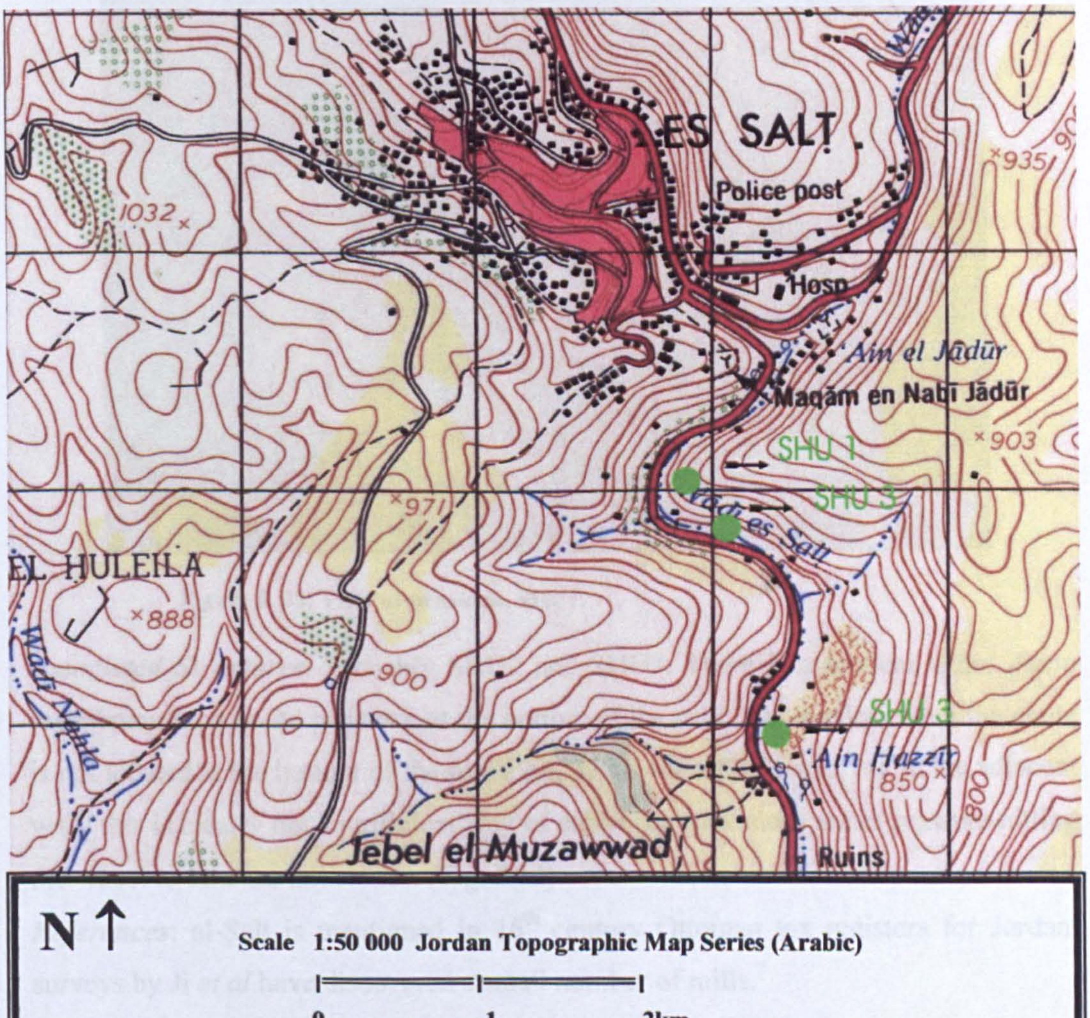

Figure 5.21. Map of al-Ṣalt and the top of Wādi Shu'ayb, with approximate locations of mills marked in green.

Building No.: **SHU 1** **Type: SHU1b/LMS III**

GPS Coordinates: E36S 0758042, N 3547185 ***Elevation:*** 749m a.s.l.

Location: On main road ca. 1km south of al-Ṣalt.

Landscape: Terraced hills and olive orchards, as well as other crops.

Architecture: This mill is partially ruined, with an intact penstock and a partially intact wheel chamber. There is some fallen masonry on top of the buried mill house which is probably the collapse of the mill house. The masonry is cut limestone, with some evidence of dressed stone, stacked in even courses. There is severe weathering of masonry on the south face of the penstock.

Figure 5. 22. View of penstock, SHU1.

Associated Structures: Probably SHU2 and SHU3. There is a modern water pump installation next to the penstock at the bottom of the mill. The outflow from the chute is not located at the bottom of the penstock, inside the wheelhouse, but in the adjacent wall; this is clearly not an efficient way of achieving maximum water pressure hitting the wheel to turn the millstones. **(Fig. 5.22)**

References: al-Ṣalt is mentioned in 16th century Ottoman tax registers for Jordan; surveys by Ji *et al* have discovered a small number of mills.[7]

[7] Hütteroth 1978, 23; Ji, C. & Lee, J.K. (2002) "The Survey of the Regions of Iraq al-Amīr and Wādi Kafrayn, 2000." *ADAJ* 46, 179-195.

Building No.: **SHU 2** ***Type:*** SHU1a/LMS I

GPS Coordinates: E 36S 0757693, N 3546769 ***Elevation:*** 701m a.s.l.

Location: On the main road southwest, ca. 300m from SHU1.

Landscape: Heavy vegetation and terraced hills.

Architecture: SHU2 was not accessible because of the massive vegetation growth around the mill, and the widening of the river at this point. It was located approximately 10m from the river. From the roadside, only the penstock could be seen, and no remains of the mill house or wheel chamber were visible. The masonry had fallen from the front face of the penstock revealing the usual rubble and mortar fill. There was no visible leat, and the mill was situated against a steep terraced slope; the abundant terracing above the mill appears to have been built using limestone blocks from the mill. The front face of the penstock was covered with similarly dressed limestone blocks. **(Fig. 5.23)**

Figure 5. 23. Remains of collapsed penstock, SHU2.

Associated Structures: Probably SHU1 and SHU3.

References: As above.

Building No.: SHU 3 ***Type:*** SHU1/LMS, RM I

GPS Coordinates: E 36s 0758173, N 3546572 ***Elevation:*** 673m a.s.l.

Location: Situated about 200m further down the valley from the previous mill.

Landscape: This mill was also set against a steep slope on the south side, with abundant terracing in the hills above it. In addition, there was a modern terrace wall at the foot of the penstock between the penstock and the more modern channel which ran alongside the river.

Architecture: This mill only had remains of a partially ruined penstock, with slightly larger dressed limestone blocks than the previous two mills. The masonry had fallen off the upper 4-5 courses of the penstock, and rubble masonry was visible on the leat

Figure 5. 24. Remains of penstock and millrace, SHU3.

remains. There were no signs of a wheel chamber, but there were possible remains of a mill house wall on the south facing side of the penstock.

Associated Structures: Probably SHU1 and SHU2; there are also some stone houses probably dating from the Ottoman period across the road. The stone channel running past the mill is stone lined and still carrying water. Although the remains of the millrace were only about 5 m long, judging from its angle it was probably connected to the same system that fed SHU1 and SHU2. **(Fig. 5.24)**

References: As above.

Wādi al-Sīr

Wādi al-Sīr is a valley rich in agricultural activity located northwest of ‘Ammān. **(Fig. 5.25)** Two separate watermill sites were located in this *wādi* between 2001 and 2005.

Figure 5. 25. Map of Wādi al-Sīr. Irāq al-Amīr is marked in red.

Building No.: SĪR 1 ***Type:*** SĪR1a/LMS II

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: This mill is located next to the main road from Irāq al-Amīr leading back toward ʻAmmān.

Landscape: Stream across the road, with terraced hills and orchards.

Architecture: Built using rough limestone blocks. Two arches support the mill race, which turns sharply up toward the slope against which it is set. The penstock is approximately 4.5m high, with no visible remains of a mill house or wheel chamber; as the base of the penstock is only 2 or 3 metres away from the road, it was probably damaged when the road was built. It can thus appear that the mill house and wheel chamber were never in existence. **(Fig. 5.26)**

Associated Structures: Across the road from this mill, a set of dwellings cut into the rock of the hillside were located, and a full stream ran at the foot of these; a modern looking channel system took water from this stream, but it was not possible to

Figure 5. 26. Penstock and millrace with arch, SĪR1.

determine whether the mill had received its water supply from these channels in the past.

References: Ji *et al* discovered several watermills in their survey of Wādi al-Sīr.[8]

[8] Ji *et al* 2002.

Building No.: SĪR 2 *Type:* **SĪR1b/LMS, IV**

GPS Coordinates: Not available. *Elevation:* Not available.

Location: This mill, located outside the village of 'Irāq al-Amīr, is one of few restored water mills existing in Jordan today.

Landscape: Heavily bulldozed area surrounding the mill, with some vegetation.

Architecture: This is the only other known restored mill in North Jordan. Here one can also see the sediment that has accumulated over time, burying most of the wheel chamber where only the top half of the archway is still visible (seen in the bottom left corner of the photo). The mill house and penstock have undergone almost complete restoration, using both limestone blocks and concrete. The penstock is set against a gentle incline, and the millrace curves slightly along the slope. The mill house has three windows and an arched doorway. Grain hoppers and frames for the millstones are still present inside the mill house, but the main elements driving the mill- the water wheel and the mill stones- have been left out. **(Fig. 5.27)**

Figure 5. 27. Partially restored mill, SĪR2, Wādi al-Sīr.

Associated Structures: A modern channel carries water along the *wādi*. The channel continues on the west side of the mill, where the water is channelled into a modern rubber pipe which has been connected to it, possibly to provide water to the surrounding crops.

References: As above.

Wādi Ḥisbān is located about 20km southwest of 'Ammān, with the 'Ayn Ḥisbān ('*ayn* being the spring) at a position of about 650m above sea level. The *wādi* is joined by the Wādi Kafrayn further west as it descends into the Jordan Valley, where it flows into the River Jordan. The ancient site of Ḥisbān- or Heshbon as it was known in biblical times- is located about 4km south of the spring at the higher altitude of 870m. This *wādi* has a perennial stream, although it is fullest in spring after the winter rains and the snow has melted, but there is still plenty of water during the summer months. **(Fig. 5.28)**

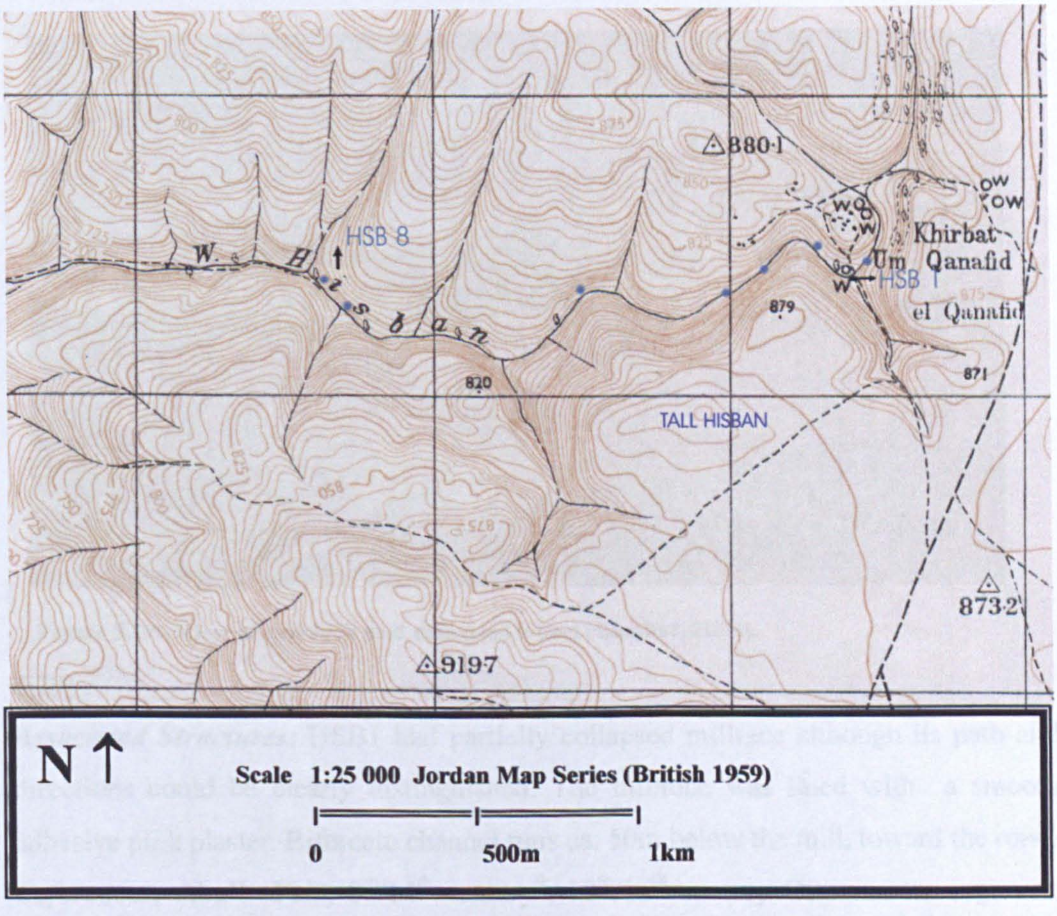

Figure 5. 28. Map of Wādi Ḥisbān with approximate location of mills marked in blue.

The landscape around Sayl Ḥisbān is predominantly agricultural; cereal crops, as well as fruit and vegetable crops, are tended throughout the year. The water mills located in this *wādi* are plentiful and also of great interest, although many of them are in state of ruin and it is only a matter of time before the only traces of them will be seen in photographs and archaeological reports.

Building no.: ḤSB 1 ***Type:*** ḤSB1a/LMS III

GPS Coordinates: E 36S 764545, N 3525624 ***Elevation:*** 671m a.s.l.

Location: Off the road leading from village into the valley, about 150m from the spring.

Landscape: Heavily farmed area.

Architecture: Masonry is of cut limestone blocks bonded with mortar, covering a rough rubble and mortar fill. The wheel chamber had an arched opening 165cm wide by 180cm high. No wheel was *in situ.* There were visible remains of an arch springer at the bottom of the penstock, where the mill house would have been located. A broken concrete millstone, ca. 1.10m in diameter, lay inside the wheel chamber. **(Fig.**

Figure 5. 29. View of penstock and collapsed wheel chamber, ḤSB1.

5.29)

Associated Structures: ḤSB1 had partially collapsed millrace although its path and directions could be clearly distinguished. The millrace was lined with a smooth adhesive pink plaster. Bifurcate channel runs ca. 50m below the mill, toward the road.

References: Abu'l –Fidā, $8^{th}/14^{th}$ century[9]; $10^{th}/16^{th}$ century Ottoman tax registers. Conder claims mills were erected here in the late 18^{th} century. The Andrews University survey recorded 10 water driven grain mills here[10].

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[9] See Chapter Two, pp. 32-33.

[10] Hütteroth & Abdelfatteh 1977; Hütteroth 1978, 23; Conder, C.R. (1989) *The survey of eastern Palestine: memoirs of the topography, orography, hydrography, archaeology, etc.: vol. I. The 'Adwân*

Building no.: ḤSB2 *Type:* HSB1b/LMS I

GPS Coordinates: 36S 0764487, N 3525507 ***Elevation:*** 670m a.s.l.

Location: 100m downstream from the previous mill.

Landscape: Mill is cut off by road.

Architecture: It is mostly destroyed, but the remains of a plaster lined chute can still be seen. A mill channel, about 10m in length, runs into the chute, although it is not clear how; the leat is adjoined to a slight diagonal, masoned slope which has clearly been affected by water pressure, although its purpose as a mill channel is unclear, particular as the penstock itself is vertical, and not sloping diagonally. **(Fig. 5.30)**

Associated Structures: The water channelled into it leads from a channel that does not appear to be connected with the lower channel system feeding the other mills.

References: As above.

Figure 5. 30. ḤSB2, with unusual sloping slabs of masonry leading to the remains of a plaster lined chute. (See Appendix B for further photographs.)

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country. The Committee of the Palestine Exploration Fund: London, 126; Ibach 1987; Geraty, L.T. & Running, L.G. (1989) *Ḥisbān 3. Historical Foundations*. Andrews University Press. Berrien Springs.

Building No.: ḤSB3 ***Type:*** ḤSB1/LMS I

GPS Coordinates: E 36S 0764443, N 3524725 ***Elevation:*** 655m a.s.l.

Location: On the upper bank of the river, ca. 150m from ḤSB2.

Landscape: Heavily bulldozed terrain.

Architecture: Ruined mill with remains of mill house and partially extant plaster lined penstock. Masonry is finely cut limestone blocks, ca. 30cm x 50cm in dimension. **(Fig. 5.31)**

Associated Structures: Possibly ḤSB1 and ḤSB2. A stone and concrete channel runs perpendicular to the ruined millrace, along the road.

References: This may be the mill Conder identified as *Shūnet Sukkar* (Sugar Hill) in 1889 when it was still in operation. The Andrews University survey identifies it with their site 47. Walker has also indicated that excavations on the Mamlūk Palace on the *tall* have unearthed sugar storage jars, and she suggests the mills were used for sugar refining.[11]

Figure 5. 31. Collapsed remains of ḤSB3; a local farmer is sitting on the remains of the penstock with the plaster lined chute visible behind him.

Building no.: ḤSB4 ***Type:*** ḤSB1a/LMS III

GPS Coordinates: E 36S 0764432, N 3524578 ***Elevation:*** 638m a.s.l.

Location: Approximately 50m from ḤSB3, abutting dirt road through farmland.

Landscape: Set on upper slopes of *wādi* bank, close to the dirt road.

Architecture: Weathered limestone masonry in neat blocks, with rubble and mortar rebuilding. The penstock had lost the outer layers of masonry exposing mortar bond. The wheelhouse was still complete, and the millstones were still *in situ*, although the collapse from the mill house and the sediment made it impossible to see it from the outside. **(Fig. 5.32)**

Associated Structures: Possibly the previous three mills. There is a modern concrete channel which runs along the ridge below; it has openings at intervals to irrigate the surrounding crops. The millrace is destroyed where the road cuts in.

References: As ḤSB1-ḤSB3.

Figure 5. 32. ḤSB4, penstock and remains of mill house and wheel chamber.

[11] Ibach *et al* 1987; Geraty *et al* 1989; Conder, 1989, 218; Walker 2003; the grain and sugar mills in this *wādi* are further discussed in Chapters Seven and Eight.

Building no.: ḤSB5 ***Type:*** ḤSB1a/LMS, RM II

GPS Coordinates: E 36S 0764501, N 3524051 ***Elevation:*** 614m a.s.l.

Location: Located 100m from ḤSB4, along the same road.

Landscape: Terracing and bulldozed land; mill set against slope.

Architecture: Constructed of cut limestone blocks with rubble and mortar fill. The penstock is very ruined with only about 1.5m of masonry left. There is an arched entrance into the wheel chamber which has mostly collapsed. The close proximity of crops indicates crop expansion as a cause of the mill's ruination. **(Fig. 5.33)**

Associated Structures: Rectangular covered channel exposed next to the wheel chamber as it was destroyed when the road was built. There is a bifurcate channel across the road, leading down into the river.

References: As above.

Figure 5. 33. Remains of penstock and collapsed mill house, with arched opening to wheel chamber visible below.

Building no.: ḤSB6 ***Type:*** ḤSB1/LMS I

GPS Coordinates: E 36S 0763866, N 3523328 ***Elevation:*** 558m a.s.l.

Location: Ca. 500m from previous mill, off road through path in orchards.

Landscape: Located close to the river bed, in the bend of the river.

Architecture: Totally ruined, with only partial remains of a maximum of 5 courses of masonry in the millrace. Remains of enclosure, possibly mill house, and bathe se of penstock. Masonry is cut limestone blocks. **(Fig. 5.34)**

Associated Structures: A concrete channel runs perpendicular to the millrace in a north-easterly direction.

References: As above.

Figure 5. 34. Collapsed penstock and wheelhouse, ḤSB6.

Building No.: ḤSB7 *Type:* ḤSB2²/LMS, BAS IV

GPS Coordinates: E 36S 0763743, N 3523276 *Elevation:* 557m a.s.l.

Location: Approximately 50m from ḤSB6,

Landscape: Located on lower bank of river, surrounded by oleander bushes. A large amount of quarried limestone was located immediately next to the mill.

Architecture: Remains of an enclosure wall with windows- probably the mill house- still stand, as do both wheel chambers, although no wheels remain inside. Broken pieces of millstones- both of the traditional limestone and the modern cement kind- are scattered around the mill. The masonry had fallen away from most of the penstock revealing chutes with multiple layers of plastering. The chutes were roughly 40 to 50 cm in diameter. The plaster layers covered a barely visible stone lined vertical shaft that formed the penstock chute, with finely cut stone blocks. Limestone appeared to be the predominant building material, although some fragments of basalt- usually used for millstones- were also present. **(Fig. 5.35)**

Associated Structures: Probably ḤSB6 and ḤSB8.

References: As above.

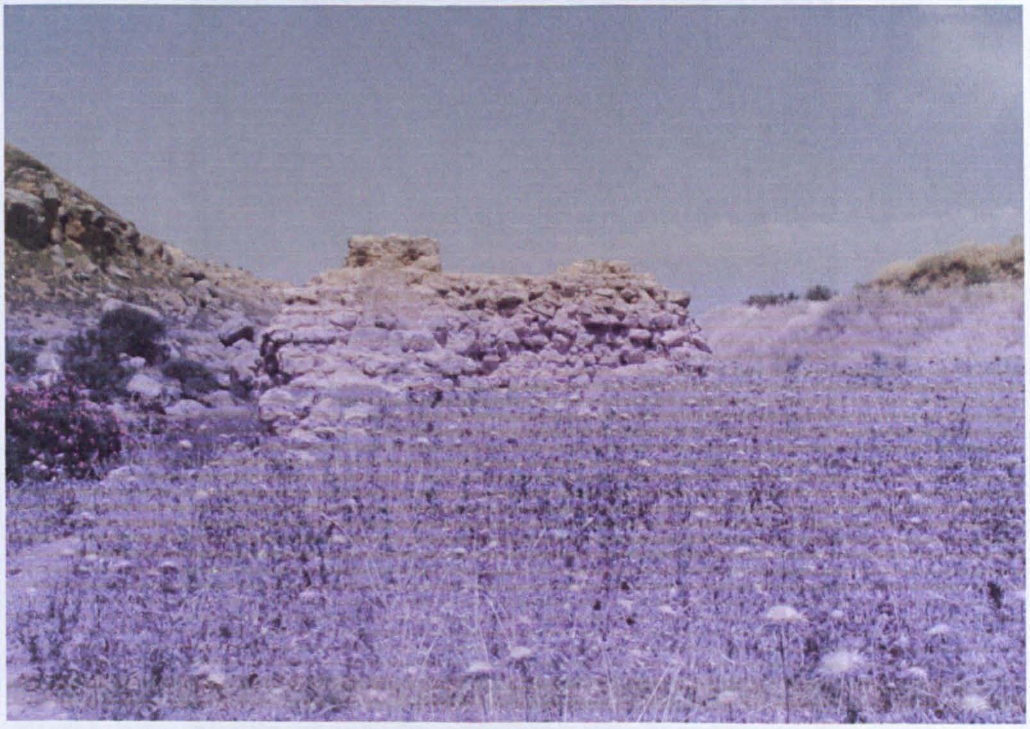

Figure 5. 35. ḤSB7, view of remains of west-facing penstock , double-penstock mill, Wādi Ḥisbān.

Building no.: ḤSB8 ***Type:*** ḤSB2^2/LMS, BAS IV

GPS Coordinates: E 36S 0763488, N 3523316 ***Elevation:*** 546m a.s.l.

Location: About 25m from previous mill, along the river.

Landscape: Limestone hills to north and west of the mill, and river to the south.

Architecture: Partially ruined mill, constructed of fine cut limestone blocks. Penstock has two chutes; arch springer by penstock divides two mill chambers. No visible mill house, but one wheel chamber just visible under a mound of sediment. Visible remains of an arch in the millrace wall also existed here, and where the arch had collapsed a path had been cleared through the rubble. **(Fig. 5.36)**

Associated Buildings: Probably ḤSB6 and ḤSB7. Mill race runs in northerly direction toward limestone hills; remains of masonry leading back to previous mill could be connecting channel.

References: As above.

Figure 5. 36. Remains of plaster lined chute, double-penstock mill, ḤSB8.

Wādi Wāla leads into the Wādi Haydān just north of the Wādi Mūjib. The Wādi Wāla/Haydān region is drier in summer months; in all areas where watermills were present, the volume of water in the river was great considering the time of year. Eleven mills were studied in this region in 2003 and 2004. Following is a brief description of the mills in the two *widyān,* divided into four sites; all mills except one are located in clusters of two or more, spanning a wide area. **(Fig. 5.37)**

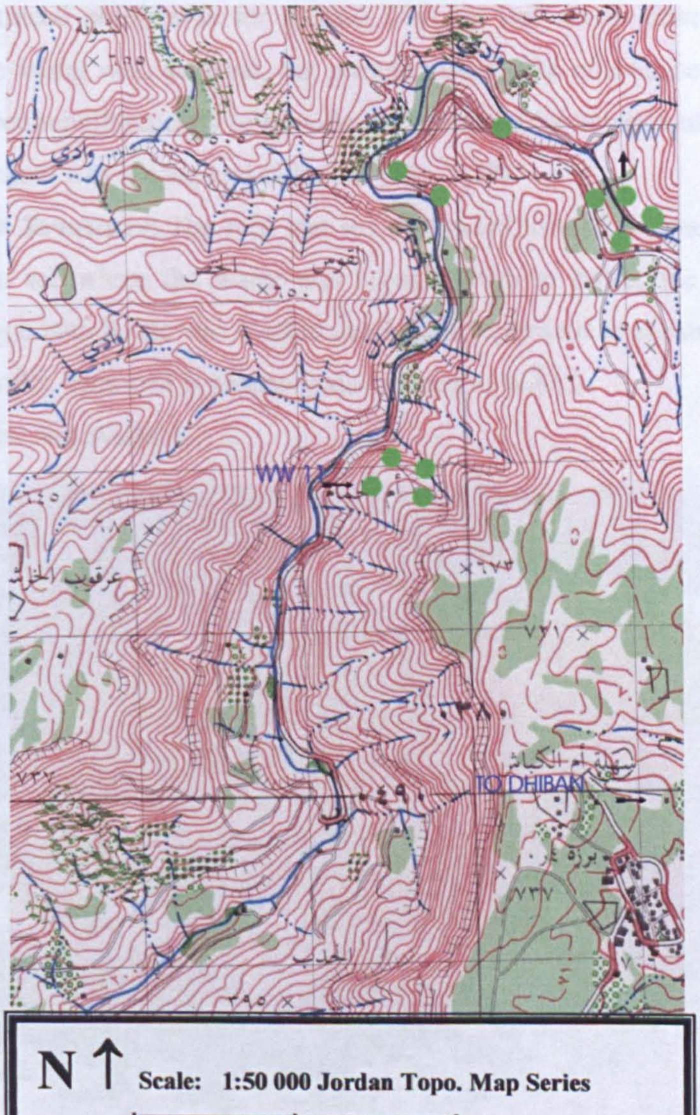

Figure 5. 37. Map of Wādi Wāla and Wādi Haydān, with approximate locations of mills marked in green.

Site 1

Building No.: WĀL1 ***Type:*** WĀL1/LMS, RM IV

GPS Coordinates: E 36S 0762093, N 3494626 ***Elevation:*** 429m a.s.l.

Location: Off tarmac road on King's Highway, near the Wāla Dam, approx. 20km south of Madaba.

Landscape: Limestone hills in the distance, ca. 20m from river.

Architecture: Limestone construction in even courses. Partially intact leat which could be traced northwards for at least 20m, as well as an intact wheel chamber, though the wheel was, as usual, not present inside. The mill house was also present, but had been rebuilt recently to provide storage space for equipment. The shape of the penstock chute was oblong and elliptical. **(Fig. 5.38)**

Associated Structures: The mill leat led northward toward a distant, terraced slope; difficult to see where the water was brought from to power the mill. A structure resembling a bath house was located nearby, and appeared in construction to pre-date the watermills. This mill is probably also related to WĀL2.

References: Not available.

Figure 5. 38. WĀL1, entrance to wheel chamber and view of mill house.

Building No.: WĀL2 ***Type:*** WĀL1a/LMS I

GPS Coordinates: E 36S 0762156, N 3494677 ***Elevation:*** 425m a.s.l.

Location: About 15m from WĀL, 15m from river.

Landscape: Built against slope of *wādi* bank, against bedrock; little vegetation.

Architecture: Penstock partially intact; outer courses of limestone masonry have fallen away. Remains of a wall abut the base of the penstock, and could have been part of the mill house. The chute is rectangular and lined with concrete. **(Fig. 5.39)**

Associated Structures: Channel coming from the east could have been connected to the leat of this mill, although it would mean the mill race takes a sharp turn in that direction.

References: Not available.

Figure 5. 39. Remains of penstock, WĀL2.

Building no.: WĀL3 ***Type:*** WĀL1/LMS I

GPS Coordinates: E 36S 0762275, N 3494680 ***Elevation:*** 435m a.s.l.

Location: Across the river to the south of WĀL1 and WĀL2, abutting road leading south.

Landscape: Built against bedrock; bulldozing for road construction has altered landscape extensively.

Architecture: Limestone construction of cut blocks in even courses; masonry has fallen away in most places. Partially intact penstock with a leat leading east; a dirt road next to it had sadly destroyed most of this mill. Unlike the previous two mills, the penstock chute was circular, as with most of the mills in North Jordan. **(Fig. 5.40)**

Associated Structures: The millrace was completely destroyed, and no other channels were visible in the vicinity of this mill.

References: Not available.

Figure 5. 40. Remains of penstock and collapsed millrace, WĀL3.

Building no.: WĀL4 ***Type:*** WĀL1/LMS I

GPS Coordinates: E 36S 0762186, N 3494605 ***Elevation:*** 429m a.s.l.

Location: Another mill was located about 20m further west.

Landscape: Mill built with bedrock in mind; wedged between two boulders. Terracing on ridge above.

Architecture: Very badly ruined; only clearly visible feature is archway, probably into the wheel chamber. Penstock is partially extant and chute exposed showing plaster lining. This mill had suffered extensively from weathering and had it not been for a few distinctive features, it would have been overlooked entirely. **(Fig. 5.41)**

Associated Structures: There was no evidence of a channel, and the penstock was completely destroyed offering no ideas as to the mill's architectural construction. In the hills north of the mills there are some modern farmsteads with olive groves.

References: Not available.

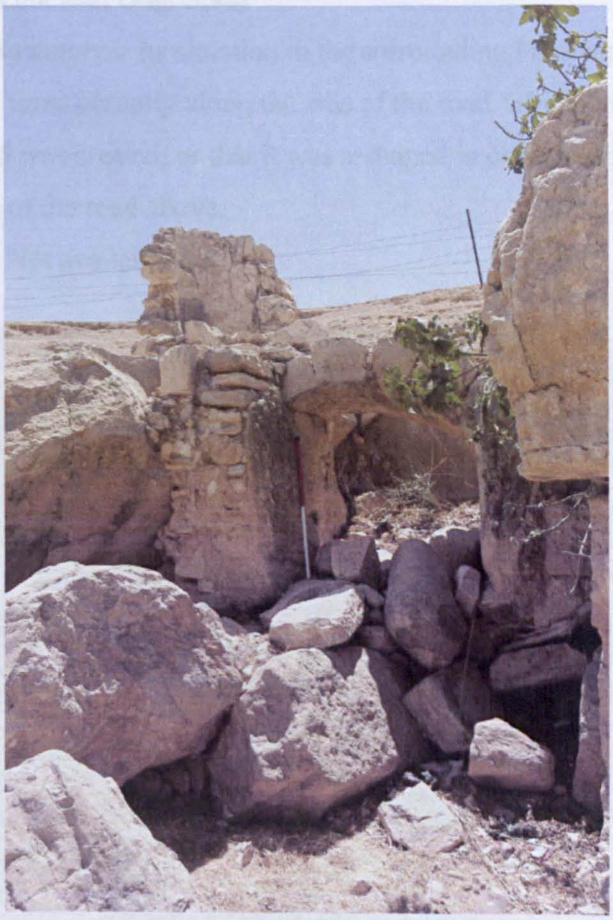

Figure 5. 41. Remains of arch to wheel chamber, with penstock chute in the background to the left, WĀL4.

Site 2

Building No..: WĀL5 ***Type:*** WĀL1a/LMS, RM III

GPS Coordinates: E 36S 0761141, N 3494833 ***Elevation:*** 454m a.s.l.

Location: About 3km southwest of site 1, another mill was located.

Landscape: The ridge had become steeper here with the incline in altitude, and the mill was set against this ridge. There had been a lot of bulldozing and landscape clearing in this area, apparently to create another dam, and this would have been the cause of some of the collapse of this mill.

Architecture: The mill itself is larger than the previous set of mills; the penstock is intact, and parts of the wheelhouse as well as the mill house are also extant. The construction is neater in appearance, but whether this is because the mill might have been built more recently, or because it was used less and thus suffered less weathering and decay, is unclear. **(Fig. 5.42)**

Associated Structures: Its situation in the surrounding landscape is somewhat odd; the mill race turns abruptly along the side of the road, which could suggest it was built after the road was created, or that it was reshaped in order to accommodate the construction of the road above.

References: Not available.

Figure 5. 42. Penstock and remains of mill house with blocked entrance.

Site 3

Building no.: WH6 ***Type:*** WH2^2/LMS, BAS III

GPS Coordinates: E 36S 0759596, N 3499766 ***Elevation:*** **333m a.s.l.**

Location: On main road from WĀL5 toward Wādi Mūjib and Dhibān.

Landscape: Directly on the stream; the wheel chamber was flooded and impossible to inspect. Terracing with olive groves to the north of the river.

Architecture: This mill had a double-penstock, of similar construction material and technique as KFR5 in the 'Ajlūn area (ashlar and rubble and mortar), although there was also some basalt in the masonry. The mill race had been cut by the main road next to it, but there was evidence of a channel continuing up into the olive orchards above. There were also the remains of a mill house, although a modern water pump was now housed inside its ruins. **(Fig. 5.43)**

Figure 5. 43. Twin-chute penstock, WH6.

Associated Structures: It abutted a steep incline in the hill, and the remains of a possible millrace could be seen running north of it, although it appeared to be used as a field wall. Several earthen irrigation channels were located around the orchards. Possibly related to WH7, although they are architecturally quite different.

References: Not available.

Building No.: WH7 ***Type:*** WH1a/LMS I

GPS Coordinates: E 36S 0759557, N 3494699 ***Elevation:*** 334m a.s.l.

Location: Across the river from WĀL6, approx. 50m NW.

Landscape: Built against a steep slope. It was surrounded by abundant terracing and tilled land, which had probably contributed to the mill's decay.

Figure 5. 44. Remains of penstock and plaster lined chute, WH7.

Architecture: It had a single, circular, plaster-lined chute, and was about 4m in height; the top courses of limestone masonry had fallen away. No visible remains of mill house or wheel chamber. **(Fig. 5.44)**

Associated Structures: Long field wall located above mill, leading from penstock chute, and could have been the mill race in the past. Earthen irrigation channels ran through the groves. Possibly related to WĀL6, but unlikely due to the dissimilar nature of the buildings.

References: Not available.

Site 4

Building no.: WH8

Type: WH1/LMS, BAS I

GPS Coordinates: E 36S 0758408, N 3490962

Elevation: 218m a.s.l.

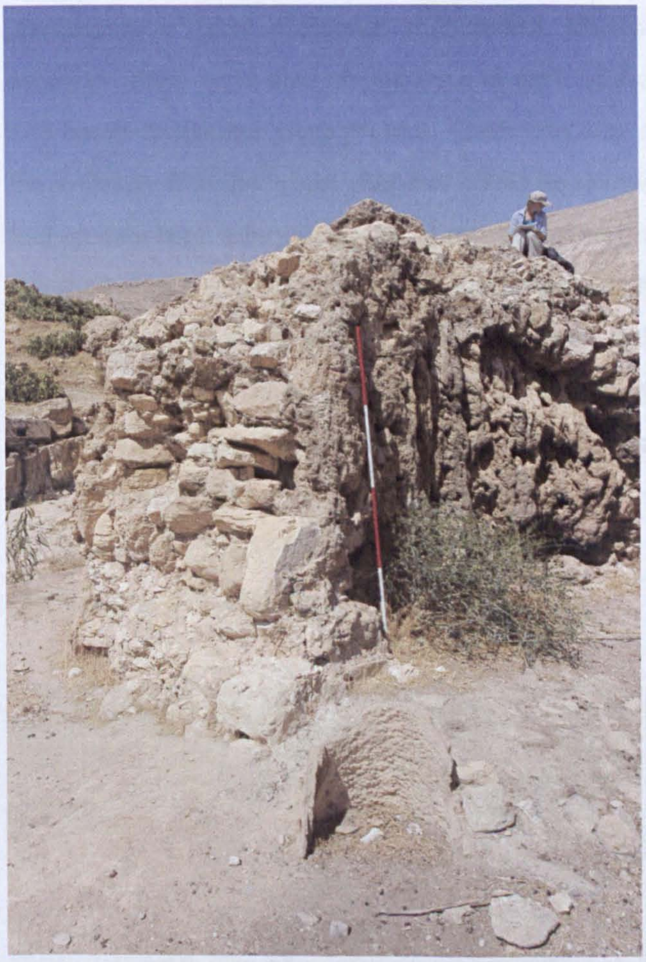

Figure 5. 45. Weathered remains of WH8, with possible remains of penstock chute in the foreground.

Location: Situated in the *wādi* below the town of Dhibān, off the main road between Wādi Wāla and Wādi Mūjib.

Landscape: Mill constructed on bedrock.

Architecture: Ruined penstock and millrace; no sign of wheel chamber or mill house. Mill suffered heavily from weathering. **(Fig. 5.45)**

Associated Buildings: Possibly the remaining three mills. Breezeblock bungalows located around the mills.

References: Not available.

Building no.: WH9 ***Type:*** WH2^2/ LMS IV

GPS Coordinates: E 36S 0758385, N 3490963 ***Elevation:*** 214m a.s.l.

Location: Immediately next to WH8.

Landscape: Appears also to have been built against bedrock. Set against slope.

Architecture: Well preserved mill house, showing two rooms separated by an archway; there were also arched bays in each of the walls. The remains of limestone and basalt millstones were present. There was also an arched entrance, and the top of the archway into the wheel chamber could be seen to the right of this doorway. There had clearly been a large amount of movement of mud and slope wash- perhaps when the road above was constructed- as this wheel chamber was almost entirely buried in dirt. The penstock was in very good condition, and the two stone lined chutes were clearly visible, forming a y-shape from the incoming leat. **(Fig. 5.46)**

Associated Structures: The millrace appeared to originate from the hills behind this mill, although there was now a large amount of rock in the way of this channel. Probably related to WH10 and WH11.

References: Not available.

Figure 5. 46. Bifurcate millrace leading to twin-chute penstock, with mill house below, WH9.

Building No.: WH10 ***Type:*** WH2²/ LMS, RM III

GPS Coordinates: E 36S 0758296, N 3490950 ***Elevation:*** 213m a.s.l.

Location: Approximately 30m further down from this first set of mills, on the edge of a sheer drop down to the river below.

Landscape: As WH8 and WH9; built on bedrock, and shifting rock probably destroyed this mill in the past.

Architecture: This mill was in good condition; both penstocks showed clear remains of a channel leading into them, and forming the necessary y-shape to feed the double-chutes. The remains of the wheel and mill houses could be seen but much of the masonry had fallen away into the valley below. **(Fig. 5.47)**

Associated Structures: Probably WH9 and WH11.

References: Not available.

Figure 5. 47. Remains of penstock and wheel chamber, WH10. The structure is resting on bedrock which may have been the cause of its collapse.

Building No.: WH11 ***Type:*** WH2^2/LMS, BAS IV

GPS Coordinates: E 36S 0758297, N 3490931 ***Elevation:*** 210m a.s.l.

Location: About 10m from WH10, almost parallel to that mill.

Landscape: As above.

Architecture: Even limestone courses; both remains of the mill house as well as the wheel chambers could be seen. The tops of the arched outflows could be seen clearly in this mill, as could the arched doorway into the mill house. This mill house was also divided into two by an archway, and there was evidence of some rebuilding inside it. An unusual feature was also the presence of two windows above the wheelhouses, indicating perhaps that the mill house had at once been a two-storey building. **(Fig. 5.48)**

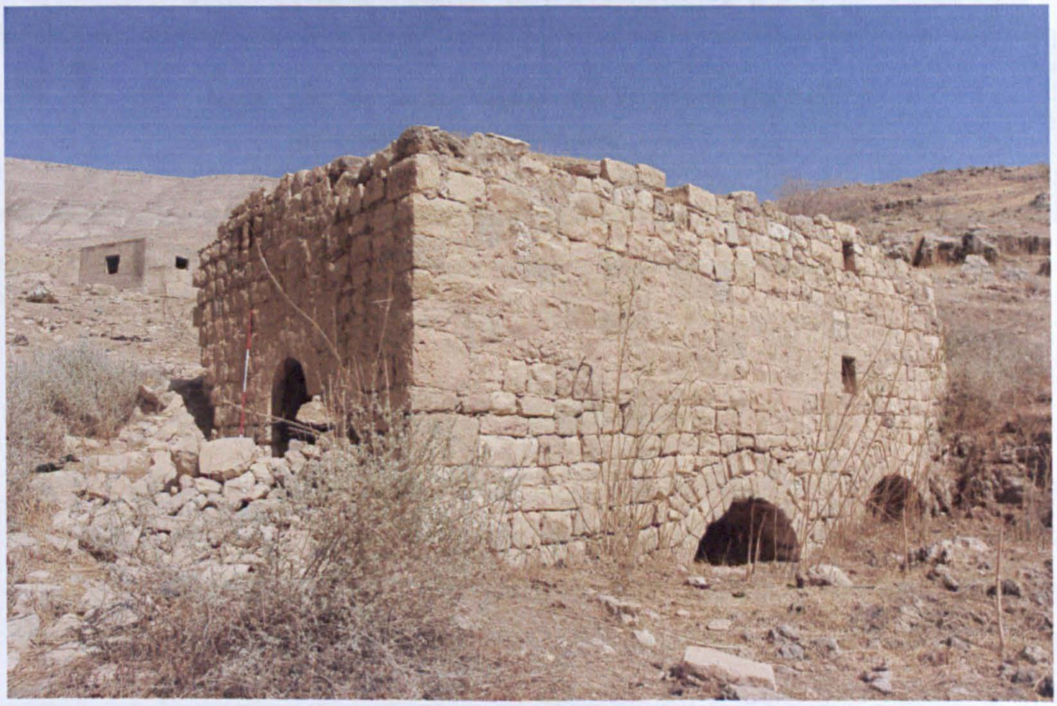

Figure 5. 48. View of mill house remains and two wheel chambers, WH11.

Associated Structures: The channel leading into the double-penstock was very well preserved, and originated from the same direction as its neighbouring mill; the presence of a breezeblock house, however, made it impossible to judge where this channel continued to. Most likely related to WH8, WH9 and WH10.

References: Not available.

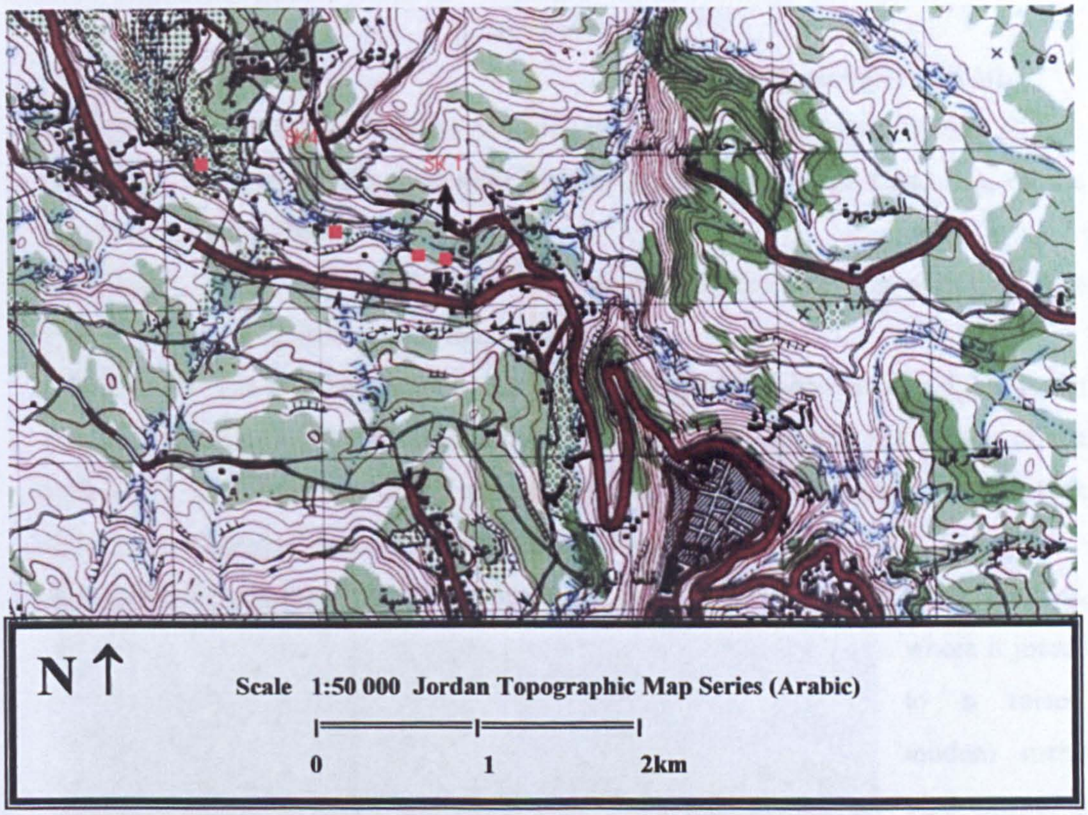

Figure 5. 49. Map of Karak region, with the mills of Sayl al-Karak marked in red. The town of al-Karak is located at the bottom right.

South of the Mūjib River

Wādi Mūjib is the largest river valley in Jordan feeding the Jordan River. The landscape changes quite dramatically, and so it is not surprising that this *wādi* is seen as a border between north and south Jordan by some scholars.[12] There are numerous sites south of the Wādi Mūjib that are littered with watermills; two of these sites- both near the city of al-Karak- are Wādi Ibn Ḥammād and Sayl al-Karak (leading into Wādi al-Karak). Wādi Ibn Ḥammād lies north of Wādi al-Karak, and is almost directly parallel to it; the multi-period site of Khirbat Fāris is located on the plateau above, and includes significant evidence of settlement during the medieval period.[13]

[12] Walmsley, A. (2000) "Fatimid, Ayyūbid and Mamlūk Jordan and the Crusader Interlude," in MacDonald, B., Bienkowski, P. & Adams, R.A. (eds.) *The Archaeology of Jordan.* Continuum and Sheffield Academic: Sheffield.
[13] Johns, J. (1992) "Islamic Settlement in the Ard al-Karak." *SHAJ IV*. Department of Antiquities: 'Ammān, 363-368; Mayer, H.E. (1987) "The Crusader Lordship of Kerak and Shawbak: Some Preliminary Remarks." *SHAJ VII*. Department of Antiquities: 'Ammān, 199-203.

Building No.: SK 1 ***Type:*** SK1/LMS III

GPS Coordinates: E 36S 0756680, N 3454829 ***Elevation:*** 690m a.s.l.

Location: Located off the main road from al-Karak down to the Dead Sea, on the way to the village of Badhān.

Landscape: Heavily cultivated area; mostly maize and cucumber. The spring of 'Ayn Sāra is located ca. 500m north of this mill.

Architecture: The mill had an intact leat, now lined mostly with concrete. Eight to ten courses of coarsely cut limestone blocks 50cm x 30cm covered the façade of the penstock; a rubble and mortar fill appeared underneath it in some gaps. The penstock chute was rectangular, and lined with plaster. **(Fig. 5.50)**

Associated Structures: Channel ran past the chute, above the mill house remains, where it joined to a raised, modern metal pipe extending over the land and the river, but continued in the other direction toward SK2 and SK3. A building adjoins the penstock with an arched entrance built using finely masoned limestone blocks, approximately 125cm wide, and partially collapsed ceiling.

Figure 5. 50. Remains of penstock, SK1.

References: Burckhardt wrote about the mills here in his visit in 1812. Ottoman tax registers for the 16th century also include mills in al-Karak.[14]

[14] Burckhardt 1822; Hütteroth & Abdelfatteh 1977; Hütteroth 1978, 23.

Building No.: SK 2 ***Type:*** SK1b/LMS I

GPS Coordinates: E 36S 756801, N 3454684 ***Elevation:*** 692m a.s.l.

Location: Approximately 200m from SK1, along the river toward 'Ayn Sāra.

Landscape: As above; set against a steep escarpment which is now a terrace wall.

Architecture: Partially intact penstock, approx. 4m high, but no remaining wheel chamber or mill house. Built of limestone blocks ca 40cm x 25cm in dimension, pink exterior plaster. The millrace stops where the wall starts. **(Fig. 5.51)**

Associated Structures: The millrace channel is also lined with pink and grey plaster, and is approx. 45cm wide. The penstock chute is 45cm in diameter, and from its angle appears to slope diagonally downward. The mill channel leading from SK1 is 5m from the penstock of SK2; the river is about 10 m further down. It is possible that they were connected to each other through this water channel. Probably related to SK1 and SK3.

References: As above.

Figure 5. 51. Remains of penstock and millrace, SK2.

***Building No.*:** SK 3 ***Type*:** SK1a/LMS, RM IV

GPS Coordinates: E 36S 0756814 ***Elevation:*** 680m a.s.l.

Location: Along the river, approximately 15m from SK2.

Landscape: Situated against slope and terraced wall; sparse vegetation. Limestone hills and terraces to the north.

Architecture: Penstock partially collapsed. Millrace has two arches, both showing some signs of rebuild in multiple places. The masonry is limestone blocks measuring

Figure 5. 52. Double-arched millrace with view of collapsed mill house and penstock remains, SK3.

approx. 50cm x 30cm. The mill is crudely buttressed, as the wall becomes wider after the first arch (nearest the penstock); this was probably added later, possibly when the arch was modified. The other interesting feature of this mill is that the millstones are still intact above the wheel chamber. The wheel chamber is still mostly intact, and although it was filled with a lot of mud and sediments, the top shaft of the wooden wheel could be seen clearly. This is the first mill with both *in situ* wheel and millstones known to have been found in Jordan. The mill house remains show evidence of a vaulted plastered ceiling. The extant walls of the mill house measure 2.3m in height. **(Fig. 5.52-5.54)**

Figure 5. 53. Penstock and arched entrance to wheel chamber, with *in situ* millstones above, SK3.

Associated Structures: The penstock of this mill twists slightly toward the north, meaning the channel has to curve slightly before it reaches the penstock chute. Modern concrete channel runs past the mill further down toward the river bank, leading from SK2. Probably related to SK2, and possibly the terraced wall behind the mill.

References: As above.

Figure 5. 54. Inside wheel chamber; the wooden shaft connecting the wheel to the millstones above is still in situ.

Building No.: SK 4 ***Type:*** SK1a/LMS, RM IV

GPS Coordinates: E 36S 756401, N 3455006 ***Elevation:*** 680m a.s.l.

Location: South of SK1-3, along road from Badhān. Abuts a steep limestone hill.

Landscape: The river widens here, and there is farmland surrounding the mill. The valley deepens sharply shortly past the mill.

Architecture: Intact penstock and channel which was approximately 15m long. The building material was limestone masonry; visible remains of a mill house and/or wheel chamber. Difficult to determine as it was impossible to cross river to inspect further. **(Fig. 5.55)**

Associated Structures: The mill, facing a North-North-Westerly direction, was situated about 10m from the river; a channel network was visible, and may even have twisted around the slope against which SK4 was built, coming from the southeast.

References: As above.

Figure 5. 55. Remains of penstock, mill house and wheel chamber, SK4.

Three mills were located in this *wādi* in 2001, two of which were located near the spring below the plateau. Unfortunately, these were inaccessible. However, there

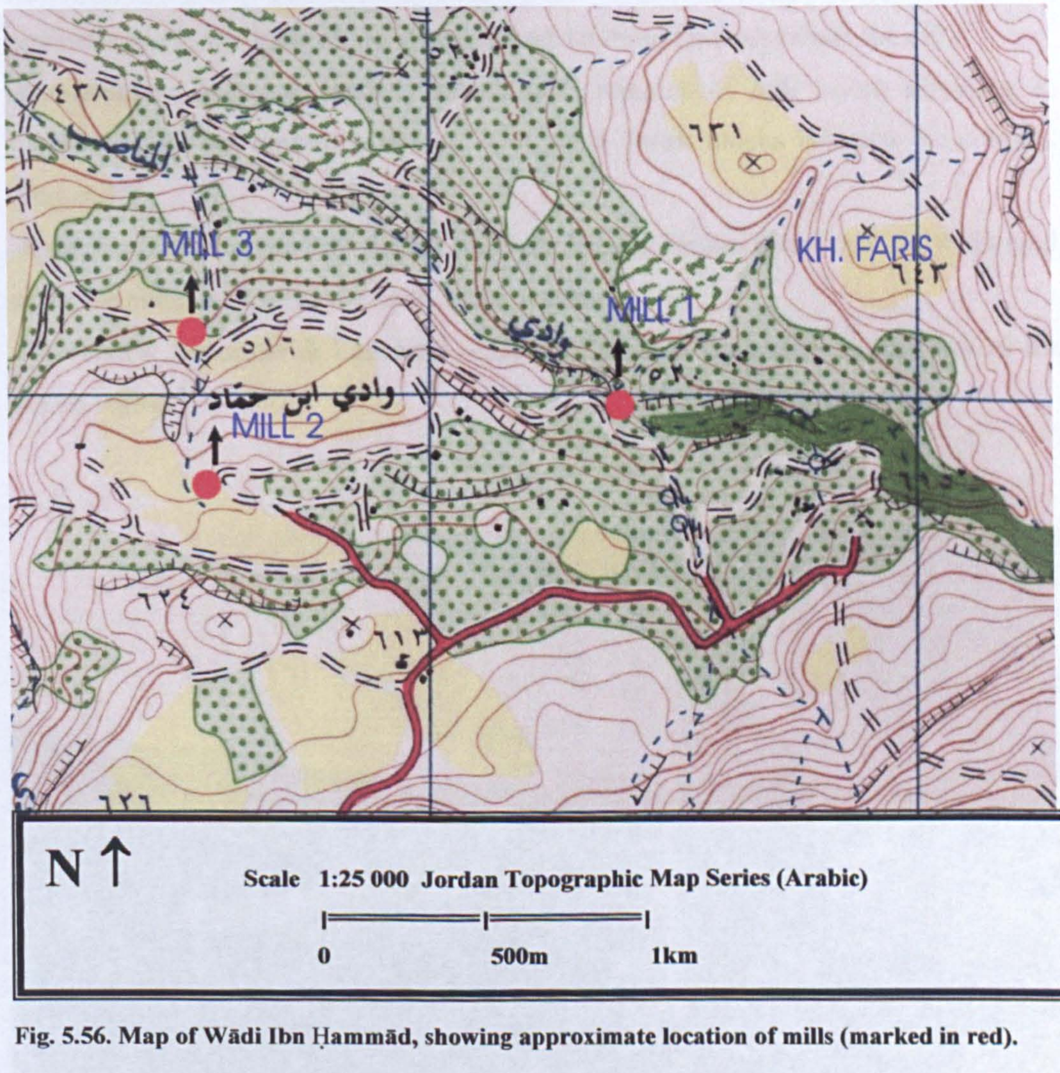

Fig. 5.56. Map of Wādi Ibn Ḥammād, showing approximate location of mills (marked in red).

appeared to be a general architectural uniformity in all the mills. The construction was of limestone, and they bore similar appearance to some of the mills in the Wādi Wāla/Haydān region (specifically the single penstock mill at site 3). No wheelhouses or mill houses remained extant, although partial walls could be found attached to the penstocks of the mills further down the valley. **(Fig. 5.56)**

Building No.: ḤAM1 *Type:* ḤAM1a/LMS, BAS III

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: North of Sayl al-Karak and the town of al-Karak; situated below multi-period site of Khirbat Fāris.

Landscape: Located 5m from the stream, surrounded by oleander bushes. It is set against a gently inclining slope. Abundant agricultural land surrounds the mill.

Architecture: Penstock partially intact, with remains of mill house adjoining it. Predominantly cut limestone blocks, with some basalt blocks between the courses. **(Fig. 5.57)**

Associated Structures: Two further mills are located further away, near the main road up to the plateau, close to the bank of the stream.

References: Lancaster & Lancaster write briefly about watermills in this area of the Karak region.[15]

Figure 5. 57. Remains of penstock and mill house, ḤAM1.

[15] Lancaster & Lancaster 1999, 276-78.

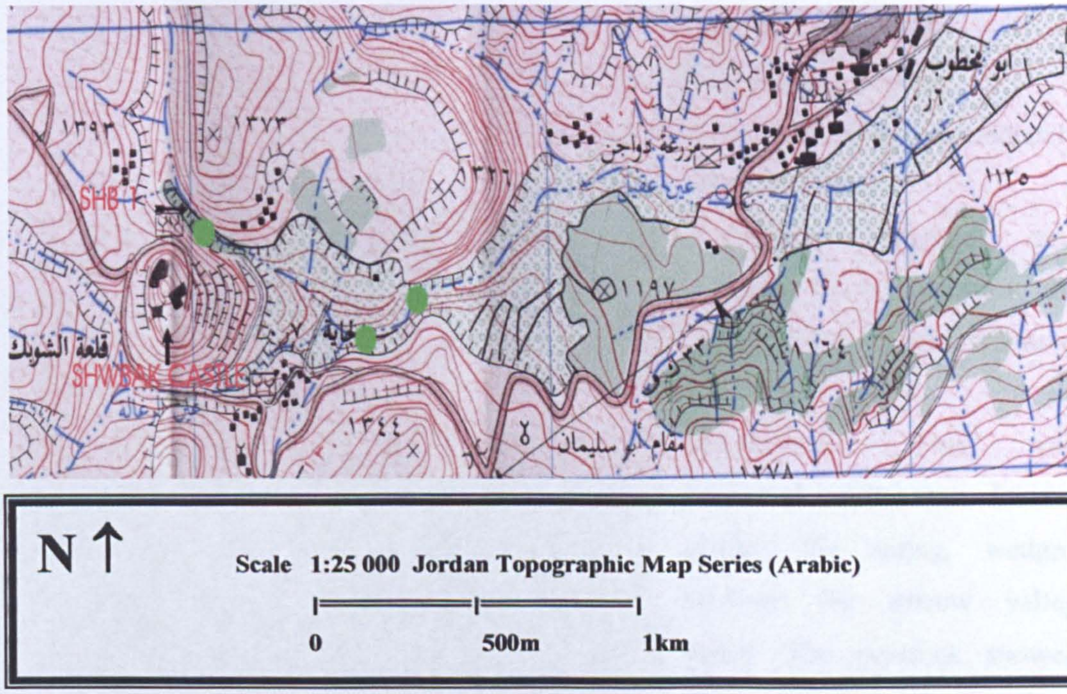

Figure 5. 58. Map of Wādi Shawbak, with approximate location of mills marked in green. Abu Makhtūb is located in the top right corner of the map.

Shawbak

A number of water mills were located around the foot of the castle here in 2003, and a total of eleven watermills were recorded during a survey later the same year carried out by the Institut Français du Proche Orient (IFPO) in ʻAmmān[16]. These mills were all located between the foot of the castle and the village of Abu Makhṭūb. An interesting water channel system was also present, as were a number of older buildings and archaeological features. Some archaeological work has been done on the castle[17], apart from the survey mentioned previously. This work mainly focussed on the castle itself, and although the *wādi* is mentioned as the water source for the castle, although there is no mention of any watermills. **(Fig. 5.58)**

[16] Cedric Devais, pers comm., ʻAmmān 2004.
[17] Brown, R.M. (1988) "Summary Report of the 1986 Excavations, Late Islamic Shawbak". *ADAJ* 32, 225-245.

Building No.: SBK 1 ***Type:*** SBK1a/LMS II

GPS Coordinates: Not available. ***Elevation:*** Ca. 1100m.

Location: Off main road from Shawbak Castle to the Jordan Valley, immediately below the castle.

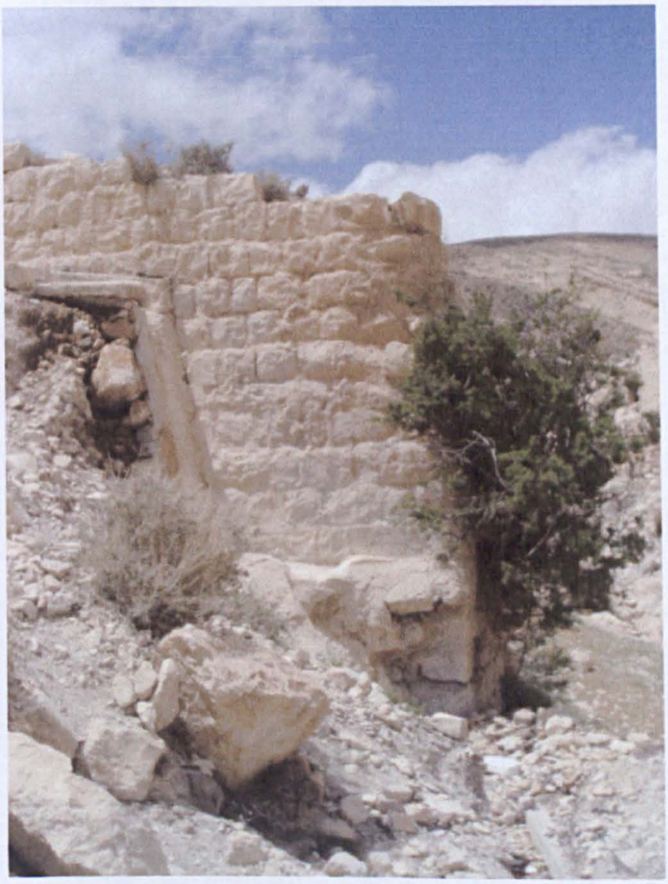

Figure 5. 59. Remains of penstock, SBK1.

Landscape: Orchards and terraced fields surround the mill, which is set against a steep *wādi* slope.

Architecture: This well preserved mill was located nearest the spring, wedged between the narrow valley heads. The penstock showed even courses of limestone masonry; no mill house or wheel chamber was visible. **(Fig. 5.59)**

Associated Buildings: The millrace turned slightly northwest, and there was no further sign of either a channel or another mill further up the *wādi* bed. Two mills were located further down the river bed, and were surrounded by terraced fields, both old and new, as well as orchards or different kinds.

References: Mills near Shawbak and Wādi Mūsa are mentioned during Crusader expeditions here in the early 12th century; Pringle indicates presence of sugar and grain mills in the *wādi* below the castle. Shawbak is also mentioned in 16th century Ottoman tax registers.[18]

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[18] Mayer, H.E. (1990) *Die Kreuzfahrerherrschaft Montréal (S̄obak) : Jordanien im 12. Jahrhundert.* Abhandlungen des Deutschen Palästina Vereins Band 14. Otto Harrassowitz: Wiesbaden; Pringle D. (1997) *Secular buildings in the Crusader Kingdom of Jerusalem : an archaeological gazetteer.* Cambridge University Press: Cambridge, New York, 75-76.

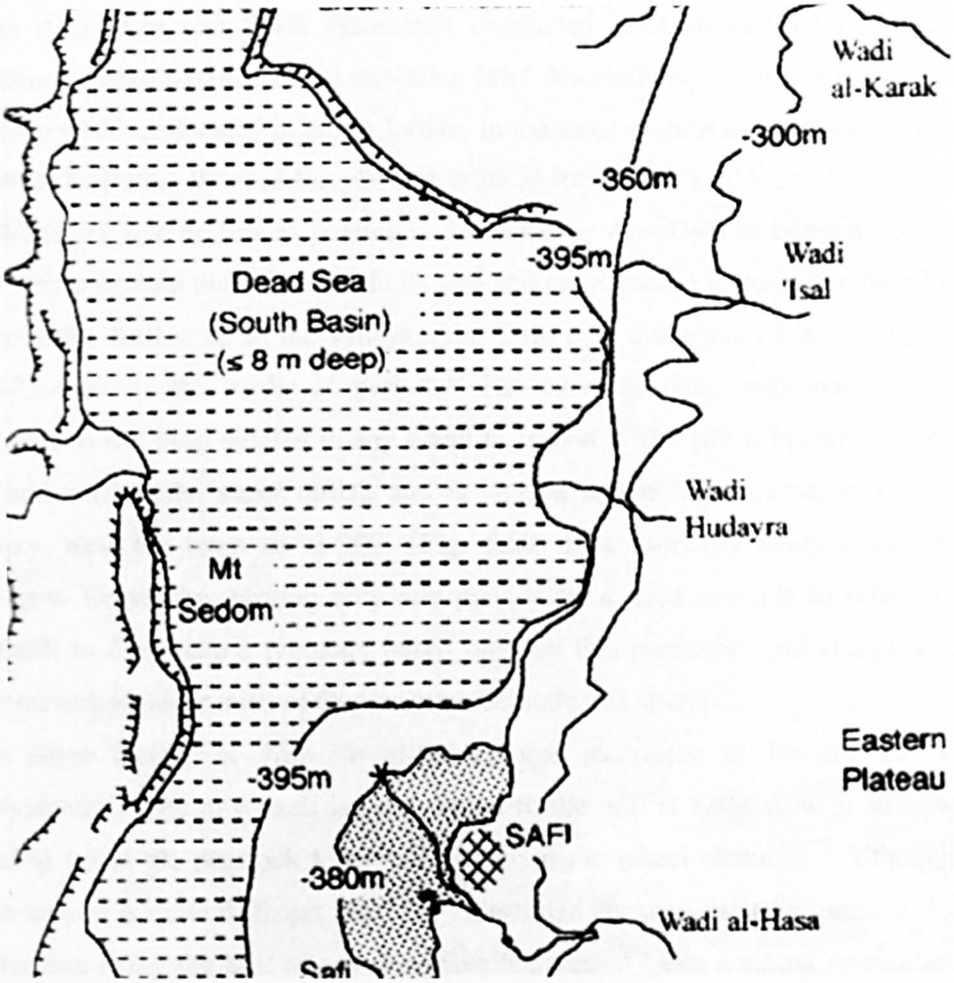

Figure 5. 60. Map of Ṣāfi area. *Ṭawāḥīn al-Sukkar* is marked with crosses. (From Photos-Jones et al 2002)

Sugar Mills

Ṭawāḥīn al-Sukkar

As mentioned previously, Ruba Abu Dalu has also studied watermills in Jordan and notes several sugar installations across the country. She has given brief descriptions of the types of installations that can be found, or that have been described by travellers to the region in the last few centuries.[19]

Hütteroth & Abdelfatteh 1977; Hütteroth 1978.
[19] Abu Dalu 1995.

Ruba Abu Dalu and Sāleh Hamarneh conducted brief surveys of the historical literature related to sugar mills, providing brief descriptions of some of these.[20] Many of these mills are located in North Jordan, in the same *widyān* as the grain mills, such as Wādi Kufranja, Wādi al-Rayyān and Wādi al-Rājib. One mill located at the bottom of Wādi Shu'ayb at *Tall al-Ṭahūna* is described by Abu Dalu as being a sugar mill; this would explain the difference in its size and architectural features compared to the water mills further up in the valleys. Abu Dalu puts the origin of these sugar mills (معاصر السكر) to the medieval period.[21] However, to date, only one sugar mill installation has been studied in any detail in Jordan.[22] The site is known as *Ṭawaḥīn al-Sukkar* (literally, sugar mills), and is located in the *Ghawr* area, in the Jordan Valley, near the town of al-Ṣāfi. **(Fig. 5.60)** It is currently being excavated by Glasgow University. Having only one previously studied example to refer to, it is difficult to formulate a typology based only on this particular mill complex, but a comparison to sugar mills of Cyprus may facilitate this attempt.

The sugar factory at *Ṭawaḥīn al-Sukkar* was excavated in January 2002. The architecture of the mill itself is very similar to the mill at Kolossi, with an aqueduct leading up to the penstock to provide water to the wheel chamber.[23] Although this architecture is quite different from the Palestinian sugar mills[24]- the most noticeable difference being the lack of any defensive features- it bears a strong resemblance to the grain mills of Jordan and Cyprus. The technology of the mill has not yet been uncovered with any certainty, other than that it was probably a horizontally wheeled mill; the gearing is speculative, and based on the work at Episkopi by von Wartburg.[25] It also appears that the water would have entered the wheel chamber at an angle, and not vertically, as with most grain mills. The mill at the bottom of Wādi Shu'ayb at *Tall el-Ṭaḥūna*, also presumed to be a sugar mill by Abu Dalu and discussed in the following section, has a similar sloping water channel running in to the wheel chamber. At *Ṭawāhīn al-Sukkar*, the wheelhouse was filled with sediment and was

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[20] Abu Dalu 1995; Hamarneh 1978.

[21] Abu Dalu 1995, 39.

[22] Photos-Jones, E., Politis, K.D., James, H.F., Hall, A., Jones, R.E. & Hamer, H. (2002) "The Sugar Industry in the Southern Jordan Valley: An Interim Report on the Pilot Season of Excavations, Geophysical and Geological Surveys at Tawahin al-Sukkar and Khirbat al-Shaykh 'Isa, in Ghawr al-Safi." *ADAJ* 46, 591-614.

[23] Aristidou, E.C. (1983) ***Kolossi Castle through the Centuries***. Published by author: Nicosia, 32.

[24] For detailed information on sugar mills in Palestine, see Pringle 1997. These mills are also briefly discussed in Chapter Six.

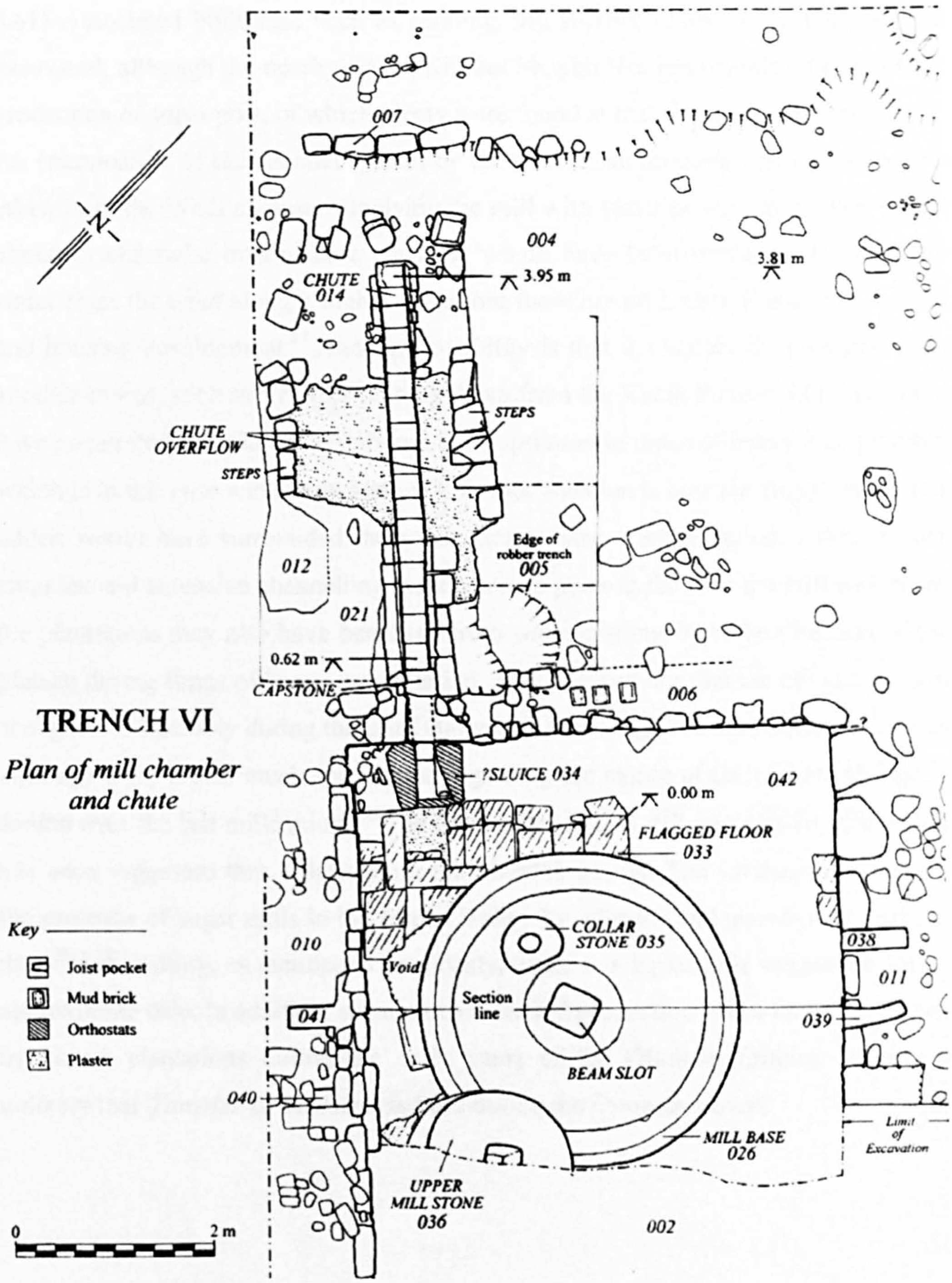

Figure 5. 61. Plan of sugar mill at *Ṭawāḥīn al-Sukkar*. (After Photos-Jones *et al* 2002)

not excavated at that time, but a view through the floor of the mill room revealed a barrel vaulted chamber with an arched opening to the right of the wheel bed.[26] **(Fig.**

[25] Photos-Jones *et al* 2002, 604.
[26] Photos-Jones *et al* 2002, 602.

5.61) Associated buildings, such as refining and stoking rooms, have not yet been excavated, although the nearby site of Khirbat Shaykh ʿIsa has revealed a kiln for the production of sugar pots, of which plenty were found at that site, and at the mill.
An examination of the channel system by the excavators revealed that the water was taken from the Wādi al-Ḥasa, supplying the mill with water power via the two extant aqueduct channels; intermediate channels would have been necessary to carry the water from the *wādi* along a higher ridge, but these are no longer visible due to road and housing development.[27] Another possibility is that the water was provided from another source, such as a rivulet running down from the Karak Plateau, but this would have meant that the mill could only run at its optimum in times of heavy precipitation, which is in this case winter and spring. A further question is how the sugar plantations, which would have surrounded the sugar factory site, were irrigated; unless a very complex and extensive channelling system was in place at the time the mill was in use, the plantations may also have benefited from water coming from the direction of the plateau during times of heavy precipitation. This is assuming that the climate has not changed considerably during the last 1000 years, as is suggested by Photos-Jones *et al*, although there is still much speculation regarding the nature of the climate change in Jordan over the last millennium. [28]The date of this mill is still speculative, although it has been suggested that it dates from the Mamlūk period. The various references to the presence of sugar mills in the Jordan Valley by pilgrims and travellers as early as the 8th/14th century, as mentioned previously, make this a plausible suggestion for an approximate date. In addition, sugar cultivation and production was widely substituted by cotton plantations during the early years of the Ottoman Empire, making it unlikely that *Ṭawaḥīn al-Sukkar* was built during the Ottoman period.

[27] Photos-Jones *et al* 2002, 610.
[28] See for example Issar and N. Brown eds. (1998): *Water, Environment and Society in Times of Climatic Change*. Water, Science and Technology Library, vol 31.Kluwer Academic Publishers : Dordrecht; Brice, W. , ed. (1978): *The Environmental History of the Near and Middle East Since the Last Ice Age*. Academic Press: London; D. Stamp, ed. (1961): *A History of Land Use in Arid Regions*, UNESCO: Paris.

Figure 5. 62. Millrace and milling rooms, *Tall al-Ṭaḥūna*.

Tall el-Ṭāḥūna

This mill is located at the bottom of the Wādi Shu'ayb. It is interesting because it is unique in its construction, but also because there are no other mills in its immediate vicinity, unlike the cluster of mills located at the top of the *wādi* near al-Ṣalt. *Tall el-Ṭaḥūna* is set against a hill (*tall*). The landscape surrounding it is arid and it is difficult today to determine from where the mill would have received its water. There is no penstock; instead, there is a constructed leat that leads directly into two wheel chambers.[29] It is almost certain that there was once a penstock tower here which fed water to the wheel chambers, but collapse forced those using the mill to rebuild it in the form of a water channel which could have rendered the mill rather less efficient in terms of energy and may have caused it to be abandoned. There is also a more recent mud brick addition to the mill rooms. **(Fig. 5.62)**

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[29] This indicates that it is a Norse, or Greek, mill, of which there are no other known examples existing in Jordan today.

The wheel rooms are very small, and there are no wheels *in situ*, unfortunately; the arched entrances leading into them are constructed of finely cut limestone masonry, as is the remainder of the building apart from the more recent mud brick addition. The central mill room still has concrete millstones, as well as the metal frames supporting the millstones, *in situ*, suggesting that the mill was still in use up until fairly recently. It is difficult to determine whether this mill was a grain mill or a sugar mill; although there is no evidence today of the presence of an edge runner stone indicating the mill's function as a sugar processing installation, its situation at the bottom of the Jordan Valley- where other sugar mills in Jordan and Palestine are located- may be significant in that respect. The apparent lack of the different rooms necessary for processing sugar, however, suggests the former, although these may have been located at a site further away, as was the case with *Ṭawāḥīn al-Sukkar*. There has as of yet been no known published material on this particular mill, although Ruba Abu Dalu of the Department of Antiquities of Jordan has classified this mill as a sugar mill[30]; given its location (south of *Ṭawaḥīn al-Sukkar*}, and its architecture, this would seem a plausible suggestion for *Tall el-Ṭaḥūna*.

Kurdāna and Da'ūq: Fortified Mills

The conflicts and struggles not only between Crusaders and Muslims, but between Crusaders themselves are reflected in the nature of some of the buildings found in these frontier societies. In his comprehensive work on secular buildings in Palestine, Pringle mentions the existence of several mills, at least two of which are mentioned in the charters of the Crusades[31], as well as in treaties drawn up between Muslims and Crusaders.[32] One of these areas is *Kurdāna*, or the Crusader *Recordane*, located in the plains of Acre between the cities of Haifa and Acre. This mill is particularly interesting as it is fortified; fortified mills have not been found yet in Jordan or Cyprus. Perhaps it is evidence of the nature of social and agricultural life in a frontier society; the mill did pass back and forth from Crusader to Muslim hands, as well as being shared according to the stipulations of relevant treaties. The mill was also a point of dispute between Hospitallers and Templars throughout its life.

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[30] Abu Dalu 1995.
[31] Pringle 1997.
[32] Holt 1995.

Kurdāna (Crusader ***Recordane***) was, as discussed in Chapter Two, a subject of several disputes, not only between Crusaders and Muslims, but also between Crusaders themselves. This may explain the fortified nature of the mill, of which there appear to be very few examples in all three regions; no grain or sugar mill in Jordan or Cyprus has been provided with any defensive characteristics within the building. The value of sugar being high commercially, it is not surprising that a mill such as Kurdāna would have been equipped with fortified features, particularly as it was located in territory close to the frontier between Islam and Christianity.

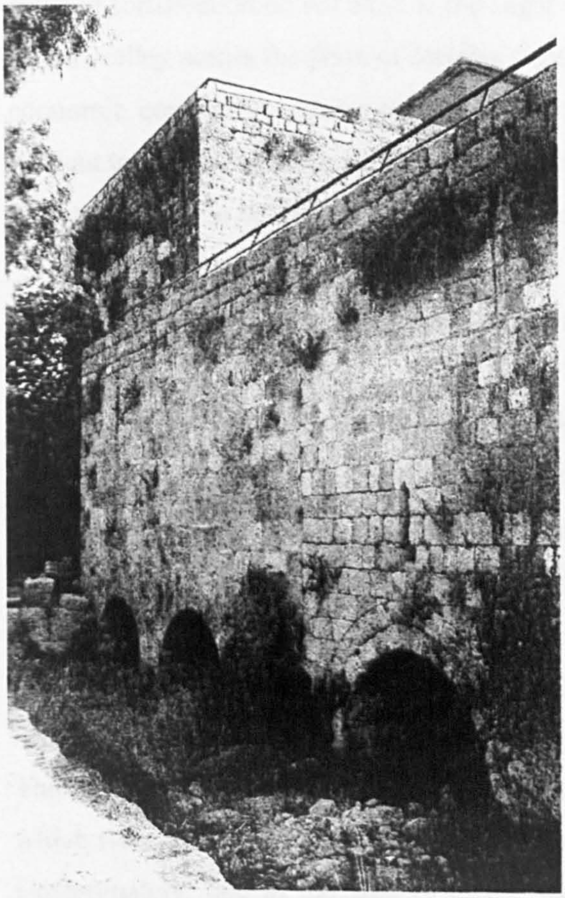

Figure 5. 63. View of multiple wheel chambers, Kurdāna. (From Pringle 1997)

The medieval mill consists of a tower and two wheelhouses, located at either side of the tower. Attached to the tower, to the west of it, is an oblong rectangular building housing four mill chambers; the southeast wall contains the mill chutes, and the wheel chambers are located at a lower level on the northwest side. On the other side of the tower stands another mill also attached to the fortified tower. Here, the wheel chamber and the "tunnel" are still extant along with the chute. **(Fig. 5.63)** Pringle has suggested that the wheels were horizontal, and not vertical, due to the position of the water-chutes, indicating the presence of a less efficient technology.[33] This is a possibility, as the sugar mill at Kolossi, for example, received water via an aqueduct from above, employing a horizontal wheel[34] ;

[33] Pringle, D. (2000) *Fortification and settlement in crusader Palestine*. Variorum: Aldershot, 69. This has been a debated point. Vertical wheels are efficient when turned by powerful currents, although large wheels with heavier machinery turn at a slower rate. Smaller horizontal wheels can rotate faster if the water hits it at a certain angle through a pressurized system. In theory, then, the most efficient way to power the mill would be to use a smaller, overshot vertical wheel, where a sharp stream of water can be directed at a more exact angle onto the wheel.

however, given the presence of a water channel running along the ground into the wheel chamber, an undershot or overshot vertical wheel may have provided greater efficiency. Its function as an industrial building can nonetheless not be disputed given the number of times conflicts occurred over the mill in a very short period of time.
The other fortified mill mentioned above was Daʻūq, located very close to Kurdāna. At Daʻūq unfortunately only the tower remains today, as well as some cisterns and chambers that may have been a part of the mill in its heyday. It is curious to note that signs of fortification do not exist in the sugar installation at *Ṭawaḥīn al-Sukkar*, in the Jordan valley across the plain of Jericho; considering that sugar was a highly valuable economic commodity during the medieval period and beyond, it would have been prudent to fortify the sugar mill to protect it from thieves and invaders. This, however, does not appear to be the case with *Ṭawaḥīn al-Sukkar*.

Grain and Sugar Mills in Jordan: A Brief Overview

The architectural features of grain mills in Jordan are, in general, similar across the study areas; in all areas, the standard composition of the mill was that of a penstock, mill house and wheelhouse complex, most commonly with a single penstock, though double penstocks were also present in two of the seven valleys that were surveyed. The building materials appeared to have been taken from the immediate area surrounding the mills, taking advantage of the locally available natural resources. This material was predominantly limestone, though in some cases basalt was also used. The masonry, which also varied in dimension and fineness, consisted of cut blocks, which were bound using mortar, with a rubble and mortar fill between wall sections.
Unfortunately, due to the lack of extant wheel and mill houses north of the Wādi Mūjib- the best examples taken from Ḥisbān and the restored mills in Wādi Sīr and Wādi Rayyān- it was difficult to determine the exact layout of the water mills in the ʻAjlūn and al-Ṣalt areas; in many cases, the use of abandoned buildings by Bedouin or farmers for their sheep and goat resulted in roughly rebuilt structures where it was difficult to see the pattern of ruination of the original mill. The restored mills, however, provide a general idea of what these mills may have looked like, even though there appears to be a slight variation in architectural features across the region;

[34] Aristidou 1983.

this can be most clearly seen between the mills in Wādi Wāla and Wādi Haydān, and the mills in 'Ajlūn. The 'Ajlūn and al-Ṣalt mills appear smaller in size, and take advantage of a steep gradient to gain their water supply, while the Ḥisbān and Wāla mills were built in similar styles- particularly the twin-penstock mills- using long mill races to bring water to the mills. This is almost unquestionably due to the nature of the landscape; although the valleys are roughly the same altitude (except for the Wāla/Haydān mills), ranging from approx. 550m to roughly 700m a.s.l, the mills in 'Ajlūn and al-Ṣalt are located in a narrow river valleys edged by woodland, while the Ḥisbān mills are dotted along a wider valley surrounded by farmland.

The Wāla mills, located at approximately between 420m and 220m a.s.l., also took advantage of the natural incline of the hills behind them, but here making use of long mill races stretching toward the Dhibān plateau, with the exception of WĀL5 and WH7, which were both located against a steep ridge. Here, there also appeared to be the greatest variation in architecture of the mills, the first three sites all showing different styles in construction, and state of preservation. The fourth site showed a uniform building style, using twin-penstocks and wheel chambers, and mill houses with barrel vaulted ceilings, in relatively good repair.

South of the Mūjib River, there appeared to be greater uniformity in architectural style- with the exception of Shawbak- although the concentration of water mills appeared less dense. The construction styles were similar both in the Sayl al-Karak and the Wādi Ibn Ḥammād, although again this was difficult to determine with any certainty due to the lack of standing remains, particularly in Wādi Ibn Ḥammād. The construction material was also similar, using limestone masonry with rubble and mortar fill and plastered millraces. The mills in the Karak area were located in similar altitudes, ranging from approximately 580m a.s.l. to 680m a.s.l. There was also a slight variation in the method water was supplied in both areas; while SK1 and SK4 received water from a long channel that passed along the foot of SK2 and SK3, these two mills received their water from the terraced wall located behind them. In Wādi Ibn Ḥammād, the first mill was set against the steep ridge leading up to the plateau, while the second and third mills were set against a gentle gradient, now cut by the main road. The Shawbak mill was different from the Karak mills, as it was built using limestone ashlar masonry, at the much higher altitude of ca. 1100m a.s.l.

The most common shape of the penstock chute was circular, varying in size from 50cm to almost 1m; there were two exceptions which had rectangular penstocks, and these were WĀL2 and SK1. It appeared that the mills which were set against a steep slope to gain their water supply had smaller sized chutes, while those that took advantage of a shallower gradient and a longer millrace had larger chutes.

Sugar mills varied more in construction between Palestine and Jordan. Apart from the fortified nature of some of the Palestinian mills, there was also a difference in the nature of the water supply and wheel mechanisms. *Ṭawāḥīn al-Sukkar* was similar in construction to many of the grain mills studied in Jordan, the difference being the size and position of the mill stones. However, it received its water through a penstock with a chute, while the Palestinian mills appear to have been turned by a supply of water entering directly into the wheel chamber, rather than from above through the use of a penstock. In addition, *Ṭawāḥīn al-Sukkar* appears to be smaller in size, with the sugar refining facilities located further away, whereas Kurdāna, for example, had the refining facilities on site. *Tall al-Ṭāḥūna*, if it indeed was a sugar mill, is also compact in size compared to Kurdāna, and there were also no visible supplementary factory buildings in which the sugar could be processed. This mill was also located against a steep hill, although there was no penstock here, and the channel led directly to the opening feeding water to the two wheelhouses. This makes *Tall al-Ṭāḥūna* a unique example of a Type 3 mill in Jordan.

SYRIA

Syria is a vast country with a varied landscape, stretching approximately 400km from north to south and 500km from east to west. The eastern half is a sparsely populated desert, while the region north of Damascus between Ḥoms and Aleppo is a blend of fertile mountains, valleys and plains. Two major rivers, the Orontes and the Euphrates, have been the natural base for human settlement throughout history and pre-history, and both regions have been subjects of much archaeological and academic interest over the last century. The focus in Syria will be on Damascus, and the relatively few mills that were visited there during the summer of 2004, and two examples from Misyāf (Central Syria) and 'Ayn Dera', near Aleppo. Previous research conducted on the mills of Ḥoms and Ḥama will also be reviewed.

Building No.: MIS ***Type:*** MIS1a/LMS, BAS II

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: Off main road, outside town of Misyāf, in the outlying village.

Landscape: Lush vegetation; mill located on banks of a full river, built on flat land.

Architecture: Built using a combination of limestone and basalt, and the stepped penstock and millrace were partly intact. The wheel chamber was not visible. A rectangular opening was visible in the eastern wall of the penstock, and could be a part of what used to be the mill house, which could be buried in sediment which has accumulated over the years.

Associated Structures: The millrace is set at a right angle to the penstock, and turns east away from the river, and continues for approximately 30m before it disappears. There are no visible signs of associated irrigation channels, which may indicate that this mill was one of a series of associated mills along the river, where the same channel may have been used to feed water to all the mills.

References: Unavailable.

Figure 5. 64. Remains of penstock and millrace, MIS1, near Misyāf.

Building No.: ALO ***Type:*** ALO1/LMS, BAS I

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: 'Ayn Deraa' is a village approximately 20km southeast of Aleppo.

Landscape: The mill was approximately 20m from the edge of the riverbank, which had been raised due to the bulldozing. A large amount of masonry rubble- almost certainly from the mill and mill channels- was scattered around the mill and in the surrounding fields.

Architecture: The penstock is partially extant; no other part of the mill remains. The construction material consists of limestone and basalt. The finely cut basalt had clearly been used to replace some limestone blocks in earlier renovations of the mill. The penstock chute was circular, approximately 1.5m in diameter, but as the top layers of masonry had fallen away here too the channel leading into the chute was no longer extant.

Figure 5. 65. Remains of penstock, ALO1.

Associated Structures: There is an Iron Age settlement on the tall next to the mill.

References: Gaube & Wirth found 59 mills in the city of Aleppo; how many were watermills is unclear.[35]

[35] Gaube & Wirth 1984; this is further discussed in Chapters Seven and Eight.

Ḥoms and Ḥama

Kamāl Shahāda provided an architectural and economic study on the watermills of the Ḥoms and Ḥama region in the 1970s[36]; other than the French study by Delpech *et al* on the water wheels of Ḥama, no other known published work exists on mills in Syria. In his surveys, he discovered there were several types of watermills in that region, primarily for processing grain. As well as the *arūbah* penstock type, he also provided examples of mills with vertical wheels (undershot), as well as undershot horizontal mills, which have as of yet not been encountered anywhere else in the Levant.

Ḥama

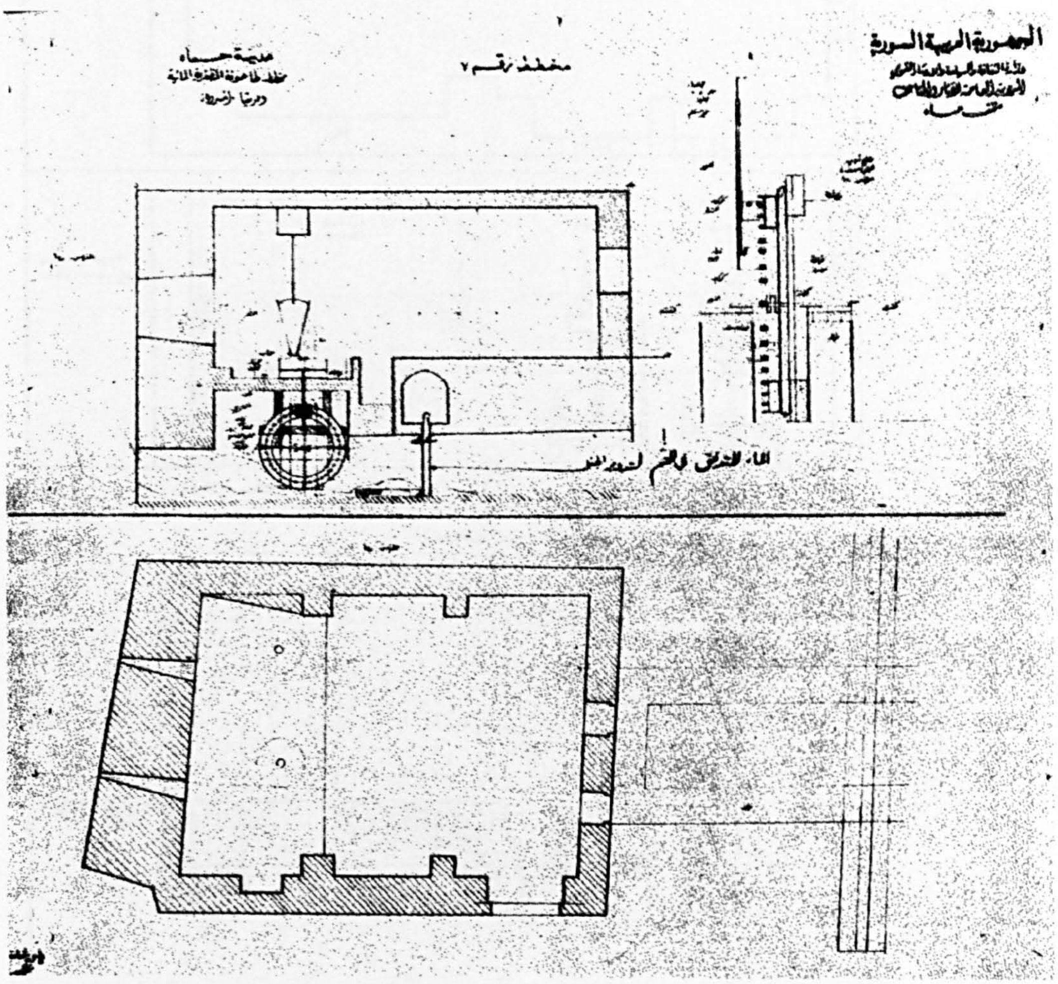

Figure 5. 66. Vitruvian-type undershot mill near Ḥama, Syria. (From Shah**ā**da 1973)

The mills described by Shahāda differ between Ḥoms and Ḥama; in Ḥama, the vertical wheel is employed in a similar manner to the *nā'ūra* used for irrigation, although the wheel for the mill is not as large. A smaller vertical wheel is attached to the millstones via gearing similar to the Vitruvian wheel. **(Fig. 5.66)** The wheel is driven by the current of the river, and thus needs to be situated on the banks of, or even in, a strong and full river.

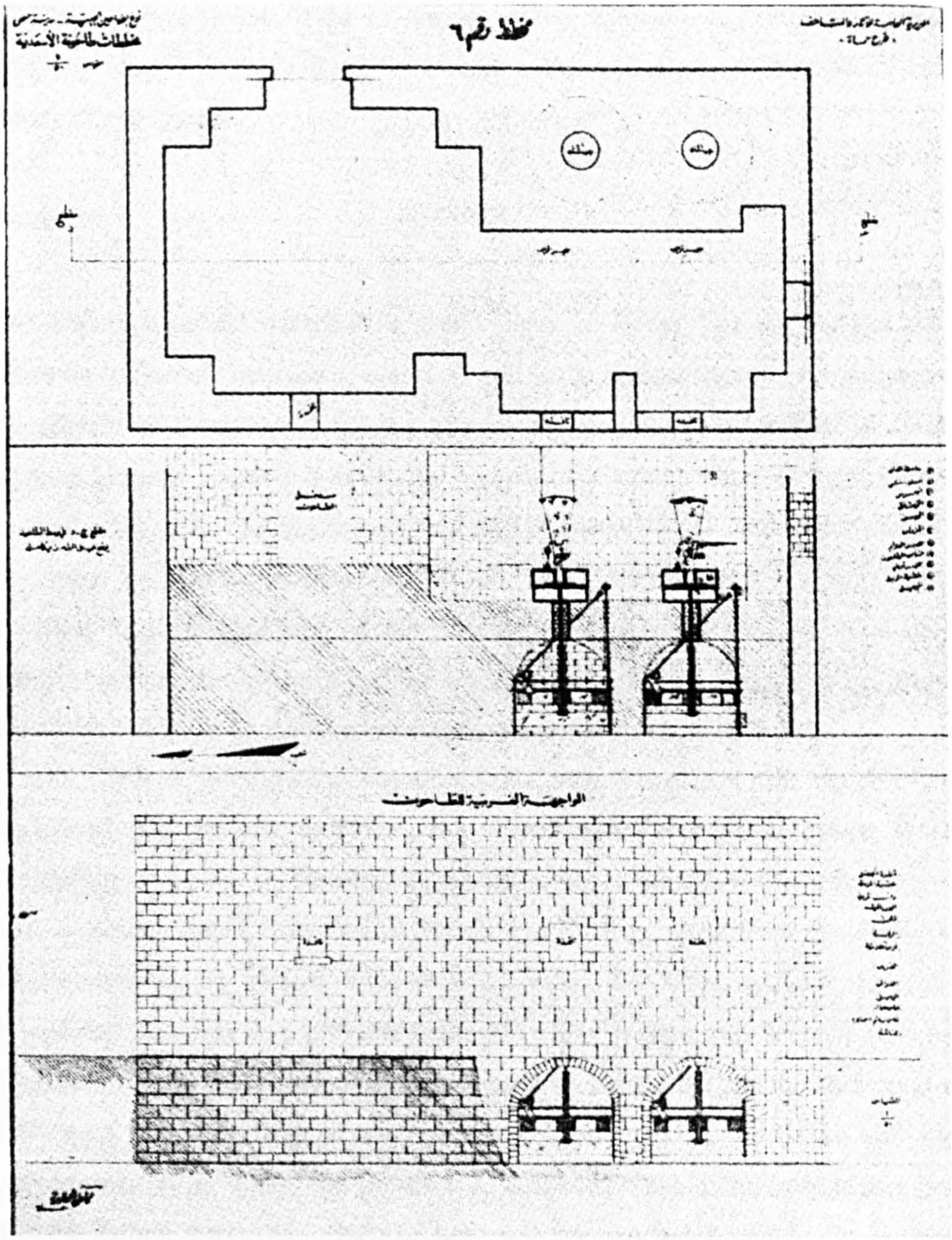

Figure 5. 67. Horizontal-wheeled mills driven by the river current, Ḥoms, Syria. (From Shahāda 1973)

[36] Shahāda 1974.

The actual milling technology does not differ; the millstones work in a similar manner to the *arūbah* penstock mill, with a hopper feeding the grain to the millstones. The size of the mill is noticeably larger than the simpler *arūbah* mill; the mill house is larger, as is the wheelhouse because of the more complex gearing involved to move the wheel. **(Fig. 5.66)** In addition there is a damming structure to increase the head of water as it approaches the mill, which forces the wheel to turn faster, making the grinding more efficient. This is similar to the mill-*nā'ūra* complex discussed in Chapter Four.[37] Shahāda does not mention the existence of horizontal- wheeled watermills in Ḥama.

Ḥoms

The horizontal-wheel watermill is predominant to Ḥoms, like the vertical wheel is common to Ḥama. One type of common mill is the horizontal-wheeled mill driven by the current of the river. This kind of mill has not been encountered in Jordan or Cyprus, perhaps because it needs the current of a strong river like the Orontes to move the wheel, as the vertical wheeled mill of Ḥama does; rivers of this size are few in Jordan or Cyprus, if they exist at all. The current-driven horizontal mill has identical basic mechanisms as the *arūbah* penstock mill, with no extra complex gearing like the vertical mill, and the wheels being attached directly to the millstones which are fed grain by the hoppers suspended above them. **(Fig. 5.67)**

Finally, Shahāda provides a description of the *arūbah* penstock mill, which is another horizontal mill present in Ḥoms, but is not mentioned as a feature in Ḥama. According to the sketch provided by Shahāda, the construction of the Syrian *arūbah* mill is almost identical to that of Jordan and Cyprus, apart from the chute, which narrows towards the bottom of the penstock, rather than being cylindrical all the way. In addition to acting as a pressure tank, this added feature may serve to increase the pressure of water at the bottom of the penstock as it exits and hits the horizontal wheel. Otherwise, the mill functions in the same manner as its Jordanian and Cypriot counterparts. **(Fig. 5.68)** The presence of different types of mills indicates perhaps that the natural resources influenced how man constructed the mills; the vertical mill in Ḥama may have taken after the *nā'ūra* that was used for irrigation, the machinery

[37] See Chapter Four, p.83.

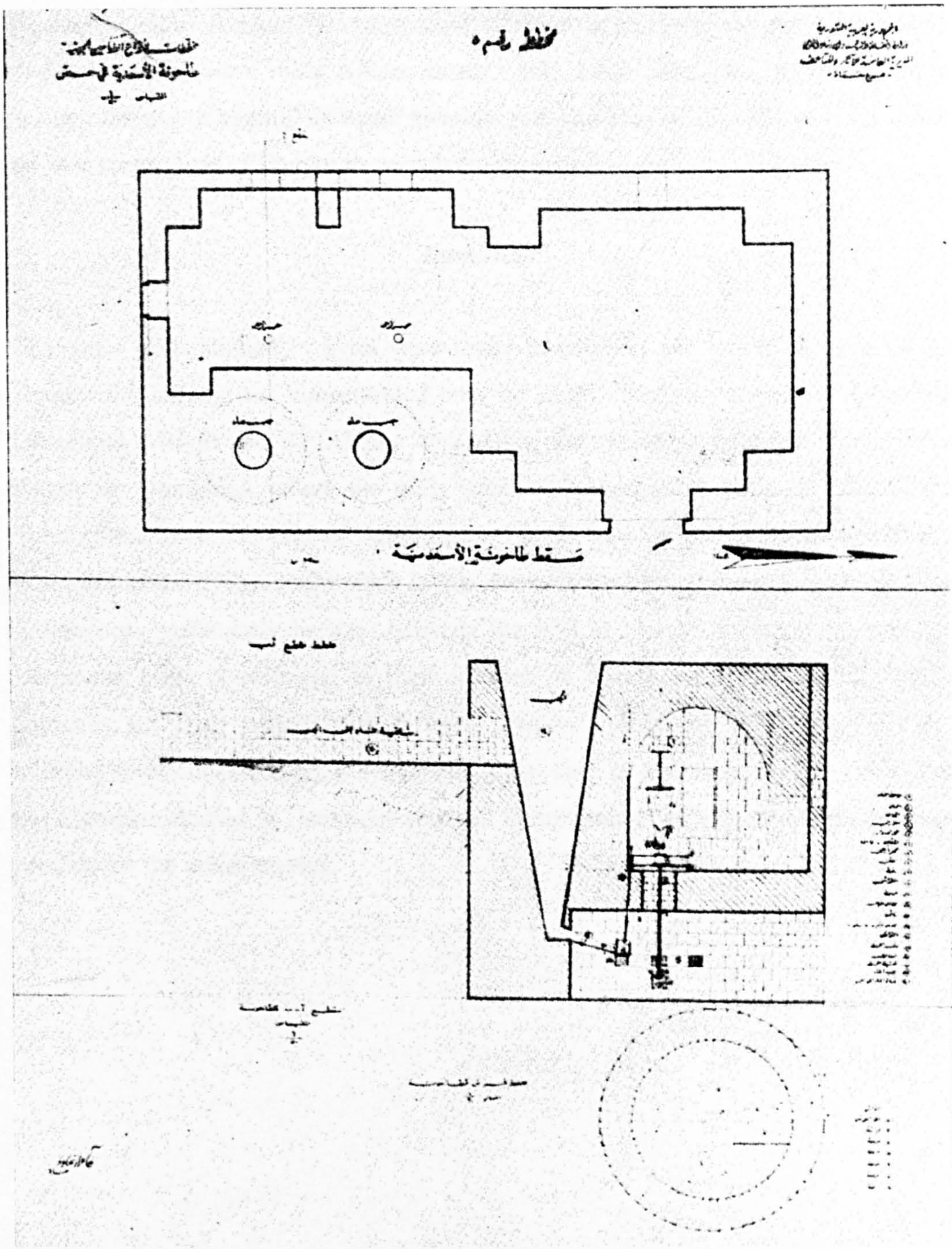

Figure 5. 68. ***Arūbah*** **penstock mill, Ḥoms, Syria. (From Shahāda 1973)**

being adapted to becoming a milling mechanism. The horizontal current-mill in Ḥoms may have been designed using a similar approach, the difference being that the wheels were horizontal, and not vertical, possibly being situated near a smaller river and being powered by a weaker current than the vertical wheel. The *arūbah* mill, of course, took advantage of long channels, dams and a penstock to power the milling mechanism, thus it could be constructed where a large river was not immediately available. These rural mills adhere to the same basic principles of milling grain through the use of slightly different technologies; this may also be the case for urban mills, such as those of Damascus, which are discussed in the following section.

Damascus

The water mills studied in Syria were fewer in number, and due to the size of the country the survey was concentrated only on areas visited in three trips including Damascus, Misyāf and the Aleppo area. Thus, the examples provided above focus mainly on Damascus, where the mills were easily accessible with the help of the Syrian Directorate-General of Antiquities. The problem with having studied fewer examples in the Syrian countryside is that one may assume perhaps to easily that the differences- particularly in size- between the mill at Misyāf, for example, and the Damascus mills is reflected in their location in a rural or urban setting, where demands for flour would have differed greatly, influencing the technology and building style considerably. Whether this is the case or not, there is little doubt that the examples studied in Damascus were all of an "industrial" nature which served to provide for the urban masses.

Building No.: DAM 1 ***Type:*** DAM3/LMS III

GPS Coordinates: Unavailable. ***Elevation:*** Unavailable.

Location: DAM1 is located within the old city wall, near the east gate of the citadel, the Bāb al-Faraj.

Architecture: The mill rooms have vaulted ceilings with multiple chambers. The roof is partially collapsed, but there are 2 five-arched bays with large rectangular windows. The arches are of dressed limestone masonry. There are 2 niches facing toward Bāb

Figure 5. 69. Facade of DAM1, situated on the Barada river.

al-Faraj, whose purpose is still unclear. The floor was mainly covered in sawdust and collapse from the ceiling, but one round hole for the millstone was visible in the floor. Approximate dimensions of the mill house are 25m long by 15m wide. It has also seen a lot of rebuilding, in concrete as well as brick and tile. The ceilings were of timber, mud and straw matting, in a similar fashion to Anatolian houses of the Ottoman period, and the rural village architecture of Jordan and Cyprus. **(Fig. 5.69)**[38]

The lower level, which was the wheel chamber, also had vaulted ceilings, with multiple arched doorways and rooms. The slots through which the water entered were

[38] The photographs in this section were kindly provided by the Syrian Directorate-General of Antiquities and Museums.

clearly visible, although confusingly they were not all located in alignment with each

Figure 5. 70. Inside of mill rooms, DAM1.

other; a concrete or stone channel ran through the centre of the wheelhouse. There were arrow slits above the water slots, perhaps to fight off any attacks by thieves trying to divert the water. A similar fortified mill is located in Palestine, at the site of Kurdāna (Crusader *Recordane*). Fortified mills are further explained in their own section. **(Fig. 5.70)**

Associated Structures: Water enters from a wide canal parallel to the river through long, vertical slots below the mill house. The strong current from the wide channel- it is actually a narrow channel approx. 4m in width before it opens to about a 12m width when it reaches the mill, thus building up momentum- turns the vertical wheels situated inside the wheelhouse below the mill rooms.

References: Ibn ʿAsākir mentions the existence of a mill near Bāb al-Faraj in the $6^{th}/12^{th}$ century.[39]

[39] See Chapter Two, p.28.

Building No.: DAM 2 ***Type:*** DAM3/LMS IV

GPS Coordinates: Unavailable. ***Elevation:*** Unavailable.

Location: DAM2 was also located within the walls of the old city, near Bāb al-Salām.

Landscape: The mill was situated near the river, but not directly on it; development of the old city around the mill, as well as a shifting river course, puts it at a rather

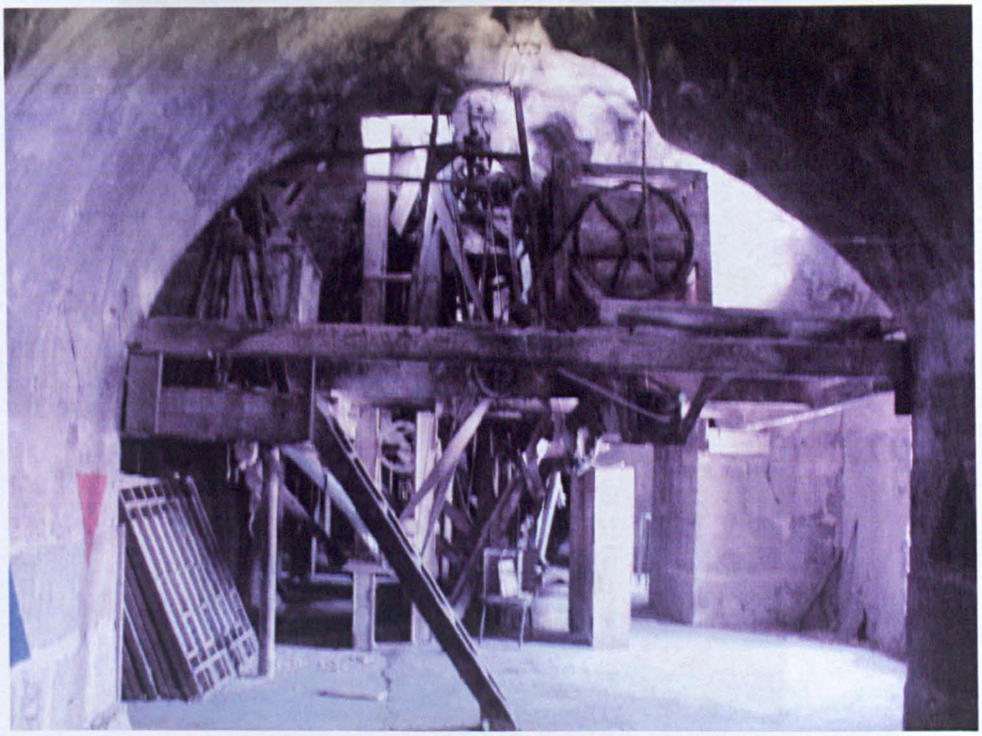

Figure 5. 71. One of the bays with the milling installations in place, DAM2.

unusual position today in relation to its water supply. This is not much different from the situation of DAM1.

Architecture: Upon entering the mill, a long cross-vaulted, or groin vaulted, bay was joined to five single bays along the western wall; each of these bays measures approximately 10m long, and rectangular openings were present in the vaulted ceilings, presumably for the wheel beams connecting to the grinding stones above. The fifth bay still had remnants of a diesel pump, and was walled in, as was the fourth bay, which was inaccessible. All bays had stairs leading to a mezzanine level, where the milling had taken place. There were remains of ten channels running into these chambers, to lead water in to drive the vertical wheels; each bay would thus have had two wheels to drive the millstones above. It can be assumed that this mill was therefore an industrial mill supplying a large part of the old city with its flour. **(Fig. 5.71-5.73)**

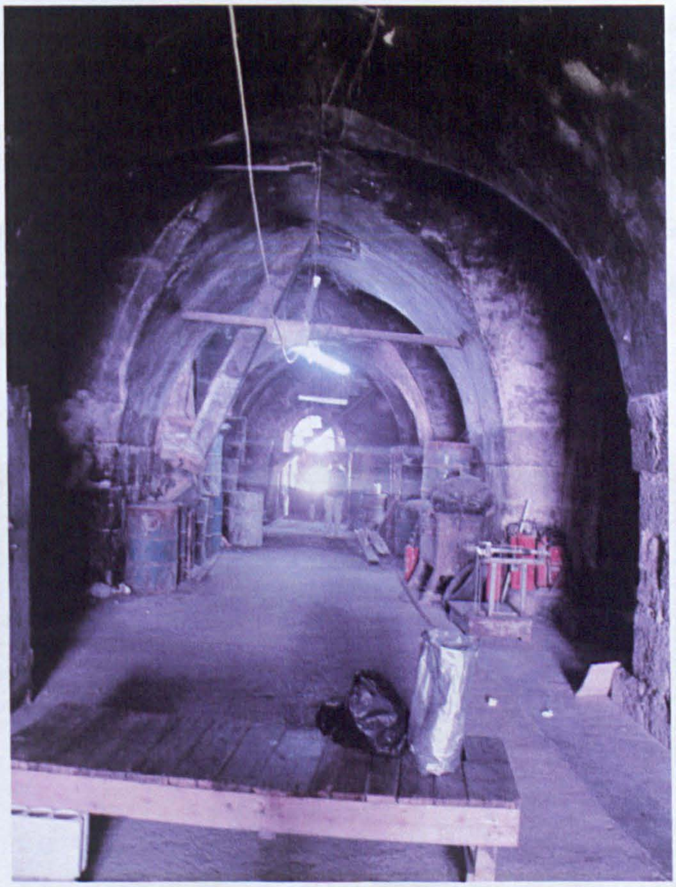

Figure 5. 72. View into wheel rooms from entrance, DAM2.

The construction material was of cut limestone blocks, ca. 40cm x 50cm in dimension; the cross vaulted ceilings were reminiscent of a pre-Ottoman architectural style, perhaps Mamlūk or even Ayyūbid, but the owner claimed the mill to have been built in Roman times. There were clear signs of rebuilding, on both floor levels, particularly with the later addition of the mezzanine level and the renovation of the upper level, and particularly the roof and arrow slits may have been later additions to the mill.

In addition to this, however, a separate set of stairs led up to a large room above, sectioned off by 2 walls. Large milling installations were still in place there, with pulleys, drums, and hoppers still *in situ*, indicating that this mill was in use until relatively recently. The layout of these rooms was similar to the lower level, except the bays were connected by open arches rather than being walled off. The walls on this level were covered in plaster, and the ceiling was a timber and slat type. A small terrace joined the exit of the upper level, and a set of stairs led down into another large room with high ceilings, which was being used for storage. This room was also clearly a later addition to the original mill, and may have served as the storage area for the large amount of grain that the mill would have needed to process during its life.

Associated Structures:.Each bay on the lower level had an emplacement for the water to enter in the form of a narrow channel.

References: Ibn ʿAsākir makes mention of a mill near Bāb al-Salām; according to the owner of the mill a German team had surveyed this building the previous year, although no pulished material has been found so far.[40]

Figure 5. 73. Modern rotating belt system, powered by diesel, with large hopper next to it.

[40] See Chapter Two, p.28-29.

Building No.: DAM 3 ***Type:*** DAM3/ LMSII

GPS Coordinates: Unavailable. ***Elevation:*** Unavailable.

Location: Located in Zabladāni/Burj Rūs near Bāb Tūma.

Landscape: Off main Bāb Tūma road, immediately on the river.

Architecture: This mill was reasonably well preserved, although the upper mill room had collapsed into the lower room. The ceiling was also collapsed. Most of the rubble had been cleared to the side, and it appeared as though some restoration work was about to take place. Upon entering the mill through a fine archway, a courtyard appeared, around which two storage rooms with high ceilings were located on the right hand wall. To the left of the entrance was another room, followed by a set of stairs leading up to the miller's house. The adjacent wall also had a room. Directly across the courtyard from the entrance a large *iwān* was visible, leading to a cross vaulted room approximately 20m x20m. There were three arched bays with a window in each wall set in a blind arch. The masonry was dressed limestone, 20cm x 30cm, slightly smaller than the masonry of the previous two mills. The wheel chamber was just visible, although it was severely flooded by the rising river. One could just see the

Figure 5. 74. View of collapsed mill house, DAM3.

top of the cross vaulted ceiling above the high water. A metal wheel was located in a corner, and rectangular openings similar to those in DAM2 were visible in the floor above the wheel chamber. A second wooden wheel was located on the upper level. The ceiling, which was almost completely collapsed, was of timber and slats; the walls inside the upper level room were plastered. Unfortunately, the miller's house could not be accessed because the wooden stairs leading up to it had collapsed.**(Fig. 5.74-5.75)**

Associated Structures: Miller's house is a part of the mill complex.

References: Ibn ʿAsākir and Ibn Shaddād make references to a mill near Bāb Tūma; the name of the mill was "al-Hallāq", or hairdresser. Perhaps the previous owner of the mill was of this profession.

Figure 5. 75. Inside of two-storey mill house, DAM3. The remains of a wooden wheel were located on the second floor.

Building No.: DAM 4 ***Type:*** DAM4/LMS IV

GPS Coordinates: Unavailable. ***Elevation:*** Unavailable.

Location: Located in Kiwān, about 5km northwest of the Old City.

Landscape: Residential and industrial surroundings.

Architecture: This mill was the largest seen yet- at least three storeys high, not counting the lower basement rooms which were inaccessible due to flooding from the river. It was also the most visibly modern mill, although it certainly had earlier foundations and had seen a lot of reconstruction and renovation. Both the modern and

Figure 5. 76. View of earlier mill room, DAM4.

the earlier parts of the building were still in good condition, but that is not surprising if the mill was still in use until ten years ago, as one of the caretakers there claimed. The caretaker put the age of the mill at 60 years, which would put the date of its construction in the 1940s, when Diesel powered mills rather than water powered mills were already being used.

Access to the mill is through an arched entrance way into a cross vaulted narrow bay, which is clearly an earlier part of the building, possibly dating to the Ottoman period, but may be even earlier. This extends for about 10m and opens into a series of rooms; there are two large connected rooms to the right, which have similar cross- vaulted ceilings and are clearly contemporary with the entranceway. These rooms measure about 20m in length and 10m in width in total. To the left, two even larger rooms with high ceilings are located. Stairs lead up to the room above, which has several milling installations. There are several more staircases and rooms located in the storeys above, which serve similar purposes.

The earlier foundations of this mill can be seen through a closed gate at the back of the modern mill; the usual slots for the water to enter into the wheel chamber were present, and it was clear how efficient this system would have been as the volume of water rushing through was immense at the time of the visit, which was the otherwise dry summertime of Damascus. A bridge crossed over the river to the front entrance of the modern mill, and the arches to the wheel chamber could be seen peeking out from the floods of water. **(Fig. 5.76-5.77)**

Associated Structures: A bridge connects the residential area to the mill.

References: The name of the mill was "al-Thayhāq".

Figure 5. 77. Modern mill room with milling installation, DAM4.

Building No.: DAM 5 ***Type:*** DAM5/LMS III/IV

GPS Coordinates: Not available. ***Elevation:*** Not available.

Location: Located in the suburb of Dūmar, roughly 8km to the northeast of the old city, next to the main road.

Landscape: Orchards and gardens.

Architecture: The inside of it was inaccessible because the caretaker was not present, but a large structure was visible from the road. It also had clear earlier foundations with modern finishes to it. The lower level of the mill was constructed using dressed limestone masonry blocks, approximately 20cm x 30cm in dimension. In the upper level, which was modern using similar construction as DAM5, the modern machinery could still be seen *in situ* as the walls and ceiling had partially collapsed. This mill was probably in use at the same time as DAM5. **(Fig. 5.78)**

Associated Structures: There were seven slots for the water to enter through; the

Figure 5. 78. View of facade of DAM5; the modern addition has been constructed over the earlier mill.

water was channelled through a wide canal in a similar style to DAM1, narrow at first and then widening to feed the mill. These slots had been reinforced with cement buttresses. There were three windows above them but these had been blocked with breezeblocks.

References: None available.

Watermills in Syria have not been studied in a wider context, and the previous information provided on a handful of these mills does not attempt to place them in as detailed a context as Jordan and Cyprus. Syria is a much larger country than both Jordan and Cyprus, and distances between rural and urban settlements can be vast; in addition, as the study of archaeology is a far more sensitive and politicised issue in Syria access to certain sites can be difficult. It has thus been more difficult to conduct studies there, than in Jordan or Cyprus.

As the nature of the Damascus mills is so different from the ones in Jordan and Cyprus, their setting is naturally also different. The Damascus mills rely on a strong river with a great volume of water to turn the wheels, while the mills in Jordan and Cyprus rely on a channel system and water transportation network in order for them to be fed from above, not from below. This is expected, as the size of the wheels present in the Damascus mills would have been larger than the smaller wheels in Jordan. The landscape surrounding the Damascus mills is therefore also quite different; there is no need for them to rely on slopes to further the momentum of water, as may be the case for other mills. Terracing and agricultural areas need not be a feature in the mill landscape of Damascus, either, as the mills rarely interact with an irrigation system. This would explain the presence of watermills within the old city walls, where there would have been little room for agriculture. It must be reiterated here that the scale of the Damascus mills compared to its rural counterparts speaks alone for the scale of production, necessary to supply a large, urban population. The Jordanian and Cypriot mills appear somewhat "provincial" in scale, their efficiency perhaps sufficient for supplying smaller towns and villages, with much smaller scattered populations.

Mills with the ***arūbah*** penstock appear to be a frequent occurrence in the Syrian countryside, like Ḥoms, but not in urban areas such as Damascus. Further north, however- in particular around Aleppo and Misyāf- the architectural features are more similar to those found in Jordan and Cyprus. There may be several explanations for this; the region is equally abundant, if not more, in waterwheels, and the ***nawā'ir*** have a role to play concerning the water-driven grain mills, as discussed in Chapter Four. An ***arūbah*** penstock would not be necessary if the mill were to have a guaranteed supply of ample water to power the mill wheel, which could be almost certainly guaranteed by the vast volume of water provided by the Orontes River for most of the year, particularly around Ḥama and Ḥoms. This could be provided by the *nawā'ir* along the river; as well as irrigating the agricultural lands, it is possible that some of the water harnessed by the large turning wheels could be channelled off into *qanawāt* leading to mills further away.

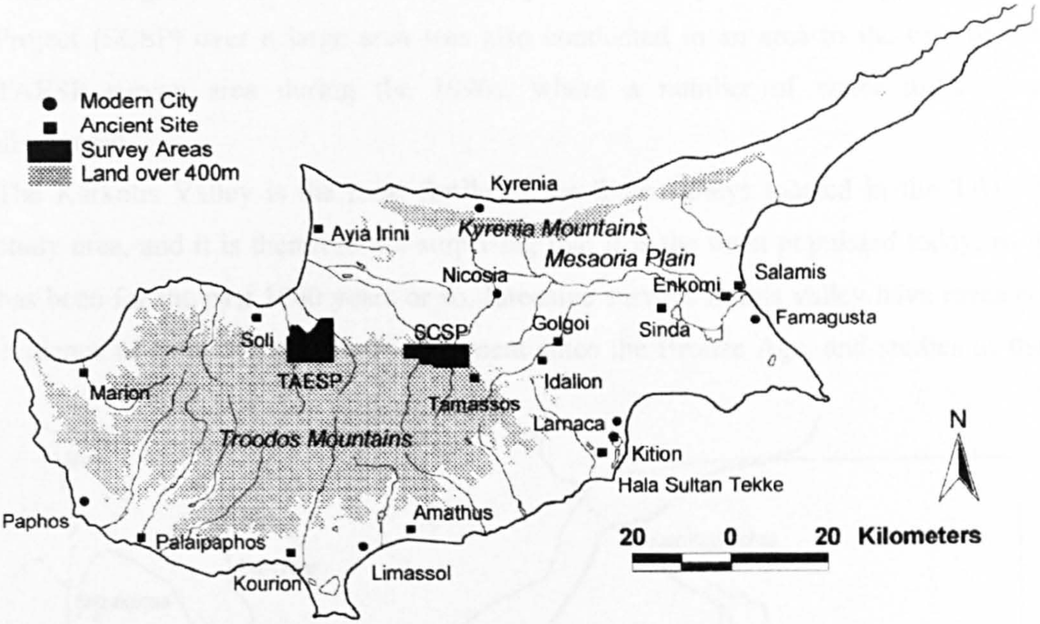

Figure 5. 79. Map of Cyprus showing TAESP and SCSP study areas and major towns.

CYPRUS

The aim of this section is to provide a series of case studies from Cyprus as a part of the Levant, which can be compared to the case studies of Jordan and Syria. A summary of all the watermills studied in the TAESP survey areas will be provided. They are not listed in order by the assigned TAESP catalogue numbers, but by valley, like the watermills of Jordan and Syria were listed. The information will include observations on architectural elements, dimensions, location and where available, local information regarding the watermills. As an extensive photographic record for the watermills exists in the TAESP photographic archive, only photographs of watermills of particular interest will be included in this chapter.

TAESP conducted intensive survey seasons of an area of the northern Troodos mountain range between 2000 and 2003. This area of Cyprus had previously not been studied to a great extent. An intensive survey conducted by the Sydney Cyprus Survey Project (SCSP) over a large area was also conducted in an area to the east of the TAESP survey area during the 1990s, where a number of water mills were discovered.[41]

The Karkotis Valley is the most fertile of the three valleys located in the TAESP study area, and it is therefore not surprising that it is the most populated today, as it has been for the past 1000 years or so. Intensive surveys in this valley have revealed evidence of an active pattern of settlement since the Bronze Age, and studies of the

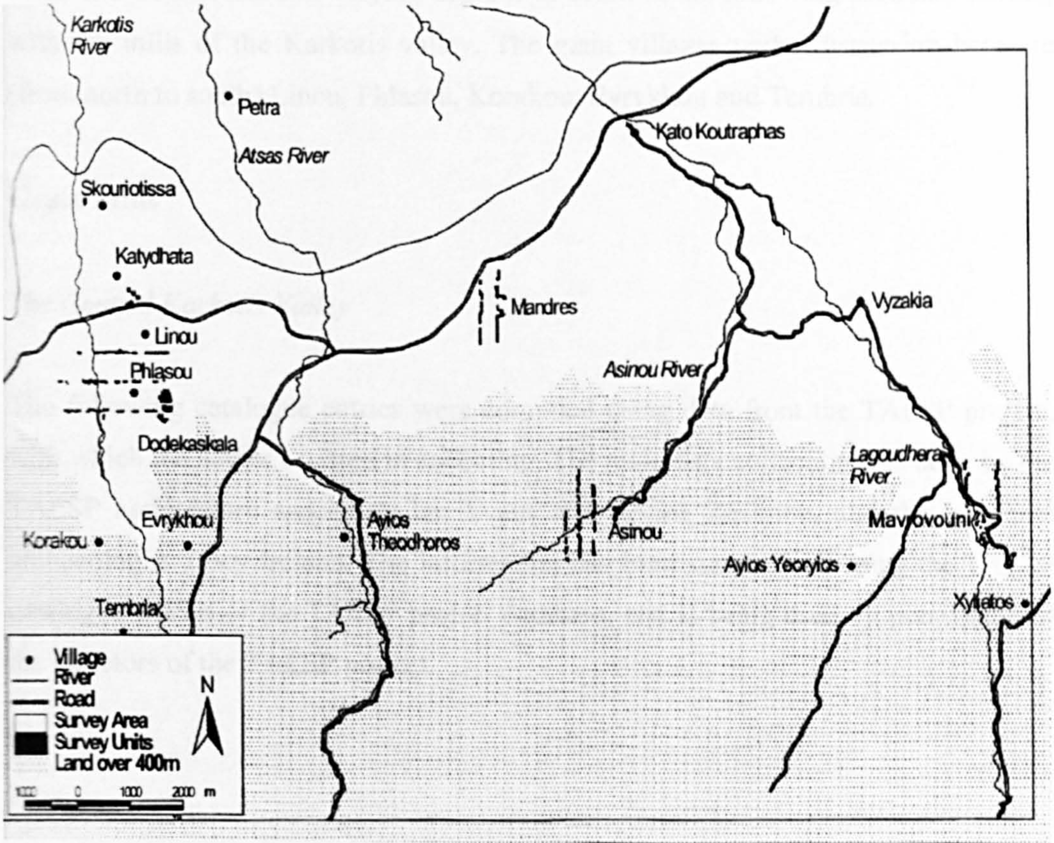

Figure 5. 80. Map of TAESP survey area, with relevant villages mentioned in this work.

41 Given 2000, 225-227.

geomorphology of the island have equally revealed evidence of agriculture and land use throughout these periods of settlement.

The Lagoudhera and Asinou valleys to the east are less fertile and more arid, yet they are also home to a number of water mills in the TAESP area. Of these, the Lagoudhera valley-the more fertile of the two- hosts 5 watermills, located near Vyzakia and Pano Koutraphas. A single structure which may be a mill has been located in the Asinou valley, although its function is still speculative. The Asinou valley- despite its settlement history- is probably the most hostile environment of the three valleys; the landscape consists mainly of wooded mountainous areas not conducive to land use or settlement.

The area covered in this study can be seen on the map **(Figs. 5.79 and 5.80)**; 25 watermills were recorded in all three valleys between 2001 and 2004, and most of these will be discussed in varying degrees of detail in the following sections, starting with the mills of the Karkotis valley. The main villages under discussion here are (from north to south) Linou, Phlasou, Korakou, Evrykhou and Tembria.

Grain Mills

The Central Karkotis Valley

The following catalogue entries were compiled using data from the TAESP project, with which the author assisted in collecting. The main data collection was done by the TAESP architecture specialists Ian Evans and Sevina Zesimou, and the historical archaeologist Tracy Ireland. The information has been summarised using the TAESP catalogue entries of the TAESP project database, and is being used by permission of the directors of the TAESP project.

Building No.: BU002 ***Type:***(K) BU002,1a/LMS III

GPS Coordinates: E 490497 N 3881818 ***Elevation:*** 291m a.s.l.

Location: Situated ca. one mile south of Katydhata, outside village of Linou, near the Skouriotissa mines.

Landscape: Built taking advantage of a natural bedrock spur. Set in olive groves. Stream nearby.

Architecture: Penstock is intact, but cut by road leading to Katydhata; any remains of leat are no longer visible. The wheel chamber is visible, but there is no sign of a wheel *in situ*. The construction material consists of lime wash on top of a lime and brick mortar. Northeast penstock face is of dressed ashlar courses and river cobble masonry half way down. Only a part of the mill race and the 6m high penstock tower survive. The interior of the penstock chute is of a smooth greyish-white plaster. The corner quoins of the penstock have also been quarried. The exterior south wall has crumbled at the base revealing inner plastered wall. This mill is also said to have belonged to Ahmed Agha.

Associated Structures: BU003 and BU004. Water supply consists of earthen irrigation channels along the edge of the orchards combined with concrete channels running between the orchards. The channel network is a combination of open and closed channels.

References: Oral information provided by Mr. Styllis, Evrykhou miller (owner of BU0049) and Mr. Andreas Shizas from Katydhata; the mill was one of seven mills owned by Ahmed Agha (Turkish Cypriot).

Building No.: BU003 ***Type:*** (K) BU003,1a/LMS II

GPS Coordinates: E 490593 N 3881901 ***Elevation:*** 276m a.s.l.

Location: Approximately 200m along the secondary road from BU002.

Architecture: Constructed using roughly coursed masonry on bedrock, overlaid with thin pinkish-white lime plaster. There were slots within the masonry perhaps for beams. The height of the millrace ranges from 1 to 10m in height as it is set on a slight slope; the penstock is 10m high. A section of the millrace has collapsed before the penstock and it appeared on closer examination that there had been an arch which had caved in. An arch springer was barely visible jutting out above the fallen masonry. Another arch springer was located on the lower side of the north face of the penstock, and in the right light, Arabic script could barely be seen. This mill also belonged to Ahmed Agha, who according to local farmers owned at least seven mills in this area. **(Fig. 5.81)**

Figure 5. 81. View of remains of millrace and penstock, BU003.

Associated Structures: BU002 and BU004, and water channels described in previous entry.

References: As previous entry.

Building No.: BU004 ***Type:*** (K) BU004,1a/LMS II

GPS Coordinates: E 490755 N 3882060 ***Elevation:*** 269m a.s.l.

Location: 200m down from BU003.

Landscape: Adjoining gravel road had destroyed the millrace, now 20m in length, and therefore only a small section of the leat remained intact.

Architecture: The 5m high penstock in good repair; an arch supports a large part of the remaining section of the millrace. Basalt masonry also covered in a pink plaster. Beam slots are also present in masonry. **(Fig. 5.82)**

Associated Structures: Channel system, as described in the previous entry.

References: As BU002.

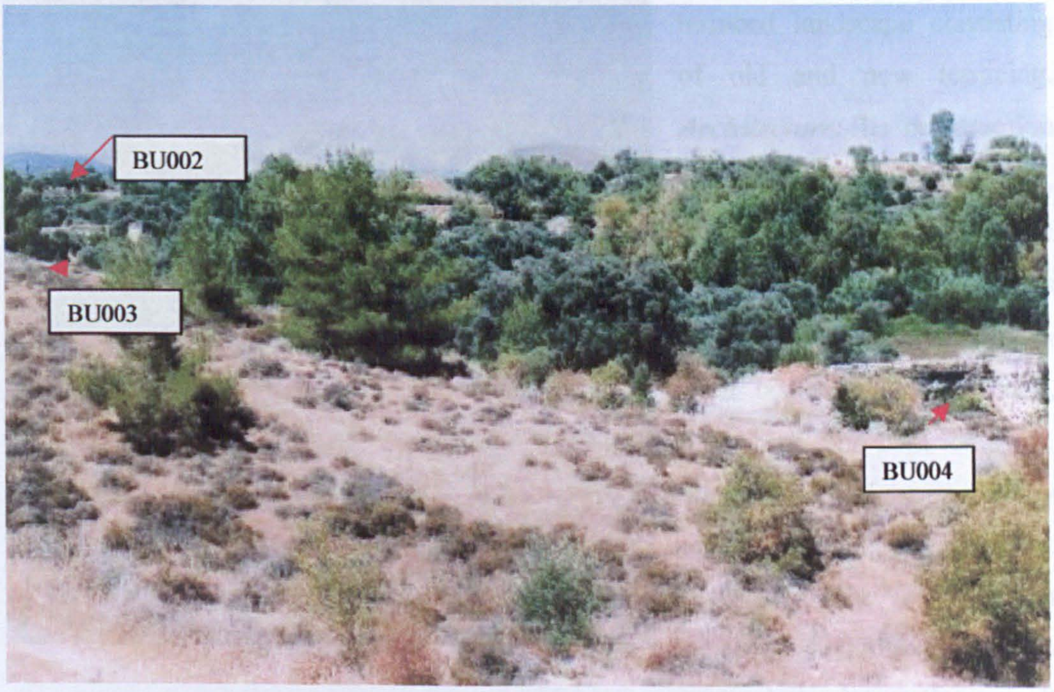

Figure 5. 82. BU002, BU003 and BU004 in relation to each other.

Building No.: BU0044 ***Type:*** (K) BU0044,1a/LMS III

GPS Coordinates: E 489334 N 3882064 ***Elevation:*** 254m a.s.l.

Location: Located northwest of the pink-plaster mills, near the gravel road leading west from Katydhata village to the Skouriotissa mine, on the east bank of the Karkotis River.

Figure 5. 83. Penstock and wheel chamber, BU0044.

Landscape: Running from east to west, the mill is situated in an extensively terraced landscape consisting of old and new terracing. ***Architecture:*** Its construction is of rubble in rough courses, with stone foundations; a soft pink lime plaster finish covers the exterior. Similar beam slots occur in the penstock, 6.7m high, and 29m long leat, which is partially supported by an arch abutting the penstock. Unusually, the arch has a keystone. This mill is particularly interesting, as it still has the wooden wheel *in situ* in the partially ruined wheelhouse beneath the mill; the mill house has collapsed, but the millstones can still be seen in situ above the wheel. **(Fig. 5.83)**

Associated Structures: The penstock outflow does not run into the river, but leads into a channel. An elaborate concrete channel network runs along the gravel road and into the cultivated terraces, and the millrace may have been a part of such a network in earlier times; it widens considerably and may once have been a bifurcate channel leading off into different directions of the orchards and groves.

References: This mill is also one of the seven mills belonging to Ahmed Agha.

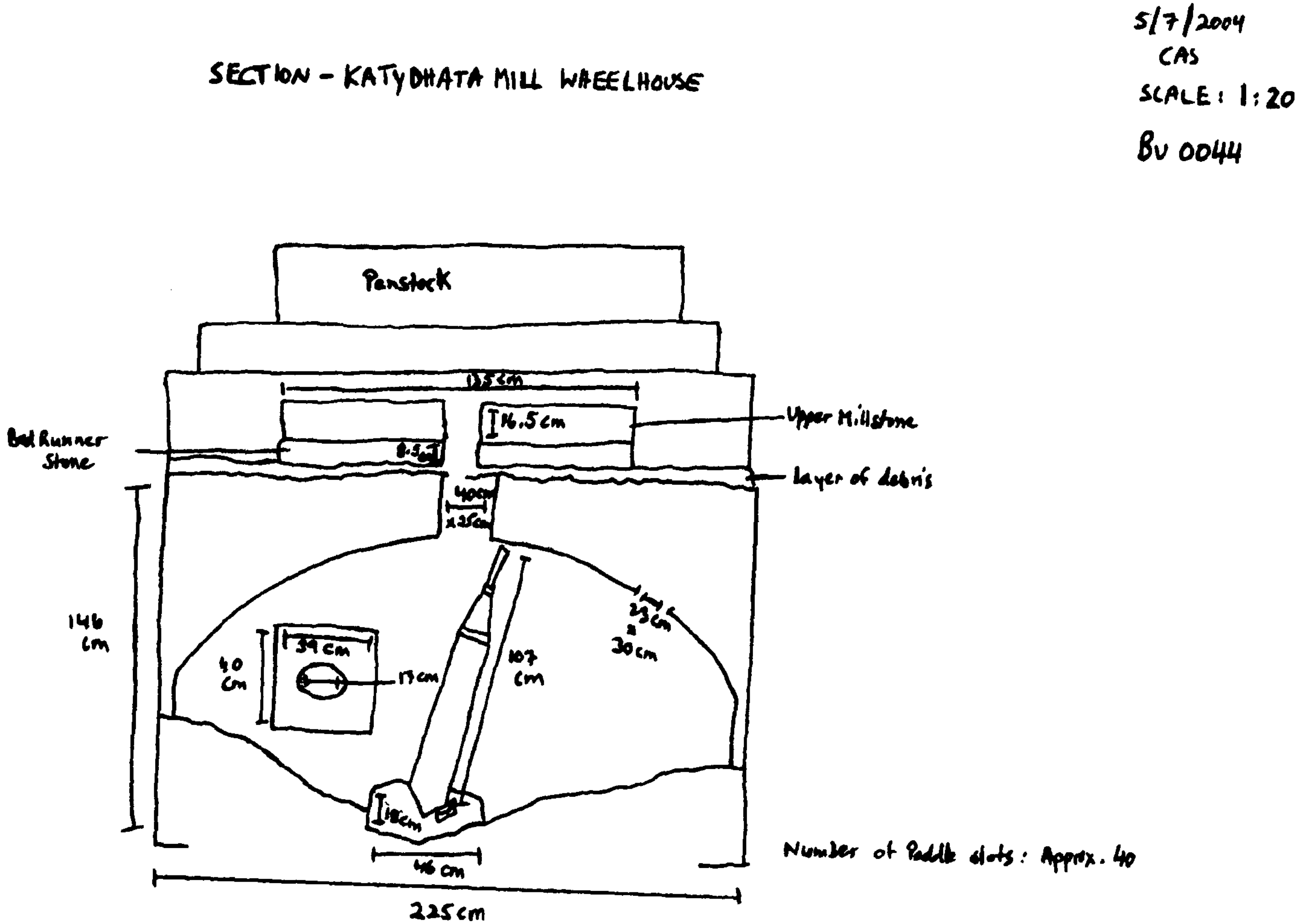

Figure 5. 84. Sketch of wheelchamber with *in situ* wooden wheel, BU0044.

Building No.: BU0053 ***Type:***(K)BU0053,1a/BAS-LMS/II

GPS Coordinates: E 491158 N 3882602 ***Elevation:*** 239m a.s.l.

Location: This mill is also located in Katydhata, adjacent to the Skouriotissa mine waste dump, northwest of the Aya Saranta creek. Access to this mill is via dirt road leading from Katydhata village. Its name is Mylos toy Ahmed Agha.

Landscape: Mines and wheat fields.

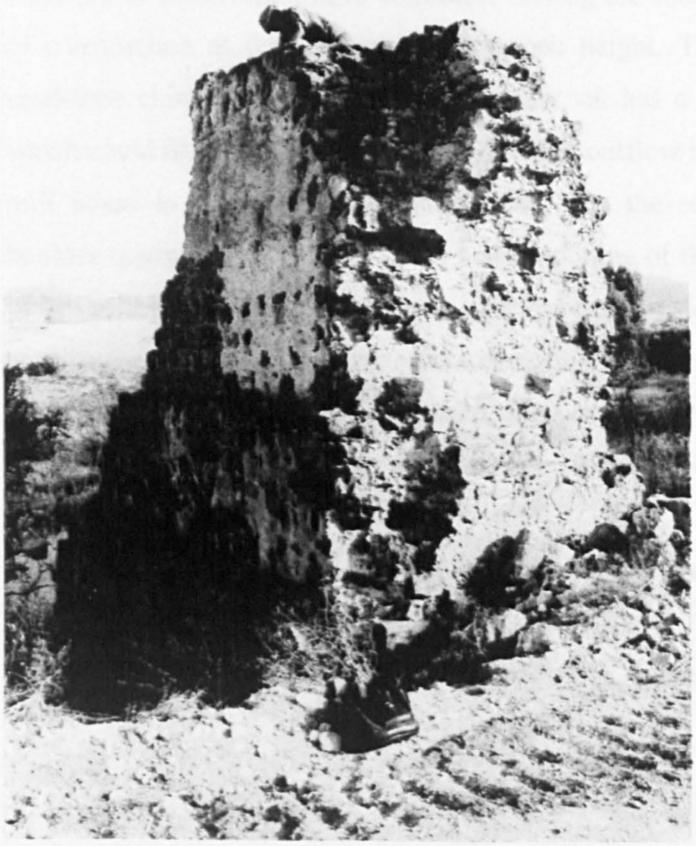

Figure 5. 85. Remains of penstock, BU0053.

Architecture: The penstock and mill race are visible, but the bulldozed dirt track has destroyed what may have been an arch carrying the leat to the penstock. The penstock is two-tiered on the north east and southwest sides, and four-tiered on the southeast face. Construction material is of irregular basalt rubble with some coursing using large stones as edging at the top of each tier. There is basalt and limestone chinking in the plaster. The penstock base measures 4.2m x 7.9m, and the millrace is 11.5m long by 1.45m wide; the channel width is 0.55m. The section demolished by the road is 9.5m long; the leat curves and is wider at the highest gradient of the hill before it straightens in the approach to the penstock. **(Fig. 5.85)**

Associated Structures: Possibly BU0059.

References: The owner was a Turkish *Cypriot* named Ahmed Agha, and according to the miller of the mill in Evrykhou, this mill is also one of seven mills in Ahmed Agha's ownership.

Building No.: BU0059 ***Type:*** (K) BU0059,1a/BAS I

GPS Coordinates: E 491426 N 3882699 ***Elevation:*** 217m a.s.l.

Location: This mill is located approximately 50m down from BU0053.

Landscape: There are barley fields to the north, and the river is to the south.

Architecture: This is a multiple level mill of irregular coursed basalt construction with an exterior lime plaster. It is 10m in length, 1.57m wide and 2.3m high. The sidewalls of the millrace have crumbled, leaving the channel floor as the highest level of construction at 0.8m above the penstock height. There is some tile and white sandstone chinking in the plaster. The penstock has a mostly decayed upper chute which could have been of the hopper type. The outflow is submerged in earth, and the mill house is ca. 10m further north-west; only the southwest corner of the river boulder courses is visible as well as a scant outline of the west wall. Special features of this mill included a quern, located on the northwest side of the water race, 8m from the penstock. A niche was located on the north face of the penstock in the shape of an irregular half-sphere. An incised basalt stone was situated on the northeast corner of the front face of the penstock, and a modern fragment of a clay bowl with a painted wing was found. **(Fig. 5.85)**

Associated Structures: Possibly BU0053; two stone wells were located about 150m across the Green Line.

References: Another mill owned by Ahmed Agha, according to oral information.

Phlasou

Building No.: BU0062/ Mylous tou Krommidhos ***Type:***(K) BU0062,1b/BAS III

GPS Coordinates: E 489641 N 3879871 ***Elevation:*** 339m a.s.l.

Location: Between Kato Phlasou and Pano Phlasou.

Landscape: Situated in the village, surrounded by houses.

Architecture: Water leat supported by arches still in good repair. It is built of irregular basalt river boulders and limestone chinking, and has an intact round arch under the leat. It is 41m long and the penstock is 10m high. The stepped, two-tiered sloping penstock tower is not unusual for watermills in the Troodos region. The mill house in ruins, but beams and cane make up the ceiling remains, and the roof is covered in Ottoman tile. There are some alterations; it also functioned as an olive mill before it fell into disuse. Oblong openings in the wall of the two-tiered mill house divide the flour mill from the oil press, and allowed canvas belts to enter lower mill house. The lower mill house contains early industrial machinery, suggesting it was still in use until relatively recently. According to local history they date to 18th century.

Associated Structures: The mill got its water from a diversion in the village centre, beside the public water fountain. The millrace bends at an obtuse angle and lead water into the chute, which was of dressed ashlar. There is a cemented stone overflow on the left side of the channel. Special features of this mill include an inscription over the north upper mill house door, and an inscribed basalt stone in the lower west pillar of the penstock arch.

References: Greek owner, who also owned BU0075 and BU0076.

Building No.: BU0076/ Molos ***Type:*** (K) BU0076,1b/BAS IV

GPS Coordinates: E 489556 N 3880093 ***Elevation:*** 305m a.s.l.

Location: Located northwest of the Shaban Bey Mill, also on the east bank of the river near the road.

Landscape: On east bank of Karkotis River.

Architecture: Constructed using irregular basalt boulders and chinking; the millrace leads from a water canal parallel to the road, and runs over a crude, narrow archway before it enters the penstock. The penstock has two tiers with dressed ashlar quoins on all fours sides. A restored mill house adjoins the bottom half of the penstock, and below it is a vaulted chamber which can be seen through an arched outflow constructed of dressed limestone masonry. The mill house may have had adobe courses to raise the roof, indicating the presence of a flat roof in earlier times. Limestone ashlar quoins are present on the southeast corner of the mill house. The water is guided through the outflow channel back into the Karkotis River. There are two millstones in the mill house, along with a disused wooden wheel, possibly intended for the reconstruction of the mill. A date of 1690AD is inscribed in one of the masonry blocks in the north wall of the penstock.

Associated Structures: BU0062, BU0075. Bifurcate channel with sluice gates leads along road and into millrace.

References: The mill was renovated in 2000-2001.

Building No.: BU0075/Shaban Bey ***Type:*** (K) BU0075,1b/BAS-LMS III

GPS Coordinates: E 489717 N 38798572 ***Elevation:*** 320m a.s.l.

Location: Located approximately 500m west of the Krommidhos mill, on the east bank of the Karkotis River.

Landscape: Towards the river, as you leave

Architecture: Very well preserved, but has a ruined mill house. Three well-defined arches support the water channel, about 20m long; these sit directly on the bedrock. Two of these arches are pointed and one is round. The leat leads into a relatively small chute, about 50 cm in diameter, and surrounded by a balustrade of approximately the same height. The penstock is stepped in four tiers, and faces west. The ruined mill house has remains of basalt river boulder and adobe brick walls, with basalt chinking, on which wooden beams to support the ceiling rested at one time.

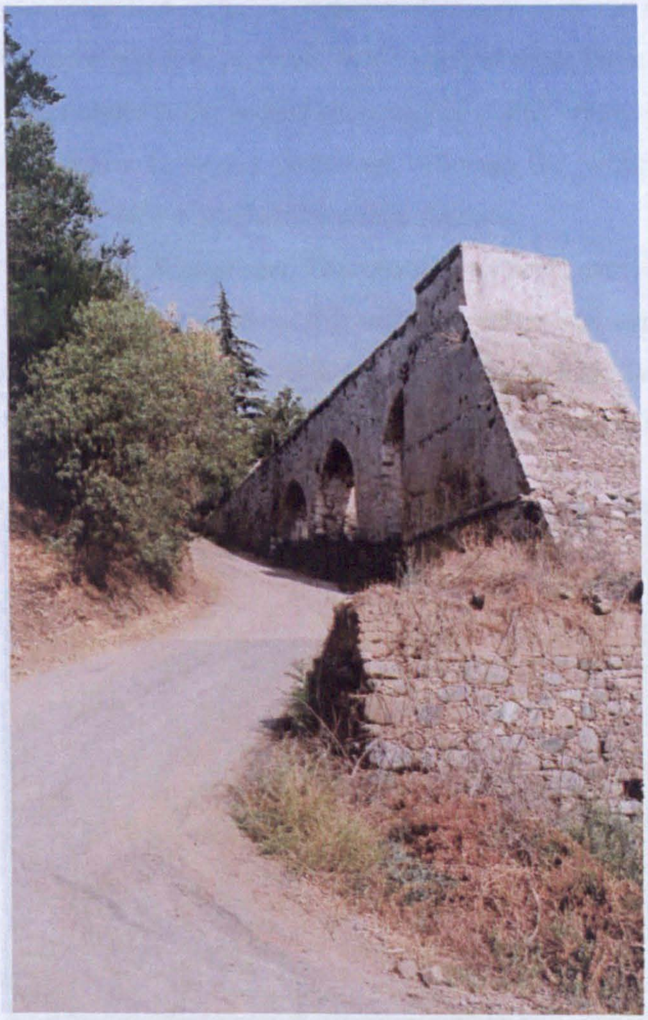

Figure 5. 86. Triple-arched millrace and penstock, with remains of mill house in the foreground, BU0075.

Associated Structures: The millrace is connected to an irrigation channel leading into the village of Kato Phlasou. Probably associated with BU0062. **(Fig. 5.86)**

References: According to oral information, the Shaban Bey Mill was famous as the most productive mill in the area, and was still in use around 60 years ago. It was the model for the penstock of the Stylianides mill in Evrykhou.

Building No.: BU0070 ***Type:*** (K) BU0070,1a/BAS-LMS III

GPS Coordinates: E 490054 N 3877967 ***Elevation:*** Not available.

Location: Located to the east of Evrykhou, near an abandoned railway station.

Landscape: Surrounded by barley fields and olive groves.

Architecture: Built using rough rubble basalt and river boulders with abundant chinking and covered in a lime plaster, and shows several phases of construction or reconstruction. It has an intact wheelhouse, with the horizontal mill wheel still in situ; the mill wheel is of wood, with diagonal slots for wooden paddles in the frame. The water chute is the largest encountered in this area yet at a diameter of ca. 2.20m. The mill house is mostly destroyed, although the south side still survives, which has a window with dilapidated wooden shutters.

Associated Structures: The channel network around this mill is extensive, and an interesting feature about this mill is its water leat, approx. 36m in length, which winds and curves along the landscape. It seems to have been rebuilt, or possibly added to, throughout the history of its use. The water channel is four-tiered with 5 supporting

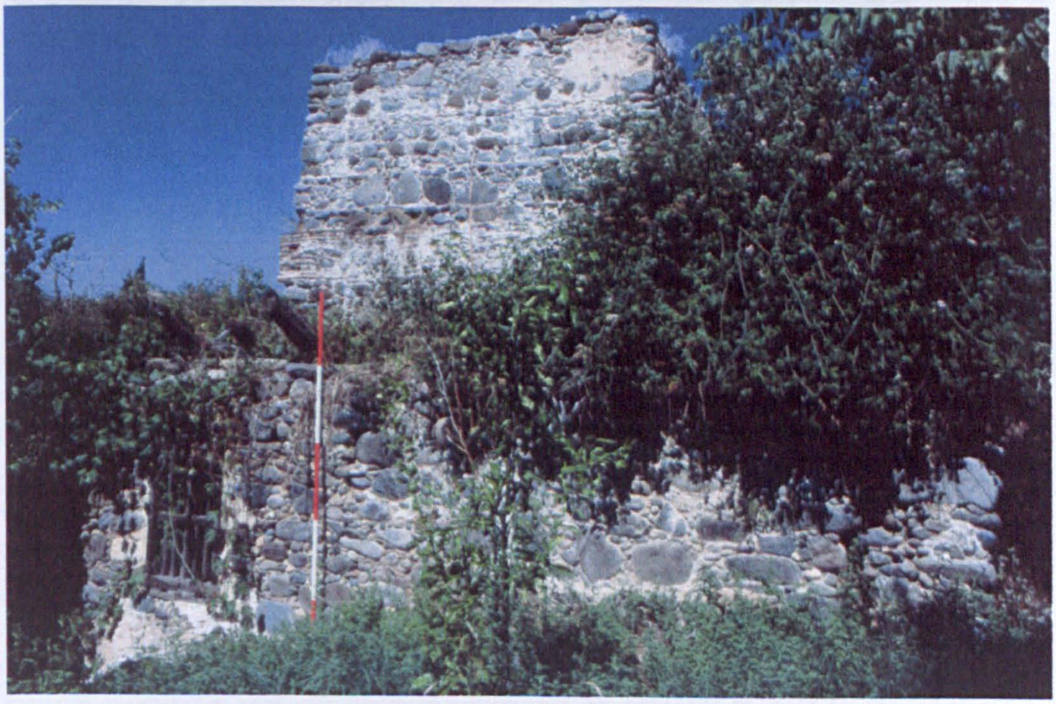

Figure 5. 87. Penstock and remains of mill house, BU0070. (Photo: Chris Parks)

buttresses, approximately at 3m intervals. The first 15m- section takes water from a primary water canal which flows in a North-South direction. The channel then makes a 45 degree turn, continuing perpendicular to the first section of the leat. The south side of the mill has an adjacent primary water channel which takes water down a sloping channel parallel to the mill channel. There is also a shrine to Ayios Nikolaos in a concrete retaining wall nearby. **(Fig. 5.87-5.88)**

References: Greek owned mill. According to oral information provided by Mr. Styllis and Machi Antoniou, an Evrykhou carpenter, 'Lachistos' could refer to its position, being set low in a ravine (*latchia*). The mill may have been endowed to one of the churches during the Ottoman period to avoid taxation.

Figure 5. 88. Inside of wheel chamber, BU0070. Remains of wooden paddles which were once attached to the wheel are scattered around the chamber. (Photo: Chris Parks)

Building No.: BU0049 ***Type:***(K)BU0049,1b/LMS IV

GPS Coordinates: E 490778 N 3877206 ***Elevation:*** 441 a.s.l.

Location: In Evrykhou, on the edge of the village to the south.

Landscape: Surrounded by orchards.

Architecture: Zesimou provided a diagram showing the basic components of a typical *Cypriot* mill, based on a grain mill built in 1884 and still in use up until recently. Although the actual mechanical process may be slightly different from the typical Jordanian mill, the basic parts were the same as those that were used in Jordanian mills. This is the only functioning watermill in the TAESP area. It was built in 1878, using timber for the penstock, which was replaced with stone in 1926. The wooden water wheel was also replaced with a steel turbine wheel in 1950, and a diesel engine was installed in 1961.

Figure 5. 89. Millstone, spindle and pivot inside mill house of BU0049. (Photo: Chris Parks)

The construction is the usual rubble stone and limestone quoins, covered with a plaster. The penstock is 16m high, 7.5m wide and the millrace is 19m long. The workrooms are approx. 7.7m by 7.1m; the concrete floor was originally stone, and the

Figure 5. 90. Inside wheel chamber, BU0049. The wheel is metal, and has small "scoops" against which the jet of water bounce to power the wheel. The lever on the left, next to the miller, stops the flow of water when it is not needed. (Photo: Chris Parks)

terracotta tile roof is now supported by two steel girders. The engine room is 3.4m by 2.1m, and is of stone, earth floor and a corrugated steel roof. The mill has the usual paddle wheel in the wheel chamber below, which is attached to an iron paddle in the mill room, and not the millstone; this iron paddle is attached to another iron paddle, which is hooked up to the millstones. This rather more complicated process is put into motion through a rotating-belt system, but was probably used in case there was not enough waterpower to move the wheel and fuel had to be used. The millstones are supported by a wooden frame, and the hopper is suspended from the ceiling above the grinding stones. Once the grain has been ground, the flour leaves the millstones through a flour nozzle attached to this frame; this is caught in the flour sack to which it is attached. **(Fig. 5.89-5.91)**

Associated Structures: There is an extensive channel network, leading both from the millrace as well as connecting to the outflow of the wheel chamber. The channels continue toward the river. A bridge constructed of limestone masonry and carrying an embossed cross in the keystone of the arch.

References: Greek owner Stelios Stylianides; a full report on this mill is held in the TAESP archive, Glasgow University. Previously, R.S. Morris made a report on this mill.[42]

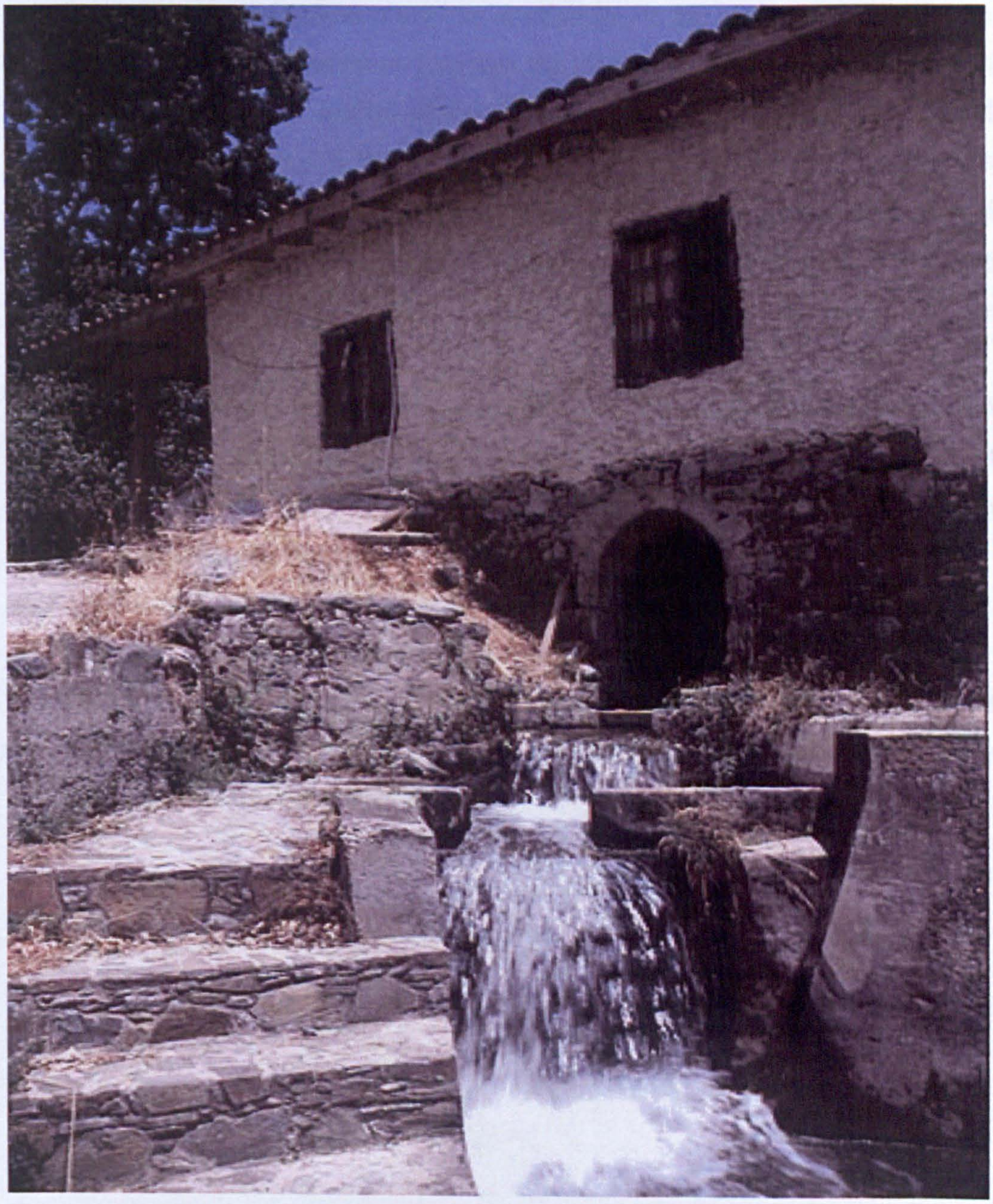

Figure 5. 91. Mill house and wheel chamber on a working day, BU0049. (Photo: Chris Parks)

[42] Morris, R.S. (1984) "The Stylianides Mill- Evrykhou." *Kipriakes Spoudhes* 57, 161-172.

Building No.: BU0074 ***Type:***(K)BU0074,1/BAS-LMS II

GPS Coordinates: E 490202 N 3877523 ***Elevation:*** 391m a.s.l.

Location: Situated on the outskirts of Korakou, to the southeast of the village.

Landscape:

Architecture: This is one of the smaller mill types, with an overgrown water channel and a penstock which is only constructed partially in stone. The upper part of the penstock is a cylindrical metal drum, set at an angle, on top of which two oil drums have been placed, presumably to lengthen the chute. Irregular coursed basalt and limestone form the lower section of the penstock, while the mill house was of mud brick and irregular courses of basalt. One of the millstones is still in situ. A window is located above the outflow from the wheel chamber, which is constructed of dressed limestone blocks. The outflow is approx. 3.5m from the edge of the river, where there is a well-aligned man-made rock hewn bank from the bottom. The height of the outflow arch is 1.4m.

Associated Structures: The house of the owner is located higher up adjacent to the mill house, a little further west. There are three bays, with a central *iliakos* [43]closed toward the street with a double door. Facing the river is an open loggia. There is no date of construction for this mill.

References: According to Mr. Styllis his father built this mill, which is called Koumis Mill, but also as *Mylos tou Zografou* as the last owner was called Zografos. The penstock was finished in this comparatively crude manner as the family ran out of money; the metal cylinder and oil drum offered a cheap alternative which was just as effective. The mill was abandoned in 1970.

[43] Courtyard.

Building No.: BU0046 ***Type:*** K1a/BAS II

GPS Coordinates: E 490427 N 3877177 ***Elevation:*** 403m a.s.l.

Location: Situated on the corner of the main road between Evrykhou and Tembria, north of BU0070.

Landscape: Road junction; on the river.

Architecture: Only the penstock survives, as the rest of it was destroyed when the main road was built. There are no traces of a mill house or a wheel chamber, but its situation near a bridge is interesting. The mill is of basalt masonry, with a whitish-grey exterior plaster. The penstock is three-tiered, the last tier extending 3m to a river channel. There is a vaulted wheelhouse below with a pointed arch to the entrance.

Associated Structures: The penstock is situated near an old bridge, probably built during the late Ottoman Period, and extended in the British Colonial Period. The bridge would have been a link between the villagers and the mill before the modern road was built.

References: Apparently the mill was abandoned in 1936 when the river carried away a part of the water channel on the 5th of December. The name of the mill is Mylos tou Koumna, and it was in Greek Cypriot ownership.

Building No.: BU0097 ***Type:*** (K) BU0097,3/LMS III

GPS Coordinates: E 490760 N 3877244 ***Elevation:*** 428m a.s.l.

Location: This mill is located on the junction from Tembria to Evrykhou, on the corner of the road going up to the Stylianos Mill (BU0049).

Landscape:

Architecture: It is now abandoned and looks like it is being used as a warehouse. In the past it was used as a corn mill, and then an olive mill. The building is a multiple level stone and mud brick construction, but there is no sign of a penstock at the south end of the mill house; a water channel runs northwest past the mill house under the bridge (BU0124). The mud brick walls on the north side are covered in modern plaster, and a corrugated metal shutter is used as a door. There is also a small mud brick structure to the southeast of the mill.

Associated Structures: A redbrick addition, located at the southeast end of the mill house, may once have been part of the penstock.

References: None available.

Building No.: BU0064 ***Type:*** (K) BU0064,3/BAS-LMS I

GPS Coordinates: E 490270 N 3875427 ***Elevation:*** 508m a.s.l.

Location: Southeast of Korakou, in the village of Tembria.

Landscape: Set in uncultivated fields.

Architecture: Known as the *Mylos tou Rotsos*. It was constructed using irregular courses of basalt, river boulders and limestone chinking, with traces of white lime plaster on the exterior. This mill is ruined; not even the whole penstock survives, but traces of a wooden sloping chute are still barely visible. This is the only example of a wooden chute to be found in the TAESP study area. The leat up to the penstock is 12m in length and ends abruptly, and it is here that a hollowed out log or tree trunk may have been placed to lead the water into the wheel chamber below the mill house. The ruined mill house and wheel chamber are located about 10m further along. There is an arched outflow into the wheel chamber of dressed limestone blocks and a vaulted ceiling. Traces of what may have been the wooden leat are visible in the form of a large piece of wood embedded into the south face of the mill house.

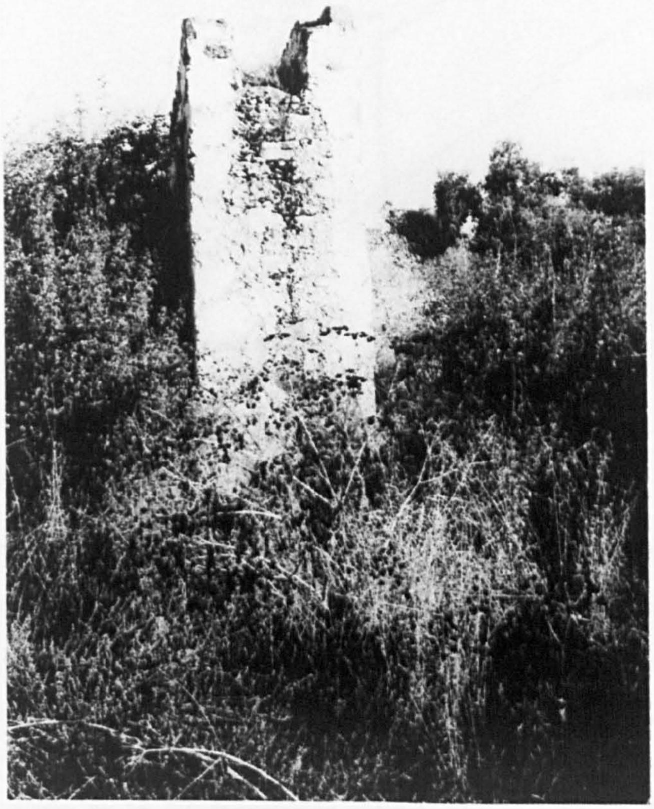

Figure 5. 92. Remains of millrace, BU0064.

Associated Structures: None visible.

References: Three families owned this mill: Christos Papanikolaou, the psalmist (also owner of BU0123); Georgios Demitriades and Loukas Demitriades.

Building No.: BU0054 ***Type:*** (A) BU0054,1/BAS II

GPS Coordinates: E 497850 N 3878392 ***Elevation:*** 445m a.s.l.

Location: Off main road from Asinou Church, across from the "Kentron" Restaurant.

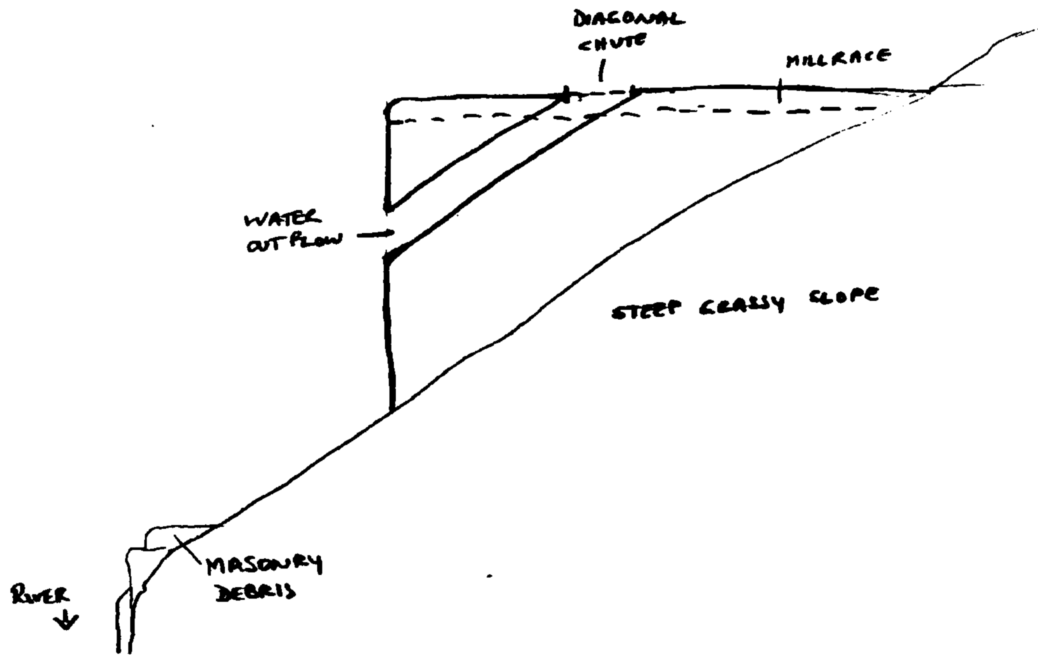

Figure 5. 93. Rough sketch of BU0054, Asinou.

Landscape: The landscape is awkward and hostile for any agricultural activity, and the mill is situated against a steep slope above the Asinou River.

Architecture: The unusual feature of the mill is its sloping hatch or chute which opens out onto the sloping hill on which it stands. This hatch is covered with an iron grid, perhaps to keep leaves and other natural debris from entering the chute. The hatch slopes at 15-20 degrees, is square, and is covered in pink plaster on all sides. The height of the penstock is 2.1m. The mill race is 7m long, and the channel is covered with lime and crushed brick, as well as soot plaster to make it water proof. No evidence of a mill house or wheel chamber. **(Fig. 5.93)**

Associated Structures: None visible.

References: Grivaud refers to a tannery having existed here.[44]

[44] Grivaud, G. (1996) "Population et Peuplement Rural à Chypre (Fin XIIe Siècle- Milieu du XVIe)", in J. Fridrich, J. Klápste, Z. Smetánka and P. Sommer (eds.) *Ruralia I: Conference Ruralia I- Prague, 8^{th}-14^{th} September 1995*. Institute of Archaeology: Prague, 217-226; Grivaud, G. (1998) "Villages

Vyzakia

Building No.: BU0073 ***Type:*** (L) BU0073, 1/RM II

GPS Coordinates: E 500397 N3882536 ***Elevation:*** 248m a.s.l.

Location: This mill is located on the detour road from Nikitari to Vyzakia, near Vyzakia village.

Figure 5. 94. View of millrace and penstock chute, BU0073.

Landscape: Mill set against steep terraced hills, in lush vegetation.

Architecture: There is no visible mill house or wheel chamber. The diameter of the chute is 1.36m. The length of the leat 24.3m, and the foundations of the mill are located on bedrock. Construction material is of rough rubble masonry with courses of river boulders. Lime plaster covers the exterior faces of the millrace and penstock. Two distinct lines of construction may indicate additions at a later time to heighten the leat. **(Fig. 5.94)**

Associated Structures: There is a rough rubble foundation of a building to the northeast of the mill, on the river bank.

References: The mill owner was Turkish-Cypriot.

Désertés à Chypre (Fin XIIe-Fin XIXe Siècle)". Meletai kai Ipomnimata, Vol. 3. Archbishop III Foundation: Nicosia.

Building No.: BU0104

Type: (L) BU0104,1a/BAS III

GPS Coordinates: E 501097 N 3881278

Elevation: 276m a.s.l.

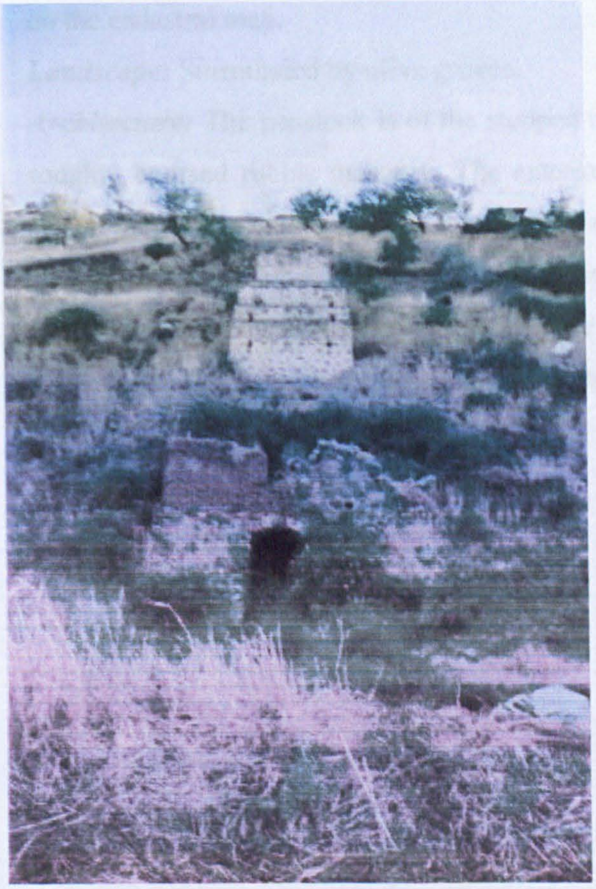

Figure 5. 95. Penstock and wheel chamber, BU0104.

Location: This mill is located right on the Madharis Potamis in Vyzakia village.

Landscape: Situated in an almond grove.

Architecture: It is a multiple level construction, with a penstock, an interrupted leat, a ruined mill house, and a vaulted wheel chamber with a horizontal metal wheel. The penstock chute is square, and now blocked; the penstock itself is 5-tiered, and of irregular coursed basalt masonry with a smooth white lime plaster face. The corner quoins are in irregular basalt blocks, and there are some limestone quoins in the lower tiers of the penstock.

The mill house is constructed from irregular basalt masonry with calcrete chinking; half of the mill house has been repaired in mud brick. The wheel chamber is partially carved out of bedrock, and the metal turbine measures 2.74m across. **(Fig. 5.95)**

Associated Structures: Probably BU109.

References: Not available.

Building No.: BU0109 ***Type:*** (L) BU0109,1a/RM III

GPS Coordinates: E 501736 N 3880484 ***Elevation:*** 400m a.s.l.

Location: Located on the road from Xyliatos to Vyzakia, and is listed as a corn mill on the cadastral map.

Landscape: Surrounded by olive groves.

Architecture: The penstock is of the stepped type, built in 5 tiers, and constructed of roughly coursed rubble masonry. The exterior surfaces and the mill race- which is 11.5m long- are plastered. The penstock is 5.8m high, and 7.1m high. There is a small round chute covered with a metal grid leading into the penstock, surrounded by a 95cm high parapet. The wheelhouse is still extant, and has an arched opening. The water outlet inside the wheelhouse is still visible. The top courses of the penstock and millrace may be a rubble masonry extension.

Associated Structures: Probably BU104.

References: None available.

Building No.: BU0096 ***Type:*** (L) BU0096,1a/RM-LMS III

GPS Coordinates: E 499486 N 3883357 ***Elevation:*** 229 m a.s.l.

Location: This mill is located close to the site of a demolished mosque, once part of the destroyed village.

Landscape: Surrounded by wheat fields.

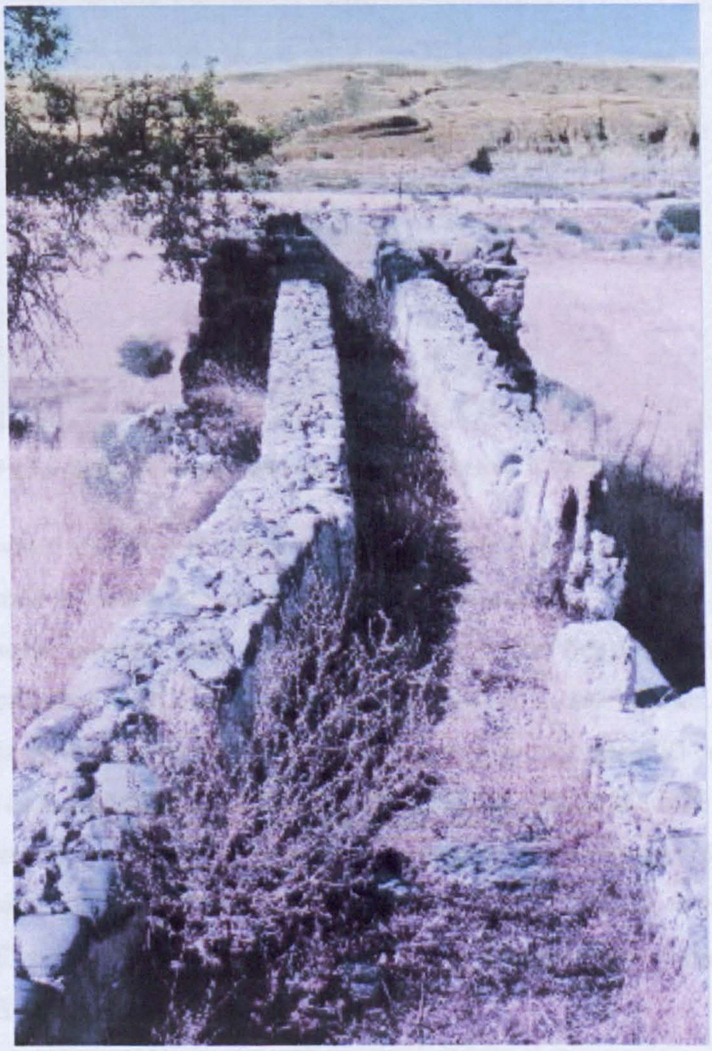

Figure 5. 96. Millrace leading to penstock, BU0096.

Architecture: Reasonably well preserved, although much of its leat has been destroyed by the road from Kato Koutraphas, which runs along the plain above it. A five-tiered penstock and a substantial mill room abut the millrace, and these are well preserved. There is a fan-shaped entry point to the millrace, with a sluice system to control overflow to the penstock chute on the eastern side. The chute measures 1.75m.The remains of the mill house is divided into three rooms by three arches. Broken millstones are scattered in one corner of the room, and a plaster-lined basin of smooth stone is embedded in the floor. Door and window above the wheel chamber still complete. The wheel chamber is long and narrow, measuring approximately 2.5m by 2m, but the wheel is no longer present. The opening into the

Figure 5. 97. Penstock and remains of mill house, BU0096.

wheel chamber is a well-constructed arch. The construction material used to build this mill is varied, but predominantly of river stones, or large pebbles; this is covered by some plaster, both on the exterior and the interior. The archway into the wheel chamber is of finer limestone masonry, as is the interior. There is some red plaster covering the uppermost layer of masonry around the mill house, and this appears to be some attempt at restoration or preservation. Inside the mill house, in the southern wall, are two niches measuring approximately 25cmx20cmx15cm each. On the northern side of the abandoned village, near the mill- which is presumed to be of Turkish Cypriot origin if it is a recent building, because of its location- is a wheat farm. **(Fig. 5.96-5.97)**

Associated Structures: There are a few remains of a ruined Turkish Cypriot village near the mill.

References: Turkish Cypriot ownership.

Kolossi

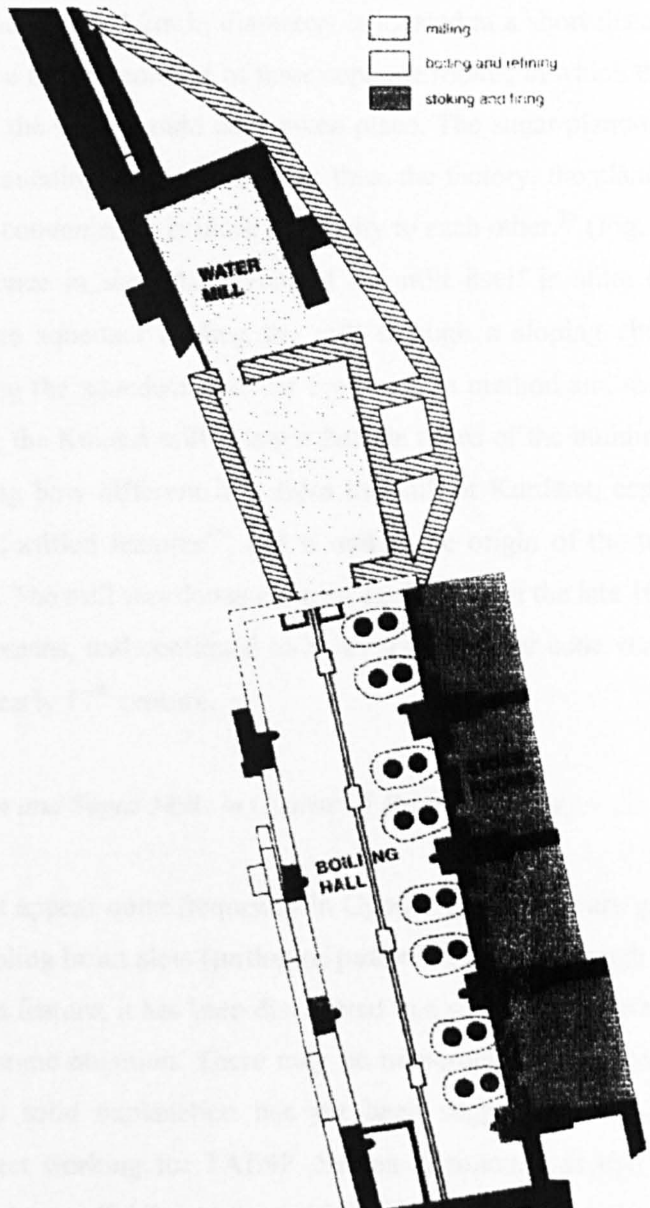

Figure 5. 98. Plan of sugar mill, Kolossi. (From V. Wartburg 2001)

Although there are a number of sugar mills in Cyprus- some of which have already been mentioned in the introductory chapters- the mill at Kolossi is a good general example to use in this study as much of the building still remains extant, and the layout of the factory and the buildings are easy to study. The sugar factory at Kolossi dates back to the 14th century, when it was built by the Knights Hospitallers. The mill adjoins a long aqueduct, contemporary to the mill foundations, which leads into the chute of the penstock, supplying the mill with its power. The wheel is no longer *in situ*, but a millstone- measuring 3.2m in diameter- is located at a short distance from the factory building. The factory consists of three separate rooms, in which the boiling, stoking and refining of the sugar would have taken place. The sugar plantations were located in the area surrounding the sugar factory; thus, the factory, the plantation and the castle were located conveniently in close proximity to each other.[45] **(Fig. 5.98)** Apart from the difference in size, the layout of the mill itself is alike to that of *Ṭawaḥīn al-Sukkar*; the aqueduct feeding the mill through a sloping channel, the square building abutting the aqueduct, and the construction method and material are very similar. However, the Kolossi mill is larger both in terms of the building and the millstones. It is striking how different it is from the mill at Kurdāna, especially as there are no signs of fortified features[46], and it makes the origin of the technology even more speculative. The mill was damaged in an earthquake in the late 16th century, but rebuilt by the Ottomans, and continued to be used until sugar cane was replaced by cotton crops in the early 17th century.

Grain and Sugar Mills in Cyprus: A Brief Overview

The main features that appear quite frequently in Cypriot grain mills are gaps within in the masonry resembling beam slots (**putlog** or **putlock** holes). Although not all the Cypriot mills have this feature, it has been discovered in a substantial number of them, and therefore merits some attention. There may be numerous explanations for their purpose, although no solid explanation has yet been suggested. One suggestion offered by the architect working for TAESP, Sevina Zesimou, was that they were used as slots for attaching scaffolding to for the times the mill needed to be repaired.[47] They may also have served to hold up temporary structures related to the use of the mill, perhaps for storage or as workshops. It is interesting to note, however, that

[45]Aristidou 1983, 32.
[46] The mill's proximity to Kolossi Castle may have rendered defensive measures unnecessary, as it could easily be defended from the castle keep.
[47] Zesimou pers comm., 2002.

almost identical openings exist in some modern structures; the school that was used to house members of TAESP in previous seasons was set on a levelled slope which was supported by a breeze block wall. Strikingly similar "beam slots" were present in this wall, but here they appeared to serve as a form of drainage.

A further feature commonly present in Cypriot mills is the sluice opening and run-off facility, presumable to divert water in case of excess volume. This is usually a part of the millrace, and may have been a mechanism for controlling the volume of water entering the penstock, which would regulate the rate at which the wheel turned and the grain was ground.

In addition to the abovementioned differences, there is an added element in its construction that is frequently found in Cypriot watermills. This is the use of chinking in the plasterwork. This usually comes in the form of pieces of broken pottery or flint that is used to bind the lime plaster or mortar in rubble fill. As for building materials in general, the majority of mills have stone foundations and masonry, but there are rare examples using mud brick as an additional building material. Another feature which can vary in the Cypriot mill is the penstock; this can vary from a single-tower stone construction to a simple, diagonally sloping wooden chute.

Conclusion

The purpose of this chapter was to present a series of case studies of water mills and irrigation systems from Jordan, Syria and Cyprus, including specific descriptions of architectural features, construction methods and materials. This has involved a study covering a large, as well as historically and culturally diverse area, where building traditions and materials can also vary greatly. The main aim was to establish a record of mills extant at the time of the survey, as they are disappearing rapidly across the rural Levant, as well as to compare construction techniques and technologies between the three study areas (see Chapter Seven). The following chapter intends to present an overview of the watermills in the Levant, also using other areas of the Islamic world for comparison. This will be followed by a section briefly summarising and comparing the results of this extensive survey on watermills in the Levant.

PART THREE

Conclusion: Economy & Society

CHAPTER SIX

Case Studies: Discussion & Overview

The previous chapter provided a number of case studies of watermills and relevant irrigation systems in the *bilād al-shām* and Cyprus. Before attempting an archaeological interpretation of the mills in the landscape in the following chapter, a brief summary of examples from other parts of the Islamic world will be provided for comparative purposes. Various ethnographic studies have also been conducted on watermills and irrigation networks in Palestine, Iran, Morocco and Turkey, and following is a brief overview of watermills in these areas.

The Watermills of Palestine

The German explorer/anthropologist Gustav Dalman spent a considerable amount of time studying the *fallāḥīn* life of Palestine in the beginning of the 20th century. As peasant life is naturally dominated by agriculture, a great part of this time was spent observing their agricultural practices and customs. This included the use of watermills. Dalman states that for farmers and Bedouin, the watermill was the most important type of mill in terms of large-scale agriculture; warring Bedouin tribes would hold a ceasefire in order for the grain to be brought to a watermill to be ground, or would provide free protection for those transporting the grain to the mill.[1]

Nablūs was- and still is- the region most densely covered by watermills in Palestine, and their aqueducts could be seen across the valleys near the city. Watermills were also abundant along Lake Tiberias, and near Jerusalem mills were located between the city and Jericho (though he does not mention any watermills present in the city itself, which suggests that mills mentioned by Ottoman tax records for Jerusalem may have been animal drawn, and not fed by water).[2] "Hardly a single river can be found along the East

[1] Dalman, G. (1964) *Arbeit und Sitte in Palästina III: Von der Ernte bis zum Mehl.* Georg Olms: Hildesheim.

[2] This is also suggested by Uriel Heyd; see Heyd, U. (1960) *Ottoman documents on Palestine, 1552-1615: a study of the firman according to the Mühimme defteri.* Clarendon Press: Oxford.

and West Jordan that does not feed a mill", quotes Dalman[3], indicating that the rural communities of Palestine relied heavily on this technology in their daily lives.

Much of Dalman's information is highly technical and explains the social context in which different solutions for effective farming techniques were adopted. According to Dalman, there were certain advantages of the water-driven mill over the animal-powered mill. Watermills were able to grind more finely as the millstones were closer to each other because there was no additional gearing separating them, unlike the animal-driven mills where the amount of gearing involved prevented the millstones from being in close contact with each other, thus producing more coarsely ground grain. In addition, the watermill was easier to maintain; once the water flowed at a good rate per minute, it could run by itself. The animal-powered mill, on the other hand, may have needed several animals to be hooked up to the mill to grind efficiently, and these animals needed to be changed frequently, rendering this process more time consuming, laborious to maintain, and expensive.[4]

Dalman mentions having visited mills in "all the lands"[5], including along the Quwayq between Aleppo and the Euphrates River, as well as numerous other places in modern-day Syria. In addition, he mentioned having visited mills in the Jibāl districts at al-Ṭafīla in Southern Jordan. He described the technology as almost identical in all these places, with the horizontal wheel on the vertical pivot powered by a strong and steady flow of water. Interestingly, he described this technology as "Arab". In only very exceptional cases was the undershot mill found, and this only occurs in areas where a strong river flowed, such as in Damascus and Aleppo. Here, a vertical wheel with wooden compartments raised the water (in the same manner as the *nawā'ir* of Aleppo); the water wheel was connected to gearing attached to a parallel wheel inside the mill house, which set the vertical rod in motion, grinding the grain. As for the areas where water was less ample, such as the East and West Banks of the Jordan River, he stated the following:

"In the Palestinian hills east and west of the Jordan River, where strong rivers are scarce, it is common that the water of a river above the mill is harnessed through channels (*qanawāt al-ṭaḥūne*, in Marj 'Ayūn *ṣidd*)

[3] Dalman 1964, 244.
[4] Dalman 1964, 244.
[5] Dalman 1964, 244.

and conducted at such a distance that it is 5-7m above the river bed. Here it is conducted across a wall with or without an arch to the mill house (*methāne*), where it falls vertically into a round or square chute (*bi'r*). Through a sluice (*loḥ*) one can close the channel when the water is not needed. When the water gathers it spills sideways. The chute is enclosed, but contains at the bottom an opening to the side (*miṣrāf* in Ṭafīla, *zummāme* in Ṣalt,....) through which the falling water exits with force, and hits the horizontal wheel from the side through a short pipe (*kuwwe*). Through a board with a long handle, this pipe can be lifted so that the water shoots out above the wheel in case the mill needs to stop rapidly. Where there is a powerful supply of water, the water can be conducted without a chute through a diagonally sloping pipe (Aleppo *shīb*, Marj 'Ayūn *sharūr*) from the channel to the wheel. I saw both systems united next to each other at a mill on the Litāni. The water exits the wheel house (in Ṭafīla *mindar*) in the riverbed below, as seen by one of the mills in Lajjūn." [6]

An unusual example of a mill is located along the 'Auja River[7]; here, the river above the mill is dammed by a sluice gate to maintain the water pressure. A channel branching off from this runs into four underground channels beneath the mill and powers the wheel of each grinding mechanism. Dalman is unfortunately not specific about whether these were horizontal or vertical wheels, but practically speaking, when channels with strong currents are involved, a vertical wheel would have been more appropriate in turning the wheels efficiently. Underground channels such as these can also be found in some of the large industrial mills in Damascus, described previously, where underground channels from the river powered vertical wheeled mills. The sugar mill at Kurdāna in Palestine also has four channels running into separate wheel chambers, where the water supply was controlled using a dam and sluice openings.[8]

The water wheel was usually located next to the chute outflow, and consists of a round block (*kurme*) with diagonally protruding wooden vanes. Dimension of the wheel varied; at al-Ṭafīla, it was 120cm wide and 15cm thick. The pivot was 12cm thick and attached to a lightening rod (see glossary) which in turn was attached to the lower grinding stones (*hajjar taḥtāni*). This stone was 110cm wide and 10cm thick. The chute was here 60cm wide and was 7m above the wheel. The runner stone (*hajjar fuqāni*) at the mill in 'Auja was 115cm wide and had a 3cm concavity on its underside; the opening in the stone had a heightened rim with a circular insert into which the grain was poured. The lower stone

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[6] Dalman 1964, 245-246.
[7] This is a *wādi* located south of Wādi Haydān and Wādi Wāla, located in Palestine.
[8] Pringle 1997.

had a groove through which the ground grain could exit. Above the runner stone was the *dalu*, or the hopper, to which was attached a bell to warn the miller when the hopper was almost empty. Another warning system was observed in al-Ṭafīla, which involved a wound up elastic band attached to a container holding the grain (*qadāḥ*). This band controlled the amount of grain that fell between the grinding stones; if it was taut, less grain would fall, and when it was relaxed, more grain fell into the hole. Thus, the coarseness of the flour could be controlled. The coarseness of the grain could also be controlled through the use of a wooden beam, on which the pivot of the wheel rested. When the beam was lifted, the pivot- attached to the runner stone in the mill house above- could adjust the distance between the runner and bed stones, thereby controlling the force with which the grain was ground, and hence its coarseness.[9]

With regards to the wooden wheel, Dalman stated that eight vanes or wooden panels around the wooden block would have been sufficient; it could also be in the form of a proper wheel, with a round disc to which the wooden panels were attached. The wooden wheels in some of the Cyprus mills were also of this type. Dalman's description of the more primitive wheel with eight vanes is very similar to those found in a study conducted by Harverson in Iran, which will be discussed later.

The most comprehensive guide to watermills in Palestine can be found in Pringle's *Secular Buildings in the Crusader Kingdom of Jerusalem*. Pringle lists 28 sites that were either sugar production sites or sugar mills, shown in **Table 1**, dating mostly to the Crusader, Ayyūbid and Mamlūk periods. Although most of these sites have been investigated superficially, there have been some efforts to plan and excavate watermills belonging to important sites; this has been limited primarily to the areas west of the Jordan River.

Apart from a detailed plan of the fortified mill at Kurdāna, Montfort Castle, in the north of Palestine, also houses a mill, which was later converted to a guest house.[10] The mill consists of two barrel vaulted chambers, one fed through an arched opening, and the other by a rock cut opening. The dam may have helped to provide the power to the mill, as stated above, but it was also employed to irrigate surrounding crops, which may have

[9] Dalman 1964, 248.
[10] Pringle 2000.

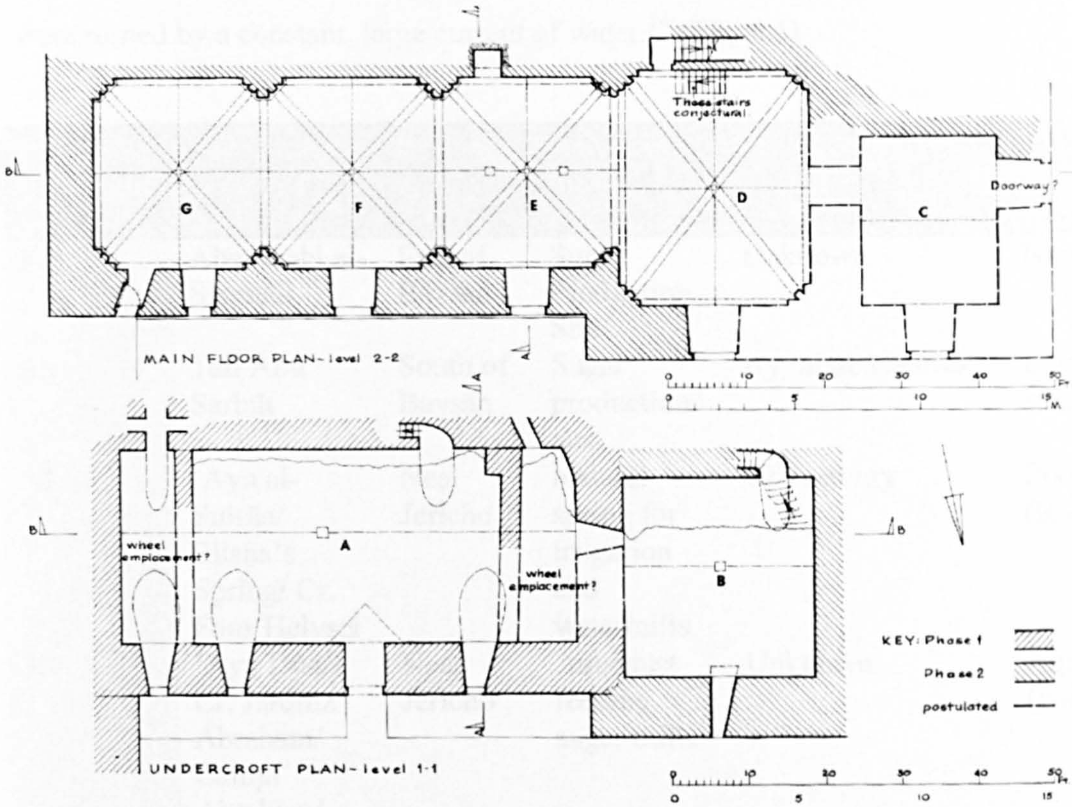

Figure 6. 1. Plan of sugar mill at Montfort Castle. (From Pringle 1997)

included sugar plantations. This mill, dating from before 1229 AD, is assumed to be of the horizontal type, using a mill pond and dam to harvest the water to power the mill, as was common in low lying areas of Palestine.[11] However, the possibility of it being a vertical wheeled mill has not been discarded; the water enters the wheel chamber at a higher level than it does at Kurdāna, perhaps indicating the presence of an overshot wheel. This is also suggested by the position of the water channel in relation to the mill wheel.[12] Pringle also points out that if this were the case, then it may point to the introduction of a Frankish technology from Europe into the Holy Land.[13] The water was channelled into an arched opening up to 80cm wide, located in the wheel chamber; thus, there was no pressure system by means of a vertical tower with a small aperture creating a strong directed flow, as is the case with the mills in Jordan. This may indicate that the wheels

[11] Pringle 2000, 69.
[12] Pringle 2000, 70.
[13] Pringle 2000, 70.

here were vertical (possibly undershot due to the large arched opening), and that they were turned by a constant, large current of water.[14] **(Fig. 6.1)**

Pringle Catalogue #	Site Name	Location	Nature of Site	Date of Site	Extant Buildings
1	Abu Arabi al-Shamāli	East of Baysān	Sugar Production Site	Unknown	None
3	Tall Abu Sarbūt	South of Baysān	Sugar production site	Ayyūbid/Mamlūk	Excavated structures
12	ʿAyn al-Ṣulṭān/ Elisha's Spring/ Cr. Fons Helysei	Near Jericho	Natural spring for irrigation and watermills	12th century	Pool (Roman)
13	ʿAyn Dūq/ Cr. Jardinz Abraham/ Campi Abraham/ Abrahe Ortus	Near Jericho	Aqueduct feeding sugar mills	Unknown	Aqueduct (collapsed)
26	Baysān/ Cr. Bethsan, Bessan, Beisan/ Hebr. Bet Sheʿan.	S of Belvoir, between Sea of Galilee and the Dead Sea	Sugar factory	Mamlūk	Castle and sugar factory.
81	Tall Dayr ʿAllah	North of the Dead Sea	Sugar mill	Ayyūbid/Mamlūk	Watermill
85	Tall Daʿūq/ Cr. Doc, Doke	SE of Acre	Templar Mill	13th century	None
92	Al-Fayfa al-Gharbiya/ Qasr al-Fayfa	South of al-Ṣāfi	Sugar mill	Possibly Mamlūk	Mill.
93	Tall Fandi al-Janūbi	East of Baysān	Sugar installations	Mamlūk	Various remains

[14] Pringle 2000, 70. See also Chapter Eight of this work, pp.304-309.

Pringle Catalogue #	Site Name	Location	Nature of Site	Date of Site	Extant Buildings
95	Kh. Fasayil/ Cr. Phesech, Fasael	North of Jericho	Probably sugar production site	Early and Middle Islamic, Crusader	Aqueduct and mill
98	Al-Haddar/ Cr. Molendina Trium Pontium, Tres Pontes	NE of Jaffa	Grain or sugar	Hospitallers- 1133 AD	Three mills and mill dam
99	Al-Haditha	NW of al-Karak	Sugar Production	Poss. 6th/12th-9th/15th century	None.
112	Jaljuliya/ Cr. Jorgilia, Jorgilra	Between Nāblus and Ars	Possible sugar factory	Crusader	Ottoman mosque
114	Jericho/ Arīḥa/ Cr. Iericho	NW of Dead Sea	Sugar installation	Unknown	Remains of sugar mills
133	Kh. Kurdāna/ Cr. Recordane	SE of Acre	Sugar	Acquired by Hospitallers 1154AD.	Fortified mill and dam.
142	Kh. Al-Mahruqāt	SE of Baysān	Sugar production site	6th/12th-8th/14th century	None
145	Kh. Manawāt/Cr. Manueth	NE of Acre	Sugar factory	Held in 1168 AD by Geoffrey le Tor	Aqueduct and mill; olive mill
154	Al-Mirr/ Cr. Molendina desubter Mirabellum	NE of Jaffa	Unknown	Roman/Byzantine, repaired by Franks before 1158/59.	Mill and dam.
156	Qal'at al-Qurayn/ Cr. Montfort, Starkenberg	NE of Acre	Castle	Built by Teutonic Order in 13th century, destroyed by Baybars 1271AD	Mill and dam
157	Shawbak/ Cr. Montreal, Mons Regalis	South of the Dead Sea	Castle	Built by Baldwin I in 1115 AD	Grain and sugar mills

Pringle Catalogue #	Site Name	Location	Nature of Site	Date of Site	Extant Buildings
172	Tall Qasīla	North of Jaffa	Sugar factory	Unknown	Factory built over remains of khān dating between 9th and 11th century
193	al-Sāfi	Near al-Sāfi	Sugar production site	5th/11th to 8th/14th century	None
219a/b	Ṭawāḥīn al-Sukkar (below site 13)	Near Jericho	Sugar		Two sugar mills.
220	Ṭawāḥīn al-Sukkar/ Cr. Segor, Palmaria	Near al-Sāfi	Sugar	Ayyūbid and Mamlūk	Mills
221	Kh. Ṭawāḥīn al-Sukkar	North of Sāfi, below al-Karak	Sugar	5th/11th-9th/15th centuries	Two groups of sugar mills
232	Al-Yanuhiya/ Cr. Lanahie, Lanoye	On coast N of Acre	Sugar production site	Unknown	None
234	Yesod Ha-Maʿala/ Near Cr. Mallaha	On SW banks of Lake Hula	Sugar processing	Possibly 13th to 14th century	Stone channels and plastered basins
Total 28					

Table 1. List of watermills located in Palestine. (From Pringle 1997)

Iran

Iran has been the subject of much archaeological and historical attention for centuries; despite this, much of Iran and its more recent material past have yet to be studied. It is no surprise, then, that the subject of watermills in Iran is relatively unknown within the study of Islamic history and archaeology. Michael Harverson, now the president of the

International Molinological Society, has conducted a wealth of research on the history and workings of the horizontal watermill in Iran. He has devoted many years to such a study and has provided much information on the role and existence of watermills in some parts of medieval Iran. Following is a brief summary of his findings, including the role of water, irrigation and watermills in the agricultural communities of Iran.

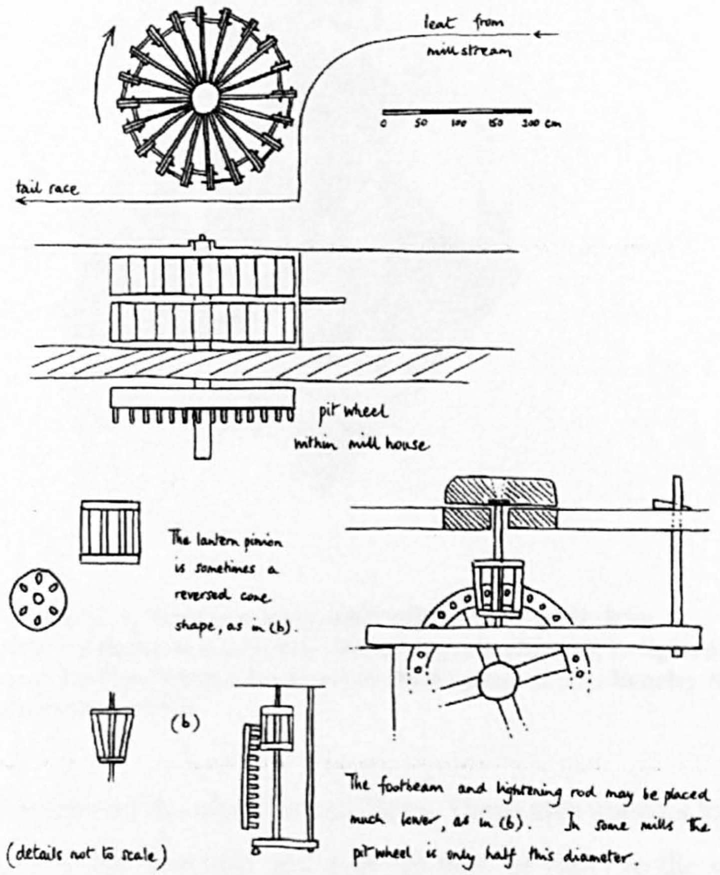

Figure 6. 2. Drawing of vertical mill wheel as seen in Isfahan. (From Beazley & Harverson 1982)

The Mills

Iran has a varied landscape, in which can be found several types of watermills. There are the wooden-chute penstock mills, as seen in parts of Turkey and Cyprus, as well as the *arūbah* types, such as the examples from Jordan and also Cyprus. As Harverson points out, their design depends on the availability of water, and the drop-tower type are located where there is a need for a lower volume of water to accumulate under pressure before it can create enough power to turn the wooden wheel.[15] In Iran *arūbah* penstock mills tend to be situated against a hill or steep incline, or at the end of an aqueduct, as they are in some cases, both in Jordan and in Cyprus, as well as in Syria. The tower itself is made of stone and its height can vary between three and ten meters[16]; the water turning the wheel exits into another channel from the wheelhouse, and is conducted to the next mill. The examples

[15] Harverson 1993; Harverson, M. (2000) *Mills of the Muslim World.* The Fifth Rex Wailes Memorial Lecture. Society for the Protection of Ancient Buildings: Mills Section.
[16] Harverson 2000, 12.

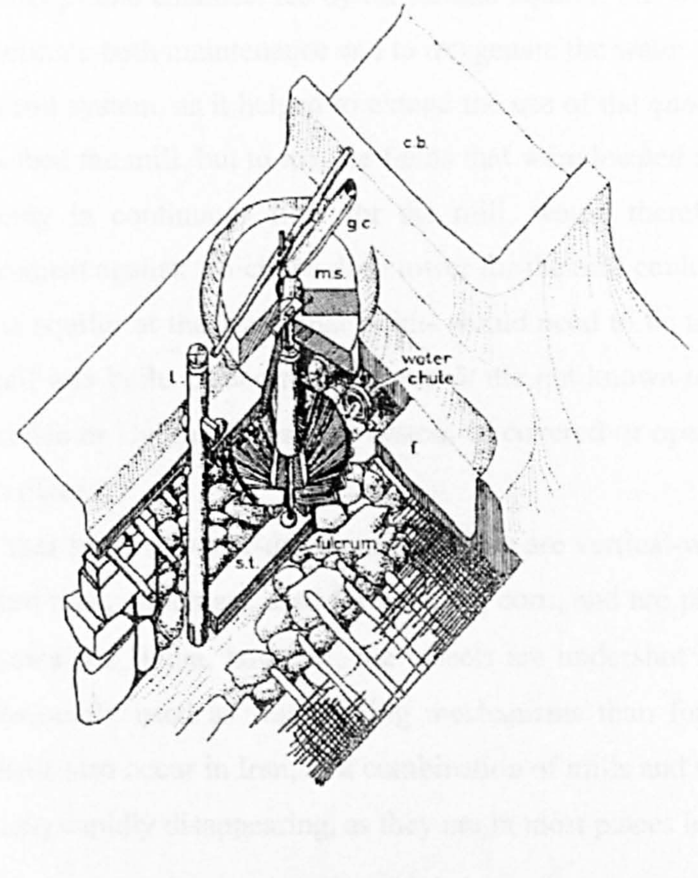

Figure 6. 3. View into horizontal mill, Band-i-Amir, Iran. M.s.=millstones; c.b.= corn bin; g.c.= grain channel; l.=lightening rod; f.= floor level; s.t.= sole tree (foot beam). (From Beazley & Harverson 1982)

studied by Harverson tend to be clusters of several mills aligned to serve each other in a line on a gradient, which is also the case for most areas in Jordan and some areas in Cyprus, as well as parts of Palestine, for example such as that of the Montfort mill.

The wooden wheel of the Iranian horizontal water mill is also quite different in design, although the same principles of obliquely placed paddles apply. The paddles are at an angle, rather than a horizontal line; the diameter of the wheel is ca. 75cm. There also appears to be no mechanism in the form of a lever that can start and stop the flow of water to the wheel as necessary, as it exists in the examples cited from Turkey or Cyprus; instead, a plank is used either to stop the water from entering the drop tower, or to block the nozzle where water enters into the wheel chamber.[17]

Mills, Qanawāt and Dams

Another type of system exists in Iran using a drop tower, but also employing the benefits of the *qanawāt* as the source for the waterpower. The *qanawāt* as described earlier are

[17] Harverson 2000, 16.

underground channels fed by the natural aquifer, but with ventilation shafts at intervals to facilitate both maintenance and to oxygenate the water. Integrating these into mills was a useful system, as it helped to extend the use of the *qanawāt* whose main priority was not to feed the mill, but to irrigate fields that were located at some distance away. The water, being in continuous flow for the mill, would therefore not evaporate. Obviously, a gradient against which the drop tower for the mill could be built- as well as a surfacing of the aquifer at that particular point- would need to be taken into consideration before the mill was built. Underground *qanawāt* are not known to have conveyed water to mills in Jordan or Cyprus, where the system of covered or open over ground stone channels was in place.

Other types of water-driven mills in Iran are vertical-wheeled mills, usually of the breast shot type, which are used for grinding corn, and are physically similar to the *nawā'ir* of Ḥama. At Ḥama, however, the wheels are undershot and not breast shot, and are more frequently used as water-lifting mechanisms than for grinding purposes. Mills beside dams also occur in Iran, as a combination of mills and water-raising devices, but these are sadly rapidly disappearing, as they are in most places in the Levant.[18]

Turkey

To date, only two published surveys of watermills have been carried out in all of Turkey; H.H. Günhan Danişman surveyed the Bolu region in the Central Anatolian plateau in 1977, providing detailed accounts of extant watermills, both abandoned and those still in use. He included architectural descriptions as well as an explanation of the terminology behind the watermill mechanisms, focussing on a small number of prime examples picked from the overall survey.[19] The other published work comes no less than 25 years after Danişman's publication. This study is part of a wider survey carried out by a Belgian team, covering multiple periods in the territory of Sagalassos, in the province of

[18] Harverson 2000, 8.
[19] Danişman, H.H.G. (1977) "A Survey of Turbine-Type Water-Mills in the Bolu Region of the Central Anatolian Plateau." *METU JFA* 3, Number 1.

Burdur, in the western Taurus Mountains of South-western Turkey.[20] The survey team conducted an in-depth ethnographic as well as archaeological and architectural research in the villages, including interviews with the villagers, observing and taking part in milling activities.

The Bolu Region

Twelve watermills were studied in this region, three of which were still operational in 1977. All mills were of the vertical shaft and horizontal wheel type, although they were not *arūbah* penstocks. The vertical shaft here consists of a diagonally sloping chute, constructed either of wood or a hollowed out tree trunk, fed by an open channel (feeder channel), and leading into the turbine wheel chamber [21] The interior of the mill house conforms to the "standard" idea: there is a hopper suspended above two grinding stones that feeds the grain that is to be ground through a nozzle onto the groove in the millstones. In addition, there is a miller's room (possibly his sleeping area during busy periods) and also a storeroom.

The main differences between the Bolu region mills and its Levantine counterparts are not in the mechanisms and functions of the milling system itself- they appear, in fact, to be almost identical- but rather in their architectural features and in the construction materials used. The most significant difference between the mills of the two areas is of course the penstock. The readily available limestone used in the construction of the Levantine mill is naturally much more durable and able to withstand the test of both time and the elements, while the slat-beam and peg construction used in the diagonally sloping Anatolian penstock is less so. The wood is easily corrupted through the constant flow of water; and- as pointed out by Danişman- is subject to contraction and splitting in dry periods when the mill is not in use. This vulnerability to the elements suggests that the penstock would have needed frequent repair or even replacement for the mill to function at its maximum efficiency.

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[20] Donners, K., Waelkens, M., & Deckers, J. (2002) "Watermills in the area of Sagalassos: a disappearing ancient technology." *AS* 52, 1-18.

[21] Danişman 1977, 24. Examples of this have not been found in Jordan, but existed until relatively recently in Cyprus.

The examples Danişman describes in detail are both similar in function, but the first mill is actually a complex of two mills situated immediately adjacent to each other. The same feeder channel supplies them both; the upper mill conducts water through its wheelhouse to a raised, open wooden channel, which feeds the lower mill. Both terraces that the mills are built on are man-made, and they can be reached from a wooden bridge across the stream (presumably the source of water power for the mills). The water feeding the mills is led through an apparently natural open canal, at whose head is located a timber lock-system.[22] There are three outlets attached to this lock, two to feed the mills and one as an overflow-canal to redirect the water back to the stream in the valley below; thus the water does not go to waste where it is not needed, and keeps the river full.

The timber penstocks are attached to a hollowed out wooden tree trunk which serves as the actual chute through which the water that hits the turbine wheel is guided. This provides a less pressurised stream of water hitting the vanes of the wheel, as the circumference of the log is much larger than a nozzle located in the wall of a penstock, and suggests that these mills may have been less efficient grinding machines.

As the mill houses of this first mill complex are in a ruinous state, Danişman uses the second mill as the best remaining example of a mill house. There is also a detailed description of the interior milling mechanisms and components that are needed to run the mill efficiently. Although it is not certain whether these components were similarly arranged in the mills found in Jordan, which appear to be smaller in size, there is a remarkable similarity between this mill in the Bolu region and the still functioning Stylianides mill in Cyprus. Despite the modern diesel pump that now provides power to the mill, the Stylianides mill- built in 1884- ran for a long time on water power (as it sometimes still does when water is allotted to him at a specific time during the week), and the arrangements of the wheel, the millstones, the hopper and the flow-lever to stop the wheel are all still present.

[22] Danişman 1977, 26.

Fifteen mills were recorded in this survey in 1999 and 2000, but only one of these mills was well preserved and provided the example for a detailed description. Two mills remained in use at the time of the survey, and the rest have been abandoned because of the increasing use of electric mills that are not reliant on the presence of water, and produce a much higher yield of flour at a faster rate.

The best-preserved mill was that of Bekir Onur, located in Ağlasun, at 1100m above sea level. (The remains of two other mills were also recorded there) This mill houses two mills, which are independent from each other, and have separate inlets and outlets for the water, akin to the double-penstock mills found in Ḥisbān or Wādi Haydān in Jordan. There are three sections that make up the mill interior itself. The lowest section consists of course the waterwheel and all its related parts, like for example the bearing block, which the wheel sits on, as well as the metal pivot, which holds it in place. The middle section is located in the floor above the lower section, and is where the millstones are located, supported by the vertical shaft attached to the wheel below. The runner stone is set in motion with the aid of the metal rind at the end of the rotating spindle, while the bed stone remains motionless, wooden rings surround the millstones to hold them together, and to keep the flour from spilling and to guide it into the lower grain hopper. This section also houses the shutter, which regulates the flow of water into the wheel chamber, stopping and starting the wheel as necessary.[23] Finally, the upper most section-, which is not separated by another floor, is made up of the hopper, the feeder channel, the oscillator for the feeder channel, and a regulator that controls the flow of grain. In addition, lifting devices exist to raise the millstones in case of necessary repair or cleaning. The average diameter of the millstones is 1.5m, about .5m larger than those found by Danişman in 1977.[24] These millstones appear large in comparison to the average vertical-wheeled millstones of antiquity, which were on average 55cm-85cm, and

[23] Donners *et al* 2002, 5.
[24] Donners *et al* 2002, 8.

never larger than just over 1m.[25] The water wheel is also larger than the horizontal wheels found in Jordan or Cyprus. **(See Fig. 1.6, Chapter One)**

Morocco

Some studies have been conducted on Moroccan mills, where they are still in operation today in the more remote areas of the Atlas Mountains. One of these studies, conducted by Patrice Cressier, explores the historical, archaeological and ethnographic aspects of the presence of watermills in al-Andalus and Morocco.[26] Moroccan mills, which are distributed across the country and its river valleys, are all of the horizontal wheel type, although they more commonly have a sloping chute leading into the wheel chamber, rather than a constructed penstock tower to lead the water, similar to the watermills found in Turkey, as described earlier. This is the main difference between the Moroccan mills and the mills of surrounding countries influenced by Islam, such as Jordan and southern Spain. Interestingly, the mills found on the Iberian Peninsula across the Mediterranean Sea are of the penstock tower type, which prompts Cressier to suggest that perhaps the technology is a local Moroccan tradition, rather than one that has been introduced from elsewhere. In addition, the remote location of the mills, as well as the use of Berber mill terminology, adds weight to this argument.

Overview of Case Studies

Grain Mills

In general, it has been established through an analysis of building techniques and construction materials that the majority of simple, rural watermills were built using similar construction methods and materials across the Levant. The materials used depended largely on the immediate availability of exploitable natural resources, such as the *nāri* limestone available in Ḥisbān in Jordan, or the pillow basalt with which BU002-004 were built in Linou in Cyprus. Exceptions did of course occur, where the stone had been quarried some distance away and transported to the site where the mill was to be

[25] Wikander 2000, 392.
[26] Cressier 1998.

built. This was the case with BU0044 in Katydhata in Cyprus, where the limestone was not located in the immediate surroundings of the mill. These are rare exceptions and occur generally if there is a lack of suitable local building materials.With regards to the building materials, for example at the mills in Linou, construction materials matched the natural resources within the local landscape, but in Evrykhou and at the Katydhata mill there was a mix of local river stones with finely cut limestone which was not available in the immediate landscape. Here, the stone had been quarried elsewhere and transported to the site of the mill.[27]

In this study, across all three regions, the predominant stone used for building watermills (or irrigation networks- where older systems still exist) is limestone and basalt, with some mills being partially constructed of both types of stone (this was particularly the case around Ḥoms in Syria, where some mills were built using both basalt and limestone). One major difference was the use of river boulders used as construction material in Cyprus. This was not the case for Jordan or Syria, where masonry was limited to finely or roughly cut stone. Cypriot watermills bear a strong resemblance in terms of building materials and techniques to those in Jordan, and the *arūbah* penstock type in Syria. As they are in better condition, it will perhaps be possible to determine a way in which watermills in general in the Levant can be dated, perhaps through comparing examples with known dates, of which there are a number in Cyprus, to those whose dates are uncertain throughout Jordan, Cyprus and Syria.

A frequent occurrence in the construction of watermills is also the use of plaster to cover the façade; this is most common in Cyprus, the material being used also being lime based. Few of the examples studied in Jordan or rural Syria showed any remains of plaster covering the masonry, although the larger, industrial mills of Damascus combined ancient building methods with modern techniques, including the use of plaster to cover walls. Chinking- or the use of broken pieces of pottery or tile to bind and strengthen the mortar- was an entirely Cypriot phenomenon. The use of putlock holes in the walls of the millrace and penstock, possibly for scaffolding needed in times when the mill needed to be repaired, was also found to be a Cypriot tradition and not encountered in either Jordan or Syria. The physical layout of the mills in Jordan and Cyprus was without exception

[27] Robbins pers.comm. 2004; Zesimou pers.comm. 2002.

almost identical in every case; the penstock, with various types of chutes- either square or circular- bore similar characteristics to each other. The design of the millhouse (where extant) also appeared to be alike in both regions, although it was difficult to determine in many cases due to the ruined state of the buildings. The main noticeable difference was greater range in size of the chute diameter in the Cypriot mills; these ranged from 0.5m across to as much as 2.20m, while the Jordanian mills tended to have a diameter of between 45cm and 90cm. This may be a reflection of the availability of potential water resources.

Watermills in Syria- at least around the Ḥoms and Ḥama region,[28] as well as Damascus- show a greater variety in construction technique than those of Cyprus and Jordan. While the predominant type of mill in these two areas is the *arūbah* penstock type, this study found at least three types of mills in Syria. As mentioned earlier, basalt being a common stone in this area, it is frequently seen either in the entire masonry of a watermill, or in combination with another kind of stone. In addition to the masonry, the architectural plan of the Syrian grain mill can also vary; the mills powered by the current of the river do not need the millrace or the penstock, as in the traditional Cypriot and Jordanian grain mills. However, the water can also be brought to the mill by a *qanāt,* which widens to feed the slots of the vertical wheel chambers; this is particularly the case in the urban Damascus mills. All watermills studied in both Jordan and Syria had penstocks of stone construction, and no evidence for the existence of the wooden chute could be found; this appears to be a feature unique to Cyprus.

The only clear distinction could be seen between the urban Damascus mills and the rural grain mills in all three areas. The Damascus grain mills resembled some of the larger Palestinian and Cypriot sugar mills in terms of size and capacity, as well as in layout, with multiple wheel emplacements and large mill rooms. However, urban mills in the Levant have not been studied extensively enough to provide a more detailed basis for comparison with rural mills. The lack of studied examples from other urban centres, such as Aleppo, is unfortunate in this case, but future research into urban mills in Syria may provide a better basis for comparison and analysis.

[28] Shahāda 1974.

Sugar Mills

The greatest variations in architectural features were seen in the examples of sugar mills across the Levant. These ranged from *Ṭawāḥīn al-Sukkar*, which has similar features to standard grain mills in Jordan, to the fortified mill complex of Kurdāna[29] in Palestine, and the large sugar factory at Kolossi in Cyprus. Generally, the nature of the technology is the same: the cane is crushed, not ground, using a bed stone and an edge runner stone to squeeze out the juice. A source of water was channelled to the wheel- which was either vertical or horizontal- which set the crushing mechanism in motion. The syrup was boiled and dried through a series of processes in the factory rooms before it was shipped off either for export or local use. The main difference between the sugar factories of Palestine, and those Jordan and Cyprus, were the defensive features; in Palestine, fortified towers and arrow slits in the walls served to defend the valuable sugar factories against invaders and marauders, a measure not deemed necessary in the other areas.

There is no doubt of the commercial nature of the sugar installations found across the Levant in this study, but it has at times been speculated that some of the grain mills studied in Chapter Five were in fact sugar mills. Hamarneh claims that a number of mills found in the Kufranja area were in fact used to press sugar cane, and Abu Dālū has suggested that there were a greater number of sugar mills in the Jordan Valley than suggested previously.[30] The Andrews University survey in Tall Ḥisbān has also suggested that the mills located there may have been sugar mills; this is due to the name of one site where a mill is located, which is called *Shūnet Sukkar* (Sugar Hill). Conder, travelling here in the 19th century, also stated that there was a mill here, but did not specify what kind of a mill, although he did believe that it had once been a sugar mill because of the toponym.[31]

It can generally be summarised that sugar mills need a larger area in which to operate, due to the nature of the processing of sugar cane. The mills in Ḥisbān are comparatively quite small, and there is a noticeable lack of buildings where the cane could be processed once it had been crushed. Another factor is the close succession in which these mills were

[29] See Chapter Five.
[30] Hamarneh 1978, Abu Dalu 1995.
[31] Conder 1889.

built; this is not usually the case for sugar mills, where one large mill serves to process large volumes of sugar cane, which has been planted in close proximity to the mill. Furthermore, the lack of historical documentation mentioning a relatively precious commodity such as sugar for this region- where it has been mentioned in other areas of the Levant- but the mention of wheat crops in al-Balqa', also suggests that the mills built here were used for grinding grain, rather than sugar. This is substantiated by the lack of sugar millstones found there; due to their size- which is usually larger than the millstones used in a grain mill- they usually remain in the ruins of the mill. Finally, the landscape is unsuitable for planting sugar cane, which fares better in well-irrigated, warm low lands, such as the *Ghawr* in Jordan.

Conclusion

A comparison between the mills of the Levant to those of the surrounding Muslim world suggests that mill construction followed a similar pattern in all areas, both in construction, technology and exploitation of the natural resources for the advantage of agricultural communities living in arid regions. It appears that in places like Syria and Iran, which are large countries with a variable landscape, large rivers provide the opportunity for greater variation in technology and architecture. Vertical wheeled mills operate successfully on large rivers, as do horizontal mills, while the smaller *arūbah* type can be found in areas where water volume is less predictable, such as Misyāf. This also appears to be the case with smaller countries like Cyprus and Jordan, which took advantage of hills and irrigation systems to power watermills, predominantly using a horizontal wheel, at least until very recently.

Turkish mills also employed the use the horizontal wheel, but here the penstock was a square wooden diagonally sloping chute or hollowed out log rather than a "pressure tank" like the *arūbah* penstock. Perhaps the single example of this kind that was also found in Cyprus indicates this to be an Ottoman-period invention, although it could as easily be taking advantage of cheaper available building materials, and not necessarily be the building tradition of a certain era or cultural influence.

CHAPTER SEVEN

The Mill, Archaeology, Landscapes & Human Settlement

Having reviewed some of the architectural and technological features of watermills across a wide area of the Islamic world, this chapter intends to review the archaeological material available to help further understand the role of the mills in the Levantine landscape, history and society. This will be done through an analysis of material from TAESP and SCSP for Cyprus, and available archaeological material from Jordan and Syria.

Following the same organisation as the case studies, this chapter will begin by examining the archaeological landscapes of Jordan, followed by Syria and Cyprus. This will be followed by a brief discussion on suggestions for dating methods regarding the watermills.

Jordan

It has often been believed by scholars and academics that Jordan played a peripheral role in the politics of the Crusaders, Ayyūbids and Mamlūks, as well as the Ottoman period; however, the presence of numerous fortifications in al-Karak, Shawbak, Petra, ʻAjlūn, al-Ṣalt and Pharaoh's Island off the coast of ʻAqaba testify to a different truth. It was a time of turmoil in many parts of the Levant, overshadowed by tumultuous political and religious activity; this turmoil may have disguised the impact on society in the peripheries of the Crusader and Saracen strongholds. The mills of northern Jordan, although not intensively studied, have been identified and catalogued either through multi-period survey projects[1] or specific studies.[2] Although some detailed surveys and studies have been carried out little in depth research has been undertaken regarding the role and history of the water mill beyond basic descriptive work. In comparison to the many studies that have been conducted on other aspects of the medieval period, such as

[1] Ibrahim, M., Sauer, J.A., & Yassine, K. (1976) "The East Jordan Valley Survey, 1975." *BASOR* 222; Hanbury-Tenison, J. (1984) "The Wādi ʻArab Survey 1983." *ADAJ* 28, 385-423; Mabry *et al.*
[2] Greene 1995; McQuitty 2004; Rogan 1995.

economy and trade, the watermills, so ubiquitous in the landscapes of the Levant, have scarcely received any attention.

'Ajlūn

The clearest evidence of the significance of 'Ajlūn during the Ayyūbid and Mamlūk periods is the castle, situated on top of a hill overlooking the Kufranja valley. Unlike al-Karak and Shawbak, it was never seized by the Crusaders. This region is an ideal setting for water mills, as the natural vegetation and soils are conducive to agricultural activity and crop cultivation, and the presence of natural water sources is abundant. In a survey conducted in this region in an area to the south-west of 'Ajlūn in 1986, more than 20 watermills were recorded.[3] Their state of repair ranged from ruined to reasonably intact during the time of the survey, but modern development in this area has caused the disappearance of many of these mills in the last few years.

The area was, rather confusingly, previously known as Jabal Jarash, but by the $6^{th}/12^{th}$ century it had become Jabal 'Awf, named after a Bedouin tribe that ruled the area.[4] Ibn Shaddād gives a detailed account of the circumstances surrounding the building of 'Ajlūn castle, as well as its history, in his work *al-A'lāq al-Khatīra* (part 3, which deals with Lebanon, Jordan and Palestine). It was built by an *amīr* belonging to Ṣalāḥ al-Dīn's brother al-Malik al-'Adil Ṣayf al-Dīn Abu Bakr Ibn Ayyūb, who had given 'Ajlūn to 'Izz al-Dīn Usāma as a fief.[5] After some resistance by the local tribe, the Banu 'Awf, he was able to build the castle, but only by convincing the tribe that it was for protection against the Franks rather than for the purposes of controlling them, although this was merely a ruse to trick them into allowing the construction of the castle.

Al-Qalqashandi also mentions 'Ajlūn in his work *al-Masālik al-Absār.* He presents the town and castle as an important beacon station, for which it was ideal because of its high elevation.[6] In his description of 'Ajlūn, Johns also states that the city was an important

[3] Greene 1995.
[4] Johns, C.N. (1931) "Medieval 'Ajlūn I: The Castle (Qa'lat er-Rabad)." *QDAP 1*:21-33.
[5] Al-Malik al-'Adil Ṣayf al-Dīn, ruler of Syria from 592/1196 to 615/1218.
[6] Gaudefroy-Demombynes, M. (1923). *La Syrie a l'epoque des Mamelouks d'apres la auteurs arabes. Description geographique, economique et administrative precedee d'une introduction sur l'organisation gouvernementale.* Librairie Orientaliste Paul Geuthner: Paris.

post-station; the Mamlūk postal system is renowned, and 'Ajlūn was apparently one of the stops for the carrier pigeons between Cairo and Damascus.[7]

The castle was built around 584/1184 and remained in the hands of the Muslims, despite several attempts by the Franks to capture it. It served as an Ayyūbid and Mamlūk outpost to overlook the activities of the Lords of *Oultrejourdain*.[8] In the centre of the city, which has today a sizeable Christian population, the only other significant buildings remaining from that period are two mosques, the mosque of Raymūn as well as the Friday mosque of 'Ajlūn. Another building said to be dating from the Ayyūbid/Mamlūk period is the *Maqām Badr*, believed to be a Sūfī *khanqah* according to Ghawanmeh.[9]

Other than the still thriving major settlement of 'Ajlūn, there are vast number of settlement ruins scattered around the region which have been classified as Ayyūbid-Mamlūk sites based on surface scatters of mainly pottery fragments.[10] More than 40 settlements were identified as Ayyūbid-Mamlūk period sites during various surveys, and although their relationship to the 20 water-mills in the area is uncertain, it is plausible, as previously suggested, that these watermills date as far back as the Ayyūbid and Mamlūk periods.[11]

Mackenzie's limited survey of the area in 2000 revealed several buildings and sites of interest, both within 'Ajlūn itself and in the immediate surrounding areas. These include the mosques mentioned above, which can definitely be dated to the Ayyūbid/Mamlūk period, and also a number of *maqām*, or shrines. A site of particular interest is Ba'ūn, which is mentioned by Abu-l Fidā in the 8th/14th century as being a wealthy suburb of 'Ajlūn. Although no references have been found so far for this town in 6th/12th and 7th/13th century sources, a relationship between the sites and the water mills of the region as has also been suggested by Malkawi, and in the study conducted by Greene in 1986, cannot be discounted.[12]

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[7] Johns 1931, 31.

[8] For a recent study of the architecture and archaeology concerning the castle, see Yovitchich, C. (2006). "The Tower of Aybak in 'Ajlūn Castle: An Example of the Spread of An Architectural Concept in Early 13th-century Ayyūbid Fortification", in H. Kennedy (ed.), *Muslim Military Architecture in Greater Syria from the Coming of Islam to the Ottoman Period*. History of Warfare 35. Brill: Leiden/Boston, 225-242.

[9] Mackenzie 2002.

[10] Greene 1995, 762; Mittmann, S. (1970). *Beiträge zur Siedlungs- und Territorialgeschichte des Nördlichen Ostjordanlandes*. Abhandlungen des Deutschen Palästina Vereins. Harrassowitz: Wiesbaden.

[11] Greene 1995; Rogan 1995; Malkawi 1994.

[12] Greene 1995; Malkawi 1994.

Figure 7. 1. Map of 'Ajlūn area, showing relevant *widyān*, mills and archaeological sites from the Ayyūbid to Ottoman periods. (After Mittmann 1970)

The extensive survey of the 'Ajlūn region provided by Mittmann has also yielded some interesting observations; there is a notable presence of Ayyūbid and Mamlūk sherd scatters on the majority of archaeological sites surrounding the watermills in the Wādi Rayyān, the Wādi Kufranja and the Wādi Rājib, and a notable absence of pottery from the Ottoman period.[13] A similar observation can be made of the architecture present in these three areas; while there are numerous remains of shrines and mosques from the middle Islamic period (mentioned above), there is less evidence of architecture dating to the Ottoman period. That is not to say that there was no Ottoman presence in later periods- that has already been established through court records- but rather that settlement was comparatively sparse during the earlier Ottoman period, which would render it unlikely that the mills were built during that period as there would have been little need for them in such a thinly populated area. **(Fig. 7.1)**

Unfortunately, very few of the watermills in Jordan have been excavated archaeologically, and where they have been, the published material is difficult to obtain, so there is little substantial archaeological evidence- other than surface scatters of pottery- that can be used for dating. Surveys have not recovered any ceramic material of profound significance, despite numerous surface collections around the mills themselves and in the nearby vicinity. As Greene suggests, this is a problem, and the archaeological dating of the mills is therefore very preliminary. He recorded 20 mills in the Wādi Kufranja, located between Wādi al-Rayyān and Wādi Rājib; as this is now almost 20 years ago, most of these have probably fallen into total ruin or been destroyed by road works, agricultural and urban expansion.

The 1987 Wādi el-Yābis survey, conducted jointly by the University of Arizona and the Università di Roma, was a multi-period survey covering the early prehistoric to the late Islamic periods. The survey covered the entire natural basin of the Wādi el-Yābis drainage system[14]in an area north-west of the town of 'Ajlūn. Almost 100 sites were recorded, 29 of which yielded artefacts dating from the Ayyūbid-Mamlūk periods. 13 of these 29 sites showed evidence of earlier occupation, and 5 sites showed evidence of later occupation. In addition to the small finds that were collected during this survey, various

[13] Mittmann 1970.
[14] Mabry *et al* 1988, 275.

buildings were also discovered, including 5 water mills. The close proximity of these mills may suggest that they formed a chain of watermills serving the greater 'Ajlūn area, possibly as early as the Ayyūbid period if one takes into consideration the settlement remains previously identified.

The presence of water mills in the *widyān* both north and south of the Wādi Kufranja may suggest that there was at one point a network of these designed to provide for a larger area than that immediately surrounding the castle of 'Ajlūn; although Greene does not favour this suggestion, settlement in this region during the Ayyūbid and Mamlūk periods appears to have been substantial enough for a sufficient demand in processed cereal products. This could be particularly pertinent if, as has been suggested in historical sources, that 'Ajlūn was a kind of relief supply centre from where products and goods were taken south to aid besieged cities such as Damietta[15]. This would also reinforce Ira Lapidus' idea of Mamlūk grain provisions, which were exported to other areas struck by famine, such as Cyprus and Egypt, in times when there was a grain surplus, and vice versa[16]; and industry to process the grain would have been necessary whether the grain provisions were adequate or not.

'Ajlūn and its surroundings continued in importance, if not as a political centre until the 19th century, at least as a continuing, although also weak, economic entity within the Ottoman administration. This is reflected in the archaeological settlements analysed by Mittmann during his survey in the region. Out of 15 sites that were surveyed for pottery, only 3 of these had sherds from the Ottoman period. All 15 sites had remains of Mamlūk pottery or architecture. These pottery finds show little settlement activity for the Ottoman period for all three *widyān* in the 'Ajlūn region compared to the Mamlūk and early Islamic periods; the lack of architecture that can be confirmed to date from the Ottoman period is also indicative of this lack of settlement. Hütteroth and Abdelfatteh list the *liwā'* of 'Ajlūn as being agriculturally active in the early Ottoman period, although apparently not as wealthy or resource-rich as Jerusalem, and Johns has pointed out its significance

[15] Johns 1931, 30.
[16] Lapidus 1969; this issue is further discussed in Chapter Eight.

because of the region's timber, charcoal and iron resources, as well as mining and smelting activity which continued into the Ottoman period.[17]

Al-Ṣalt, Wādi Shu'ayb and Wādi al-Sīr

Although a considerable amount of historical and archaeological research has been conducted around al-Ṣalt and the Wādi Shu'ayb area, located south of 'Ajlūn, there have been few in-depth publications relating to specific periods with regards to the archaeology of the region.

It was difficult to tell whether the mills located immediately south of al-Ṣalt are contemporary to each other; at first glance, SHU3 was assumed to be of an earlier date, mainly because of the larger size of the masonry blocks with which the penstock was constructed. However, the owner of the neighbouring gardening centre claimed that it was a "Turkish" mill. Previous surveys in this area have also placed these mills as Ottoman-period buildings; the Ottoman government took control of the agricultural administration in the 1860s here in an effort to regain an administrative foothold of the area after centuries of Bedouin rule, and previous research by Rogan has indicated that this sparked an increase in agricultural activity as well as the restoration of watermills.[18] As with the majority of the cases in this study, clearing land for agricultural development, as well as road construction and residential development, has altered the landscape to such a degree where it has become very difficult to determine the physiology of the landscape before the last century. However, the architectural features of the mills here, and their position within the landscape, is similar to the mills in the 'Ajlūn area which could suggest an earlier, probably at least Mamlūk, date for these mills.

The presence of a Crusader-period castle in al-Ṣalt, built by the Ayyūbid Ṣultān al-Malik al-Mu'azam in the 7th/13th century[19], is significant in itself; it is mentioned both in Crusader chronicles as well as in treaties between Muslims and Crusaders of the 6th/12th,

[17] Johns 1931; this is also further discussed in Chapter Eight, as are details of the Ottoman tax registers.
[18] Rogan 1995.
[19] Ruler of Egypt and Syria 647/1249 to 648/1250.

7th/13th and 8th/14th centuries.[20] In addition, historical sources have placed al-Ṣalt as briefly being a *niyāba*[21] in the late 7th/13th century.[22] The castle was destroyed by the Mongols in 660/1260, and subsequently rebuilt by another Mamlūk Ṣulṭān from Egypt; in the mid-19th century, it was finally completely destroyed by the armies of Ibrahīm Pāsha. The castle, as well as the town's convenient position on north-south and east-west trade routes, places it in a significant spot in the history of the region. As well as the architectural remains within the city itself, dating from the medieval to the Ottoman period, there were what appeared to be Ottoman-period village houses scattered along the main road near the watermills. Approximately 200m down the *wādi* from SHU3 there was also an archaeological site dating from the Classical period, consisting of an olive press and cave dwellings. There is a moderate spread of archaeological material from a wide span of time around the watermills, which makes it difficult to place them in one specific time period, without the aid of further archaeological explorations.

The Wādi al-Sīr, located south east of al-Ṣalt, is an area that has received some attention by archaeologists, and several archaeological surveys have taken place there.[23] In a survey conducted in 2000 by Ji *et al*, covering both parts of the Wādi al-Sīr and the lower Wādi Shu'ayb, water mills were a considerable element of discovery; seven out of forty-two sites were classified as watermill sites.[24] However, only two of the total number of sites were classified as Middle Islamic[25]. Previous investigations by the same author had revealed heavier settlements during the early Islamic period, which decreased with the middle Islamic period, except for one site, which appeared to be a fortified middle Islamic site called *Khirbet al-Sa'ada*, including remains of a city gate, walls and buildings.[26] Although al-Ṣalt, as well as the top of the Wādi Shu'ayb, did have some Ayyūbid and Mamlūk settlements there, primarily through the presence of the castle, there is less clear evidence of such settlement for the Wādi al-Sīr region; unfortunately,

[20] Holt, P.M. (1977) *The Eastern Mediterranean Lands in the Period of the Crusades.* Aris and Phillips: Warminster.
[21] *Niyāba*: district capital.
[22] Walker 2003, 244.
[23] Ji & Lee 2002; Ibrahim, M., Sauer, J.A., & Yassine, K. (1976) "The East Jordan Valley Survey, 1975." *BASOR* 222; Ji, C. (1996) "The Madaba Plains Borderlands Survey Project, 1996: Irāq al-Amīr and the Dhibān Plateau." *LA 46*, Pp. 414-418.
[24] Ji & Li 2002, 181.
[25] Fātimid, Ayyūbid and Mamlūk periods.
[26] Ji 1996, 416.

settlement here is equally obscure for the Ottoman period, and it is therefore difficult to date the watermills here to any specific era, other than through their architectural features, but this is also not a reliable method.

Ḥisbān

Ḥisbān is a small town located on the edge of the Madaba plains in Jordan to the south-west of ʿAmmān, and it has been thoroughly excavated and studied by archaeologists from Andrews University.[27] Although the layers of the historic part of the town date as far back as the Bronze Age, there was significant settlement there dating to the early Mamlūk period, including a palace and a substantial bathhouse at the foot of the *tall*. To the west of the *tall* and the modern town of Ḥisbān lies Wādi Ḥisbān, along which there are still extant numerous water mills in various states of preservation, and nestled among a vast agricultural landscape.

The Andrews University survey covered an area of approximately 25km^2, in which sites of all periods were recorded, numbering 148 in total. Of these, approximately 35% were classified as Ayyūbid/Mamlūk. 25% of the total number of sites dating from all periods located in the *wādi* were Ayyūbid; 33% of these were in the *Ghawr* (Jordan Valley), and the largest percentage at 45% were on the plateau. 33 of 73 sites located on the plateau were dated to the Ayyūbid/Mamlūk period, indicating a major settlement during these periods, not just on the *tall* but in the wider area. The *tall* has architectural remains dating from as far back as the Bronze Age, but one of the most interesting features are the remains of a Mamlūk settlement, and a Mamlūk bathhouse. The bathhouse is of particular interest, as there is some speculation as to where it would have received its water from; there is no immediate evidence of a water channelling system that could have brought water from the *wādi* up to the bathhouse and *tall*. The Andrews University survey did discover a large number of cisterns around the site, and perhaps these also supplied the bathhouse.[28]

[27] Archaeological investigations are still going on at Ḥisbān, but the data presented has been taken from excavations between 1978 and 1983; see Geraty & Running 1989.

[28] Ibach 1987. The early Islamic town of al-Fusṭāṭ in Egypt (the first Islamic settlement in Cairo) had a system of bringing water from the Nile to the town, which is located at some distance from the river, but

The Ayyūbid/Mamlūk sites mapped around the vicinity of the water mills range from very small to medium sized; the larger sites are located on the plateau, but that is not surprising. They are still within proximity of 12-14 km from the watermills. The major Ayyūbid/Mamlūk sites that were located in the Andrews University survey constitute 80% of all major sites of all periods, while those classified as large made up 83% of the total number of sites. Thus, both large and major sites made up a total of 72%, or 8 sites of 11. Of these 8 sites, 6 were located on the plateau. The Ḥisbān survey notes "a number of architectural ruins of a style noted at other Ayyūbid/Mamlūk sites......vaulted buildings, decorated lintels and arches....". [29]

Ḥisbān is mentioned occasionally in Ayyūbid and Mamlūk historical sources, the most indicative of a flourishing agricultural community being the account given by Abu'l Fidā in the 8th/14th century, mentioned in Chapter Two, where turning mills were scattered along the river. Ayyūbid sources mention Ḥisbān being used as a camping place while the troops were marching against the Franks on their way to al-Karak and Shawbak.[30] Perhaps this camping ground was really a semi-permanent settlement already then, once the Muslims realised the need for another outpost for protection against the Crusaders. Tall Ḥisbān was a convenient choice, as it had been continuously inhabited and rebuilt for thousands of years.

The presence of a considerable residence belonging to a Mamlūk governor during the 8th/14th century also indicates that Ḥisbān was an important settlement during the middle

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also has large cisterns in intermittent intervals which- along with the state-employed water bearers of the time- would have supplied the settlement with its daily water. A similar system could have been employed at Tall Ḥisbān, although at a later date, but perhaps a remnant of the brief early Islamic settlement that also took place there.

[29] Ibach 1987, 192. The study of Ayyūbid and Mamlūk buildings in Jordan has mostly been limited to palaces, mosques and other religious or official architecture; and vernacular architecture has been relatively unstudied. See Walmsley 2000; Brown 1988; Mayer 1987; Kareem 2000.

[30] Al-Isfaḥāni, Imād al-Dīn. (1972). *Conquete de la Syrie et de la Palestine par Saladin: Al-Fatḥ al-quṣsi fi'l-Fatḥ al-qudsi.* Trad. Française par Henri Masse. Documents relatifs a l'histoire des Croisades. L'Academie des inscriptions et belles-letres: Paris.

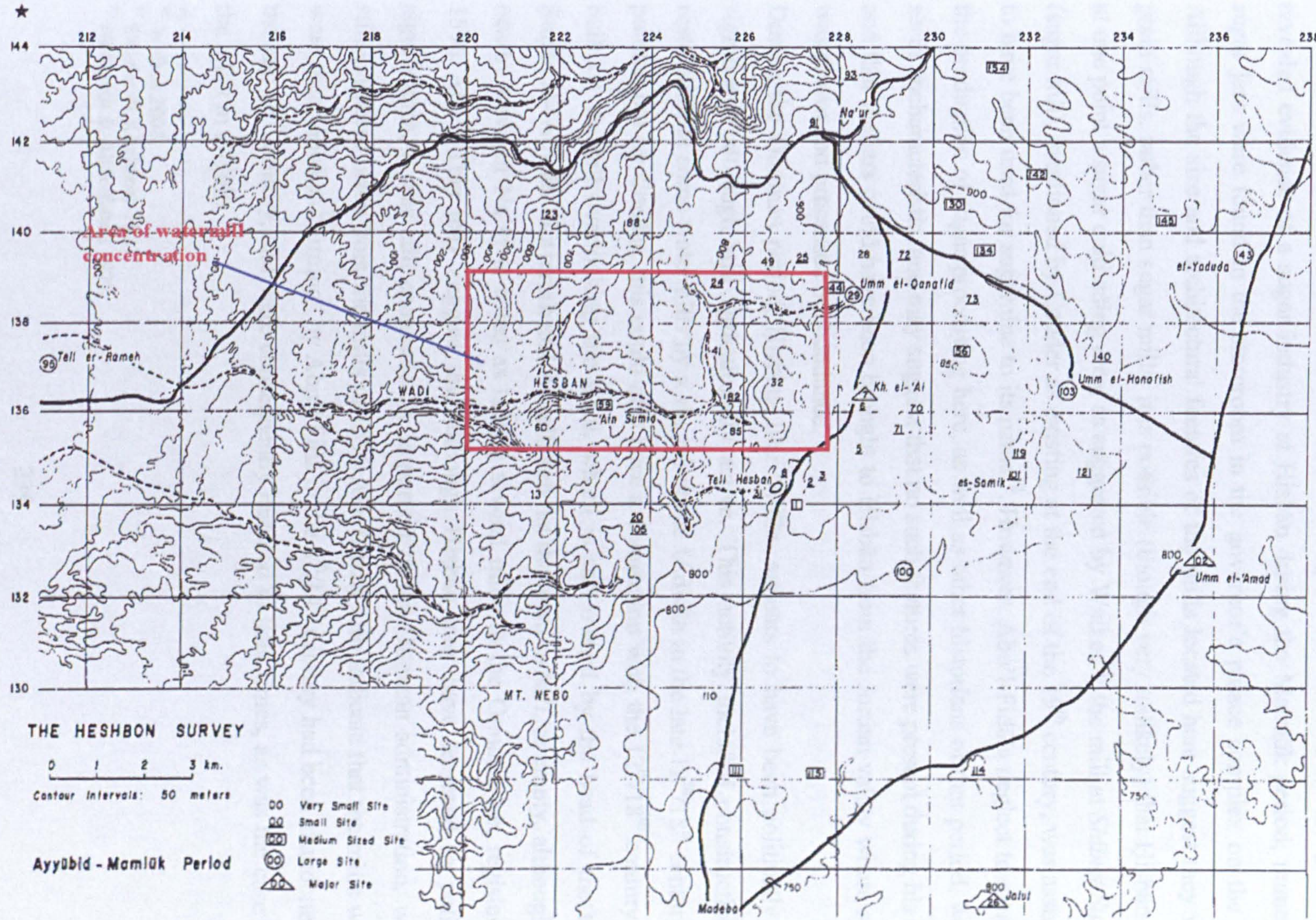

Figure 7. 2. Map of Wādi Ḥisbān. The area of concentration of watermills is highlighted in red. (From Ibach *et al* 1987)

Islamic period; its abandoned status according to tax registers of the late $10^{th}/16^{th}$ century may suggest that the area had been deserted already before then, which would make it seem improbable that there was any initiative by the Ottoman government to build the water mills present there.

In addition, recent surveys and archival investigations of the Ḥisbān region have revealed evidence of a sugar industry at Ḥisbān during the Mamlūk period; numerous sugar jars were found in the storeroom in the governor's palace complex on the *tall*. Although the size and architectural features of the mills located here suggest they were grain mills, rather than sugar mills, it is possible (though very unlikely) that Ḥisbān was at one point a sugar cultivating area, as suggested by Walker[31]; the mill at *Shūnet Sukkar* (sugar hill), mentioned by Conder as existing at the end of the 19^{th} century, was assumed to have been used for sugar due to its name[32]. However, Abu'l-Fidā's neglect to mention the production of sugar processing here, as well as other historians of that period, would seem uncharacteristic, and may suggest that no such features were present during his time and that the jars could have been brought to Ḥisbān from the Jordan valley where sugar was grown and processed in abundance.

During the Ottoman period, Ḥisbān- like 'Ajlūn- appears to have been politically less significant, although still agriculturally active. This activity included construction or restoration of some watermills by a *shaykh* of the 'Adwān in the late $12^{th}/18^{th}$ century, as pointed out by Conder; this could also have a connection with the $12^{th}/18^{th}$ century fort built on the hill overlooking the *wādi*, which is still owned by the head of the tribe, Ṣulṭān al-'Adwān. Hütteroth and Abdelfatteh list the town as *hali*, or empty, although the nearby town of Na'ūr is listed as having several mills in the Ottoman tax registers of 1596 AD.[33] This may suggest that although Ḥisbān may have lessened in political significance, it was still economically important to the Ottoman administration, which still extracted taxes from the mills in 1596 AD. It may also indicate that the mills which were mentioned as "turning" by Abu'l Fidā in the $8^{th}/14^{th}$ century had been abandoned by the late 16^{th} century, and were consequently restored in later times, as was the case with the mills in al-Ṣalt.

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[31] Walker 2003.
[32] Conder & Kitchener 1881.
[33] Hütteroth & Abdelfatteh 1977.

Wādi Wāla & Wādi Haydān

Wādi Wāla is located immediately above Wādi Mūjib, south of Madaba and Ḥisbān. The main town above on the plateau is Dhibān, which has been the site of excavations since the middle of the 20th century. Archaeologically, the area has been relatively unexplored, and the lack of any substantial knowledge regarding settlement of the region provides a rather vague picture of the historical landscape. The southern most end of the Wādi Haydān, which was surveyed for water mills in 2004, is located at the foot of the plateau on which the town of Dhibān is located. Dhibān has been studied and excavated extensively[34]; it is most famously known for its importance during Biblical times. Unfortunately, little information or archaeological evidence exists with regards to the Middle and Late Islamic Periods. Although there are various settlements that exist on the plateau, it is difficult to formulate a historical or archaeological framework in which to place them in relation to the numerous watermills in the valley below.

As mentioned previously, the settlement history in this region is vague, as few surveys and excavations have taken place around these large *widyān*, and any studies that have been conducted have been confined to the plains above. These include a survey of the Madaba plains [35], and excavations in the town of Dhibān.[36] Although these surveys and excavations focus mainly on the Biblical period of the plains, there is a significant heritage of water supply systems and conservation that settlements took advantage of in succeeding historical periods. The presence of a large number of cisterns and reservoirs attest to this idea.[37] In addition to this its fertile plains gave it the reputation of being the "'bread basket' of ancient Palestine".[38]

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[34] Tushingham, A.D. (1972) "The Excavations at Dibon (Dhibān) in Moab. The Third Campaign 1952-53." *AASOR* Vol. XL. Ed. P.J. King. ASOR: Cambridge; Winnett, F.V. & Reed, W.L. (1964) "The Excavations at Dibon (Dhibān) in Moab, 1957-58". Ed. Gus W. van Beer. *AASOR* Vols. XXXVI-XXXVII. ASOR: New Haven. Current investigations are being conducted by Dr Bruce Routledge of the University of Liverpool and the University of Pennsylvania; see **www.cbrl.org.uk/research/resarch2.shtm** and **www.sas.upenn.edu/~bporter/Dhibān.htm.**

[35] Harrison, T.P., Hesse, B., Savage, S.H. & Schnurrenberger, D. (2000) "Urban Life in the Highlands of Central Jordan: A Preliminary Report of the 1996 Tell Madaba Excavations." *ADAJ* 44:211-229; Savage, S.H. & Metzger, M.L. (2002) "The Moab Archaeological Resources Survey: Test excavations and faunal analysis from the 2001 field season." *ADAJ* 46: 107-123

[36] Tushingham 1972; Winnett & Reed 1964.

[37] Winnett & Reed 1964, 46-47.

[38] Winnett & Reed 1964, 50.

Tushingham (1972) notes the limited occupation of Dhibān itself during the Ayyūbid, Mamlūk and Turkish periods[39], and indicates no connection between the settlement of the plains and the existence of settlements or agricultural features in the valley. Ji conducted limited surveys around Dhibān as a part of the Madaba Plains Borderland Survey Project in 1996.[40] Although the sites investigated yielded predominantly high degrees of Byzantine and Roman settlements, with a decrease during the early Islamic period, there was intensified settlement increase during the middle Islamic period, which may be associated with the settlement history and political significance for the rest of Jordan during the Ayyūbid and Mamlūk periods. However, a similar picture as in Ḥisbān may be formed of agricultural life here in the medieval period, despite the minimal existence of settlement; as discussed previously, the plain above Sayl Ḥisbān showed greater settlement during the Ayyūbid-Mamlūk period than the valley itself, where the water mills were located.

The nature of the architecture of the mills is sufficiently ambiguous in interpretation, but the noticeable differences between sites 1-3, and site 4, points to a sophisticated development; again, this may also be the case in Ḥisbān, where the first six mills are single penstock, and the last two are of the double penstock kind. Unfortunately, these two mills are too ruined to determine whether they are of an identical construction technique to site 4 in Wādi Haydān, but the double arched entrances to the wheel chambers show definite similarities in their construction. The difficulty here in dating the mills is that although it suggests that they were contemporary with each other, the construction period is still undetermined.

South of the Mūjib River

The *Arḍ al-Karak*[41] has been studied in some detail[42], but as pointed out by Johns, archaeological finds have yielded a different picture of the Crusader period than that

[39] Tushingham 1972, 83.
[40] Ji 1996.
[41] This is the Karak Plateau area, which stretches from Wādi Mūjib to Petra.
[42] Mayer 1987; Miller, J.M. (1979) "Archaeological Survey of Central Moab: 1978". *BASOR* 234: 43-52; Brown 1988; Johns, J., McQuitty, A.M. and Falkner, R. (1989) "The Fāris Project: Preliminary Report upon the 1986 and 1988 Season". *Levant* 21: 63-95.

provided by historical records.[43] Ibn Jubayr's own account suggests the existence of around 400 villages around al-Karak in the year 584/1184 AD[44]; the holding of an annual merchant fair at al-Karak during this period could further suggest that al-Karak and the rest of *Jund al-Urdunn* were regions of some importance, both commercially and politically. [45] Historical sources also pinpoint al-Karak as a sugar-growing and manufacturing area.[46] Furthermore, the pillaging and destruction of the land caused by Ṣalāḥ al-Dīn in 587/1187 and its subsequent conquest by him implies that there existed significant agricultural lands and villages belonging to the Franks which would weaken the Franks economically and physically if they were destroyed or claimed[47], as also suggested by Johns.[48] Mayer has pointed to the settlement of Frankish farmers in Shawbak (Montréal) by Baldwin in the 6th/12th century[49], and Riley-Smith has also provided information on new western colonies settling in the Kingdom of Jerusalem.[50] The movement of people, whether native or "foreign", or forced or voluntary, seems to have been a frequent occurrence during the medieval period.

Al-Karak and Shawbak

The *widyān* studied south of the Mūjib River and the Dead Sea are surrounded by several important regions of settlement. The regions of al-Karak (Crusader *Crac*) and Shawbak (Crusader *Montréal*) in the 'Arḍ al-Karak were the scenes of numerous encounters between Crusaders and Muslims before they were finally taken by Ṣalāḥ al-Dīn in 1189 AD. Both fortifications were originally built by the Crusaders and modified through the centuries by the Ayyūbids, Mamlūks and Ottomans. There are numerous settlements belonging to the period of the Crusades and enjoying continuous settlement through the Ottoman period in the rural areas surrounding the town of al-Karak, one of which is at

[43] Johns 1992, 363-368.
[44] Broadhurst, R.J.C. (1952) *The Travels of Ibn Jubayr*. Johnathan Cape: London, 287.
[45] Deschamps 1939.
[46] Prawer, J. (1972) *The Crusaders' Kingdom. European Colonialism in the Middle Ages*. Phoenix Press: London.
[47] Gabrieli, F.(1969) *Arab historians of the Crusades*. Selected and translated from the Arabic sources; translated from the Italian by E.J. Costello. London : Routledge & K. Paul, 117.
[48] Johns 1992, 364.
[49] Mayer 1987.
[50] Riley-Smith 1973, 43.

Khirbat Fāris on the Karak Plateau. The settlement stretches to the edge of the Wādi Ibn Ḥammād, along which there are still extant water mills. Although they have not been studied in any detail, their proximity to Khirbat Fāris and al-Karak could imply a relationship between the rural settlements, the fortification at al-Karak and the watermills, both in Crusader and Muslim hands.[51] Miller's extensive survey of the Karak region indicates that the area was moderately populated between the 6th/12th and early 7th/15th century, and this is also the impression gained from historical sources of the time.[52] The 7th/14th century began a period of decline with the arrival of the Black Death, and as much as one third of the population, along with the cultivated land, was wiped out. This was coupled with the steady political decline of the Mamlūk period, which would reach its height with the arrival of the Ottomans. The population in the Karak region seems to have dwindled drastically by the late Ottoman period, when Burckhardt claimed that the plateau was only populated by a few permanently settled villages; however, the *defter- i- mufassal* (tax surveys) undertaken by the Ottomans in the late 16th century indicate that there was still a moderate amount of farming activity in the Karak region.[53] For the 11th/17th and 12th/18th centuries there is little information for the area, perhaps because of the loss of control by the Ottoman central administration until the 13th/19th century.

Shawbak was no less significant during this time period; strategically positioned on the road between Damascus and Cairo, it was an important point of defence for the Crusaders, and for the Ayyūbids it was a point of access to their power bases in Damascus and Cairo. This significance continued into the Ottoman period, when Shawbak castle "was a frontier post from which to insure the safety of pilgrims travelling to the holy cities of Mecca and Medina".[54] Not only was the proximity of Shawbak to al-Karak, as well as al-Wuʿayra (Crusader *Li Vaux Moise*) in Wādi Mūsa nearby, important, but its setting in a fertile landscape replete with natural resources was a favourable attribute; Renaud de Chatillon had entire ships built here before they were

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[51] This is further discussed in Chapter Eight.
[52] Miller, J.M. (1991) *Archaeological Survey of the Kerak Plateau.* ASOR Archaeological Reports No.1. Scholars Press: Atlanta; Ibn Jubayr 1960.
[53] Hütteroth & Abdelfatteh 1977; Hütteroth 1978. This is further discussed in Chapter Eight.
[54] Brown 1988, 225.

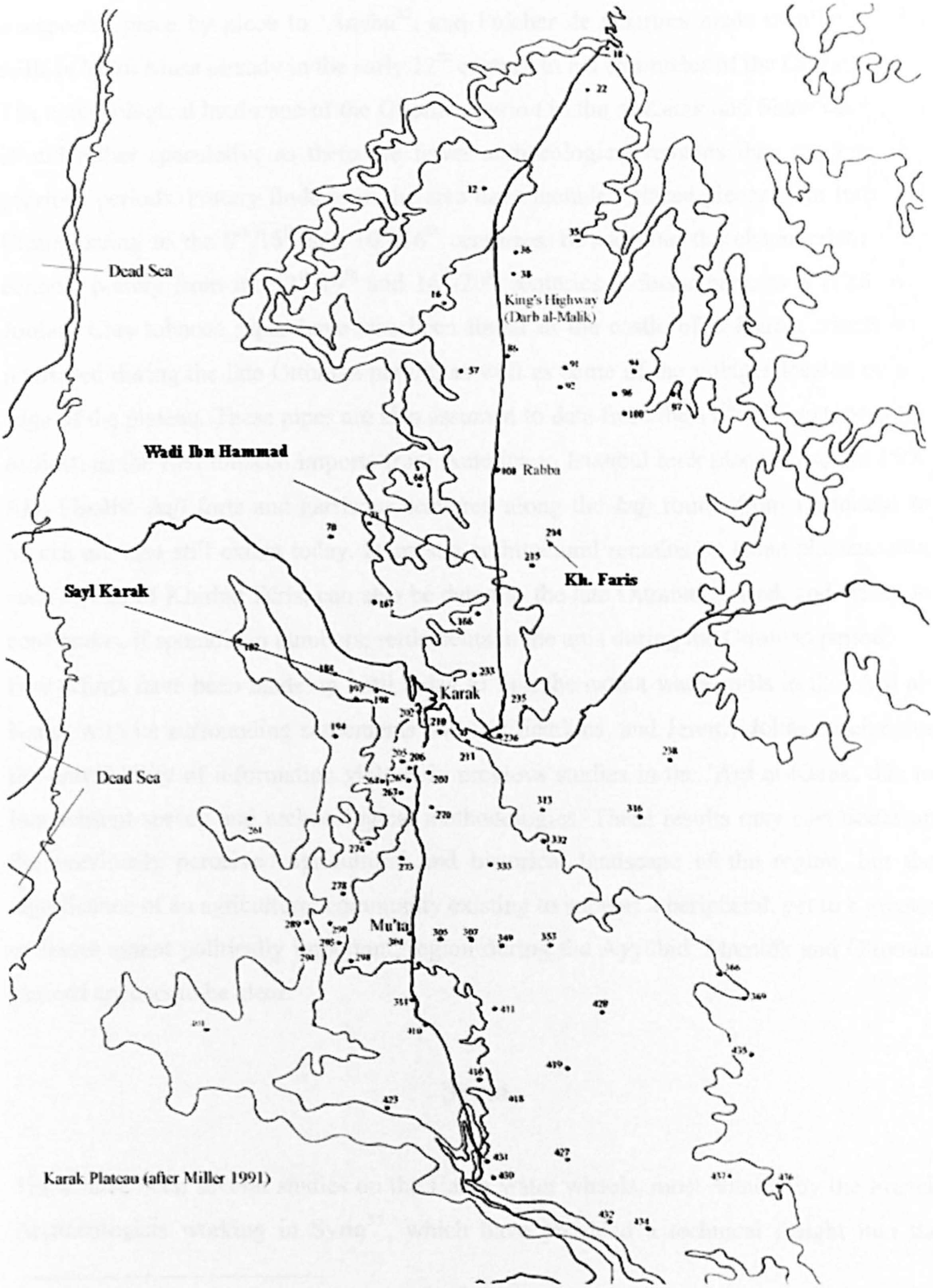

Figure 7. 3. Map of Karak area, showing relevant sites. (After Miller 1991)

transported piece by piece to 'Aqaba[55], and Fulcher de Chartres made mention of the mills in Wādi Musa already in the early 12th century in his chronicles of the Crusades.[56]
The archaeological landscape of the Ottoman period in the al-Karak and Shawbak region is still rather speculative as there are fewer archaeological remains than exhibited by previous periods. Pottery finds from the area have included glazed pieces from Italy and China, dating to the 9th/15th and 10th/16th centuries. In addition, the characteristic grey ceramic pottery from the 13th/19th and 14th/20th centuries is found here, as it is all over Jordan. Clay tobacco pipes have also been found in the castle of al-Karak, which was renovated during the late Ottoman period, as well as some of the villages located on the edge of the plateau. These pipes are also assumed to date from the 11th/17th century at the earliest, as the first tobacco imports from America to Istanbul took place at around 1600 AD. Finally, *ḥajj* forts and garrisons scattered along the *ḥajj* routes from Damascus to Mecca are also still extant today. Domestic architectural remains on some plateau sites, such as that of Khirbat Fāris, can also be dated to the late Ottoman period, and attests to continuous, if sporadic in numbers, settlements in the area during the Ottoman period.
Few efforts have been made up until today to link the extant water mills in the 'Arḍ al-Karak with its surrounding settlements and fortifications, and Jeremy Johns emphasises the unreliability of information yielded in previous studies in the 'Arḍ al-Karak, due to inconsistent survey and archaeological methodologies. These results may cast doubt on the previously perceived agricultural and historical landscape of the region, but the significance of an agricultural community existing to support a peripheral, yet to a greater or lesser extent politically important, region during the Ayyūbid, Mamlūk and Ottoman periods appears to be clear.

Syria

There have been several studies on the Ḥama water wheels, most notably by the French Archaeologists working in Syria[57], which have provided a technical insight into the

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[55] Prawer 1972, 71.
[56] Fulcher de Chartres. (1971)*The First Crusade: the chronicle of Fulcher of Chartres and other source materials.* Edited, with an introd. by Edward Peters. Philadelphia: University of Pennsylvania Press, 180.
[57] Delpech *et al* 1997.

functions of the water wheels. However, other than for the purposes of irrigation, there has been no theory to explain the existence of such an extensive network of water wheels in and around Ḥama. The presence of water wheels in the 5th/11th and 6th/12th century, as attested to by Nāsir-i-Khusraw and Ibn Jubayr, indicates that Ḥama and its surroundings have been abundant with these from earlier times, although the dating provided by the French go only as far back as the 8th/14th century at the earliest. The late Ayyūbid and early Mamlūk administrations' programme of public works to improve public water supply within larger cities may have extended to the maintenance and even construction of water wheels around Ḥama and the surrounding areas.

This program of building and renovation appears also to have been common in Ayyūbid and Mamlūk Aleppo, as Ibn Shaddād alluded to in his work. Gaube and Wirth recorded more than 50 "Wassermühlen" in their comprehensive study of Aleppo. Although they do not specify whether these were horizontal or vertical watermills, the discovery of the horizontal watermill in 'Ayn Deraa' may indicate that this was the technological tradition in northern Syrian watermills. This may also be the case for Misyāf to the south of Aleppo, which is most famously known as the home of the sect of the Assassins, which thrived there in the 6th/12th century. The architectural similarity of these two mills suggests that they are contemporary with each other.

According to a French visitor to the Aleppo area in 1756 AD, there were 16 working watermills on the Quwayq River, which were powered by donkeys in the winter when the river had dried out.[58] In addition, there are a number of *waqf* documents that refer to the watermills as early as the 9th/15th century, and a *waqf* document from 1077/1677 refers to six watermills belonging to a *madrasa* in the city itself.[59] By the end of the 13th/19th century there were apparently 59 mills in Aleppo; some of these were built outside the city walls, as this is were the Ottomans usually built watermills, according to Gaube & Wirth; this was perhaps because of the rapid expansion of urban settlement during the Ottoman period.[60] This also led to the need to improve the water supply system, which

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[58] Gaube & Wirth 1984, 109.

[59] Gaube & Wirth 1984, 139. A *madrasa* is a school.

[60] Gaube & Wirth 1984. 208; Sauvaget , J. (1941) *Alep. Essai sur le développement d'une grande ville syrienne, des origins au milieu du XIXe siècle. Texte.* P. Geuthner: Paris, 233.

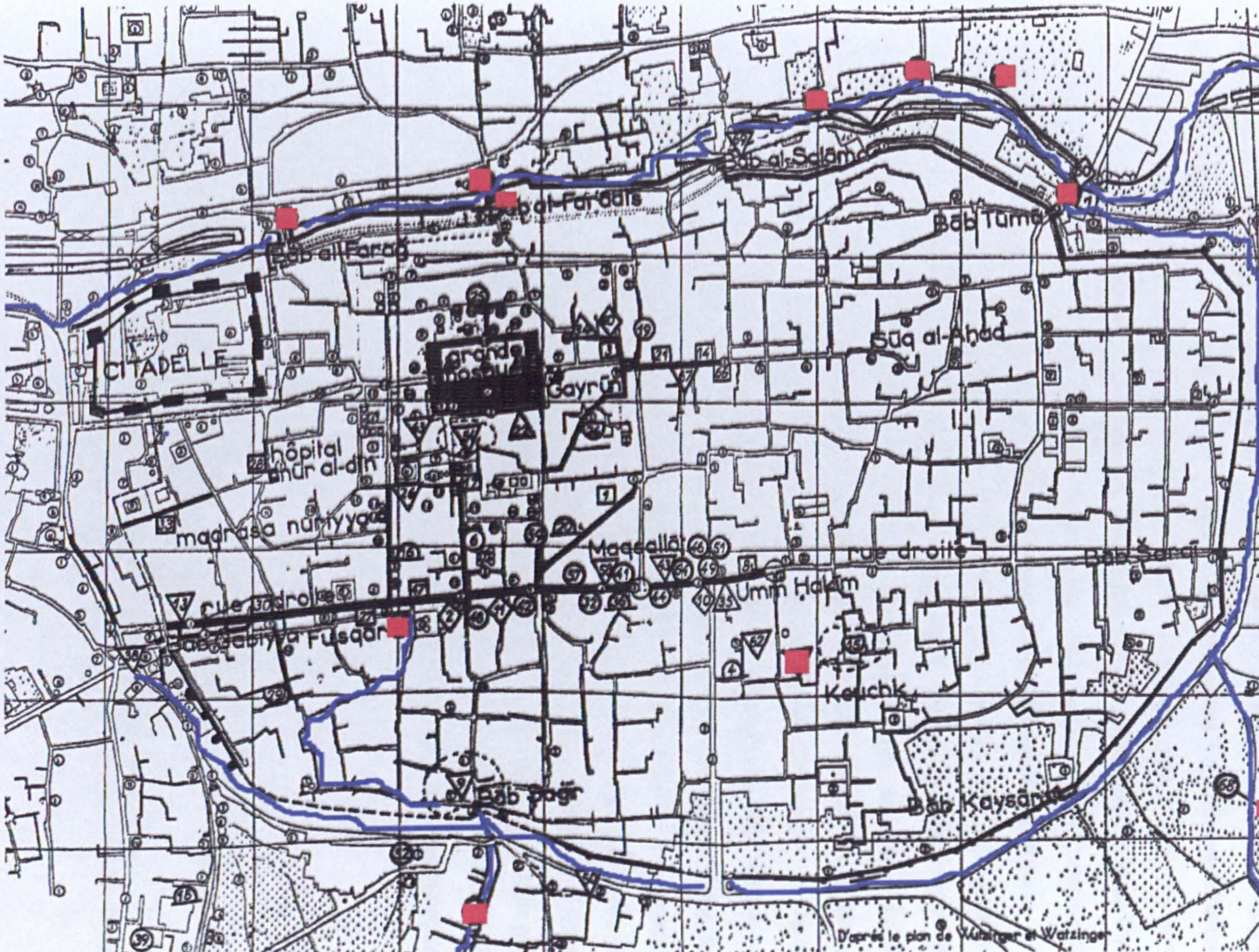

Figure 7. 4. Map of the Old City, Damascus. The watermills are marked in red, and the course of the river in blue. (After Elisseeff 1956)

underwent restoration during the late Ottoman period.[61] One quarter in Aleppo in particular, *Qastal al-Ḥarāmi*, had a high concentration of mills which, according to Gaube & Wirth, indicates that this was the millers' and wheat merchants' quarter.[62] The watermills in Aleppo are also frequently associated with nearby *khāns*, and this has not been found to be the case yet elsewhere in the Levant, but may be a trend restricted to urban areas.[63] However, the grain stores in Aleppo were conveniently located along each side of the river flowing through the city, providing easy access for grain merchants and millers to the water mills situated along the water.[64] Sauvaget also points out that the *caravanserais* built during the Ottoman period supplied flour to pilgrims passing through on their way to Mecca.[65] There appears to be a clear relationship between various urban industries and services and the water mills in Aleppo during the Ottoman period.

To the south, in Damascus, there was also a program of renovation and construction during the same period of time; water works and ways were constantly improved and constructed, and al-Idrīsī's mention of the city's turning watermills casts no doubt on the technological capabilities of the time.[66] Elisseeff has also pointed to the existence of 11 watermills which were in operation and a part of the "economic landscape" of Damascus during the time of Nūr al-Dīn.[67] **(Fig. 7.4)** One of these is located near Bāb Tūma, known as *Ṭāḥūnat al-Dabbāga* ("the mill of the tannery") and another near Bāb al-Faraj, known as *Ṭāḥūnat al-Ṭaqafiyyīn,* but also known as "the mill of the citadel".[68] Two more mills are located near Bāb al-Farādis and Bāb al-Salām.[69] In addition, there are two further mills located within the walls of the old city- these are *Rāḥa al-Ushnān* and *Ṭāḥūnat al-Sijn*, or "the mill of the prison", located off the Street Called Straight. Sack also puts one of the watermills there, the *Ṭāḥūnat al-Sijn* to the 6th/12th century.[70] Further mills are scattered along the city wall between Bāb al-Salām and Bāb Tūma; one in Baramke, near

[61] Sauvaget 1941, 233.
[62] Gaube & Wirth 1984, 208.
[63] Gaube & Wirth 1984, 210.
[64] Sauvaget 1941, 228.
[65] Sauvaget 1941, 229.
[66] Idrīsī 1974, 366.
[67] Elisseef, N. (1956) "Corporations de Damas sous Nūr al-Dīn. Matériaux pour une Topographie Économique de Damas au XIIe Siècle". *Arabica III*, 61-79.
[68] Elisseeff 1959, 78.
[69] These are further discussed in Chapter Five and Six, dealing with the mills of Damascus.
[70] Sack, D. (1989) *Damaskus: Entwicklung und Struktur einer Orientalisch-Islamischen Stadt.* Damaszener Forschungen Band 1. Philipp von Zabern: Mainz am Rhein, 95.

Bāb Ṣaghīr; and another, known as *al- Rāḥa al-Nūriyya* (the mill of Nūr al-Dīn) is located to the south-west of the city on the Naḥr Baniyās. This mill is a part of a ***waqf*** belonging to a ***ribāt***.[71] Two of the 13 mills mentioned by Ibn Shaddād in his account are the *Rāḥa al-Ushnān* and the *Ṭāḥūnat al-Sijn*; these are both mentioned by Ibn ʿAsākir in his account of Damascus.

Two of the watermills studied in this work, one of which was mentioned by the guide provided by the Directorate General of Antiquities in Damascus, are located on the map provided by Elisseeff.[72] These are located on the Old City walls, as mentioned earlier, close to both residential quarters, the Great Mosque and the Citadel. Their names sometimes suggest that they belonged to a certain type of industry, such as *Ṭāḥūnat al-Dabbāga,* which obviously had associations with a tannery, which Elisseef lists as existing near Bāb Tūma in the time of Nūr al-Dīn.[73] A mosque and a canal also belonged to the tannery. Equally, the *Ṭāḥūnat al-Sijn* may have served a prison at one time, and the *Ṭāḥūnat al-Ṭaqafiyyīn* probably belonged to the Citadel, as it is conveniently situated adjacent to it. All the mills are distributed fairly evenly around the city, but with a particular concentration on the north side of the city wall.

Damascus underwent similar changes to Aleppo during the Ottoman period. The early Ottoman period was perhaps politically more stable in Damascus than the Mamlūk period, and this provided opportunities for urban expansion. Bazaars and large commercial markets were constructed under the patronage of the powerful al-ʿAzm family, ensuring the city's cultural and material prosperity.[74] Although it could not rival the trading metropolis of Aleppo, the city's situation along the pilgrimage route meant that there was a constant movement in and out of the city. Derwish ***khanqas*** and *caravanserais* were built, and the water supply system of the city was renovated in the 11th/17th century; this may also have included the construction of water mills.[75] Unfortunately, the economic landscape of the city during the Ottoman period is still relatively unstudied, and it is more difficult to determine the nature of the relationship between the watermills and other urban industries for that time.

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[71] *Ribāt*: A frontier fortress and residence for Muslim warriors and mystics.
[72] The mills are marked in red, and those that were found during this survey are labeled as in the case study.
[73] Elisseeff 1956, 76.
[74] Sack 1989.
[75] Sack 1989, 34; Sack 1989, 107.

Cyprus

The term "Levant"- normally a geographical term denoting the area south of the Taurus mountains to the Mediterranean Sea, across the north Arabian Desert to Mesopotamia- is loosely coined in the modern day, incorporating anything from Jordan, Lebanon and Syria, to Iran, Iraq and Turkey; in this study, Cyprus is included in the Levant. The main reason for including Cyprus is its physical location in relation to Jordan and Syria; being very close to the mainland Levant, as well as Egypt and Greece, it is culturally and historically closely linked to all these regions. As in Jordan and Syria, the Crusader and Ottoman periods were an important part of the history of Cyprus, and the island was affected in many different ways by its different rulers.

The island of Cyprus played an important role in the time of the Crusades and later, politically and economically, and did not escape the turbulent political climate and its frequent changes between the 12th and the 19th centuries that were happening in the rest of the Levant. Occupied first by the Franks, and subsequently by the Venetians in the late 15th century, it was perhaps here that the changes in the Crusader Kingdom can be seen most clearly, and the administration and social change that took place were inescapable. These changes did not stop with the end of the Crusades, but continued well into the 20th century, first with the arrival of the Ottomans in 1571 AD, and then with the island's colonisation by the British Empire, a change which similarly affected the rest of the Levant, and in particular Jordan and Syria.

The European settlers of Cyprus first arrived after the capture of the island by Richard I in 1191 AD , before more colonists arrived from Europe. They took with them the legal, religious and administrative organisation of the Crusader lands, and this became absorbed into the existing Byzantine system, which resulted in a fused administrative system in use by the Crusader rulers. However, many changes took place in matters of landownership, the military and the ecclesiastical organisation, as well as in the social structure of the ruling class.[76] But as the island remained under Latin domination from 1191AD to 1571AD, the agricultural life was not seriously affected, unlike that of the colonies on the

[76] Edbury, P. (1991) *The Kingdom of Cyprus and the Crusades, 1191-1374.* Cambridge: Cambridge University Press.

Syrian coast.[77] During the 13th and 14th centuries the main population of Cyprus lived in the countryside[78], and this would doubtless have included the fertile Troodos mountain region. The Franks populated the island at the end of the 12th century in response to their possessions in the Holy Land (Syria) being seized by the conquering Muslim armies; otherwise, land in Cyprus was seen as having considerably less worth, which is why the Crusaders had no vested interest in the island previous to the arrival of Guy de Lusignan in 1192 AD.[79]

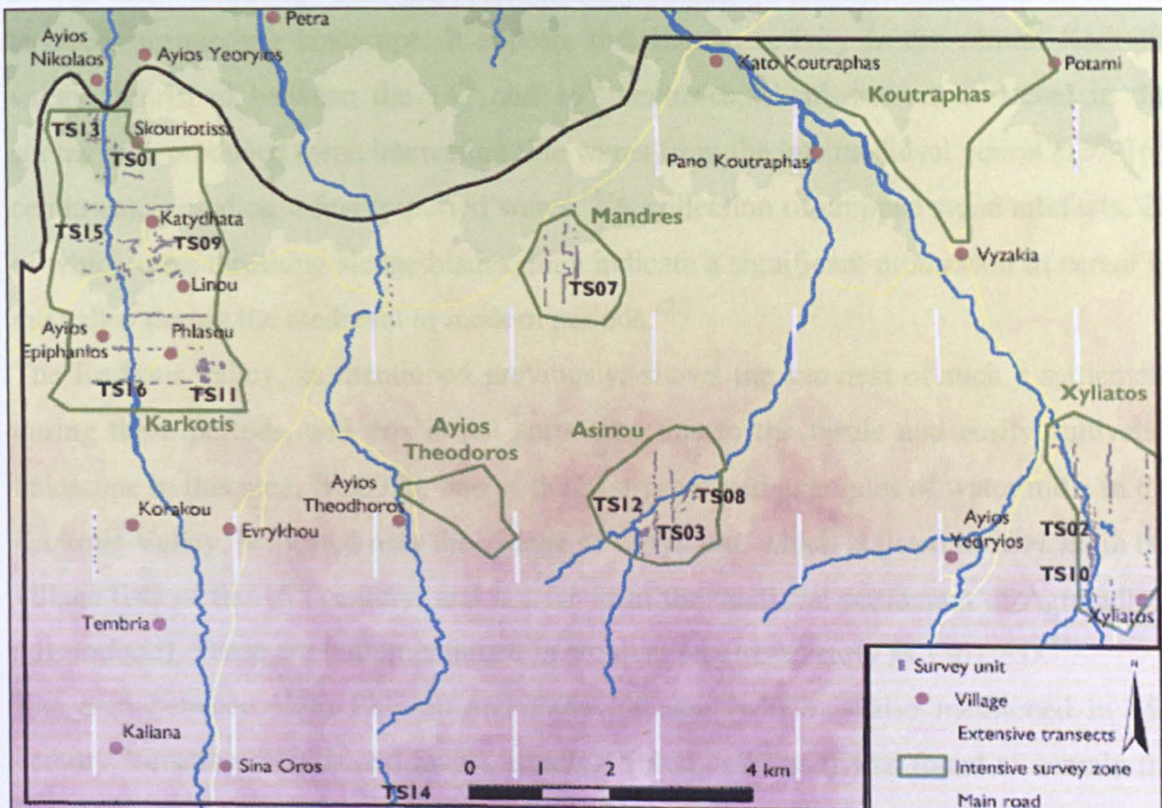


Figure 7. 5. Map of survey unit, intensive survey zones and villages in the TAESP survey. (Courtesy of TAESP)

[77] Setton, K.M., ed. (1985) *A History of the Crusades. Vol. 5, The impact of the Crusades on the Near East.* Edited by Norman P. Zacour and Harry W. Hazard. University of Wisconsin Press: Madison.
[78] Edbury 1991, 14.
[79] Edbury 1991, 17-18.

The TAESP surveys[80] have revealed several areas which showed significant occupation of settlements during the Medieval and Ottoman periods, many of which are located near water mills and irrigation works. Watermills in the Karkotis valley are ubiquitous, and their presence is not surprising considering the excellent quality of the soil and ready availability of water in this region. The area has been heavily settled since the medieval period; this is reflected in the collection of surface finds in this area, and the extensively terraced surrounding landscape. It appears that human activity in the central Karkotis valley flourished between the 14th and 19th centuries; sherd scatters collected in the survey area produced some interesting fine wares from the late medieval period (15th-16th centuries), including a few imported wares.[81] A collection of chipped stone artefacts, 20 of which were threshing sledge blades, may indicate a significant production of cereal in the valley during the medieval to modern periods.[82]

The Karkotis valley, as mentioned previously, shows the heaviest of such a settlement during these periods, and this is not surprising due to the fertile and easily cultivated landscape in this area. BU0070, one of the best-preserved examples of water mills in the Karkotis Valley, is located near the village of Evrykhou, which is listed as *Evrichu* in the village lists of the 15th century, and not far from the medieval settlement of Agroladhou (*Agriodada*). These are both mentioned in archival records as early as 1367 AD.[83]

The area between Kato Phlasou and Pano Phlasou (which is also mentioned in 15th century Venetian records and maps, usually written as *Flessu*) was found to contain the heaviest distribution of pottery from the medieval period, concentrated along the East bank of the river, peaking East and South of the medieval settlement of Ayios Dimitrianos (*S. Dimitri*). The heavy concentration of pottery from the Medieval-Frankish

[80] Permission to present the following information in this section has kindly been provided by the Directors of the TAESP project, to whom I am very grateful.
[81] Given et al 2002.
[82] Given *et al* 2002; Given 2000; Whittaker, J.C. (1999) "Alonia: Ethnoarchaeology of Cypriot Threshing Floors." *Journal of Mediterranean Archaeology* 12, 7-25.
[83] Richard, J. (1962) *Documents chypriotes des archives du Vatican (XIVe et XVe siècles)*. P. Geuthner: Paris. For further information on village lists of the Venetian and early Ottoman periods, see de Mas Latrie 1970; Grivaud 1996, 217-226; Grivaud 1998.

period also extended to the medieval settlement of Ayios Epiphanios[84] (*S. Pifani*), in the areas around Katydhata (*Cattidata* in the Venetian records) and Linou (*Linu* on the 16th century Venetian maps), which also had a considerable amount of pottery dating from this period, scattered around either side of the village but intensifying immediately around the village itself. (As a note of interest, the TAESP architect dated the water mills in Linou, BU002-004, back to the Venetian period due to their building style, which differed from other mills in the area.) However, here, the quantity of pottery dating from the early to mid-Ottoman period was greater, indicating perhaps an increase, or a transfer, of population during this period. This has also been suggested in a study of the land use in the Karkotis which has indicated intense cultivation and a steady population increase from the 16th century onward in the Upper Karkotis region; this area also has the highest concentration of watermills.[85] Population surveys from the medieval and Ottoman periods have revealed that there were 385 *francomati* (free peasant farmers) living in the villages stretching from Tembria north to Katydhata in 1565 AD, and 228 *hāne*[86] in 1826 AD.[87]

The Asinou Valley

The Asinou valley has only the remains of one watermill today; this may be reflected in the pattern of land use over time, which has been considerably less intense than in the Karkotis valley. The location of the medieval painted church of *Panayia Phorviotissa* there, dating from the early 12th century, suggests the area was a significant spiritual centre already during this time; the pottery distribution in this survey zone indicates the presence of settlements from the medieval to the Ottoman period inclusive, and this could be linked to the medieval settlement and church of Ayios Yeoryios *Aspri*, also located here, approximately 4 km south of Asinou village. *Aspri* is listed as having 6 *francomati* in the 1565 AD population survey.[88] Oral information has also dated this settlement back

[84] A water mill is located here in the *Mylaria* ("many mills") area (BU0098); 15th century Venetian village lists also mention a village called *Milar*. The toponym may have been kept from that time until the present.
[85] Jay Noller, pers. comm., TAESP Publication Meeting, Glasgow, 5th September 2005.
[86] *Hāne*- heads of household, usually calculated as the number of married men in a household.
[87] Given *et al* 2002, 34.
[88] Grivaud 1998, 470.

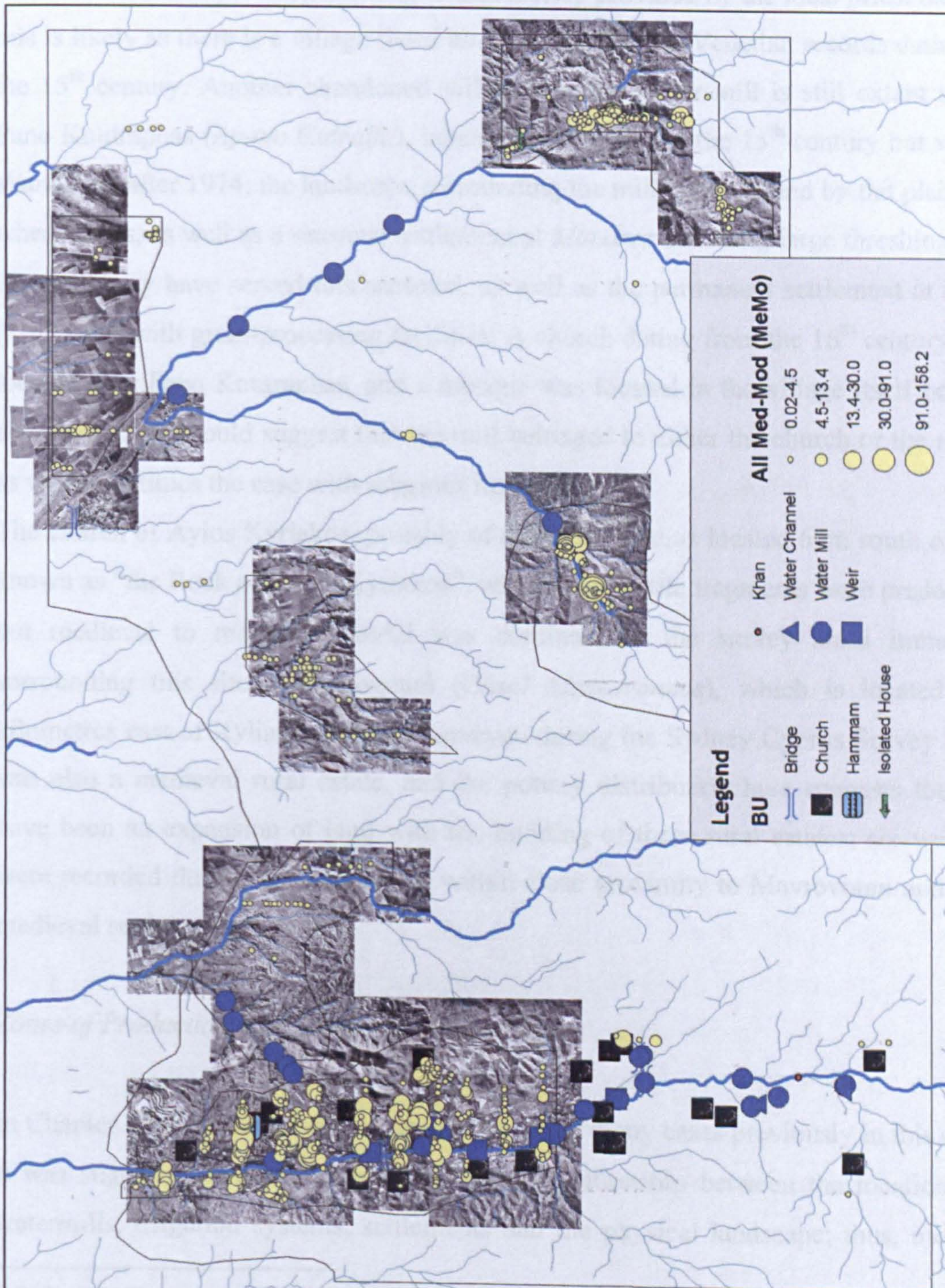
to the 16th century. The abandoned village of Asinou, located on a spur 500m southwest of the painted church, has remains of eight domestic dwellings which have shown frequent rebuilding. There is a dense scatter of pottery 100m below, where the abandoned settlement of Nikitari *Khalospitiaes*[89] is located. The pottery, which includes fragments of *pithoi* (storage jars) and water jugs, can be dated to the Ottoman and modern periods.[90] Many of these estates turned into seasonal settlements in the late medieval and Ottoman periods, which may also explain the substantial lack of watermills in this area compared to the Karkotis Valley, where permanent settlements would make use of the mill and its profits throughout the year. This is also suggested by the oral information provided by locals living in the Asinou area, who indicated that grain in the Asinou valley was not ground in the immediate vicinity, but taken to Evrykhou or Petra in the Karkotis Valley to be ground there.[91] The presence of the remains of what appears to be a grain mill here is therefore doubly intriguing, and may suggest that the building was an other type of mill, perhaps used in conjunction with a nearby tannery located there in the medieval period.[92] In addition, the concentration of pottery in the valley floor correlates with the Asinou river valley being a good communication route to the Mesaoria Plain to the north-east, as well as northwest to *Mandres*, and west to Ayios Theodhoros.[93]

The Lagoudhera Valley

Although still not as fertile as the Karkotis valley, the Lagoudhera valley has also shown signs of continuous settlement at least since the Roman period through to the modern day; much of the settlement has been related to the mining industries located at Alestos and Xyliatos.[94] The mills here are less concentrated in this valley, but pottery distributions and official records have shown that this area was settled during the medieval and Ottoman periods; the estate of Athassi (*Athasy*)

[89] Khalospitiaes means "ruined houses".
[90] Given *et al* 2002, 34.
[91] Erin Gibson, pers. comm., TAESP Publication Meeting 2005.
[92] Ian Evans and Michael Given, pers.comm., TAESP Survey Season 2002.
[93] Given *et al* 2002, 33.
[94] There is also an undated watermill near the Roman mines in Wādi Faynān in southern Jordan.

Figure 7. 6. Map of TAESP survey area, showing location of watermills, villages and pottery distribution. (Courtesy of TAESP)



are both mentioned in 14th and 15th century documents[95], as well as appearing on Venetian village lists from the same time period. Xyliatos may also have been settled since the medieval period, according to oral history provided by the local priest there, and this is likely as there is a village listed as *Casal Xyliatos* in Venetian records dating from the 15th century. Another abandoned village where a water mill is still extant today is Pano Koutraphas (*Apano Cutraffa*), inhabited at the end of the 15th century but virtually abandoned after 1974; the landscape surrounding the mill is dominated by flat plains and wheat fields, as well as a seasonal settlement at *Mandres* including large threshing floors. The mill may have served this seasonal, as well as the permanent settlement at Nikitari (*Michitari*) with grain-processing facilities. A church dating from the 16th century is also located near Pano Koutraphas, and a mosque was located in the village itself before its destruction, and could suggest that the mill belonged to either the church or the mosque, as was sometimes the case with religious institutions.

The church of Ayios Kyriakos, possibly of medieval date, is located 60m south of a rock known as "the Rock of Ayios Kyriakos", where Roman tile fragments were predominant, but medieval to modern material was dominant in the survey areas immediately surrounding this site.[96] Mavrovouni (*Casal Mavrovounos*), which is located a few kilometres east of Xyliatos and was surveyed during the Sydney Cyprus Survey Project, was also a medieval rural estate, and the pottery distribution here suggests there may have been an expansion of land with the building of these rural estates; six watermills were recorded during this survey, all within close proximity to Mavrovouni and related medieval settlements.[97]

Zones of Production, Landscapes of Profitability

In Chapter Four of this work, and as established in many cases previously in this chapter, it was suggested that there was a significant relationship between the location of the watermills, irrigation systems, settlements and the physical landscape; thus, inevitably,

[95] Richard 1962.
[96] Given *et al* 2002, 29.
[97] Given, M. & Knapp, A.B. (2003) *The Sydney Cyprus Survey Project: Social Approaches to Regional Archaeological Survey.* With twenty contributors. Monumenta Archaeologica 21. University of California at Los Angeles, Cotsen Institute of Archaeology: Los Angeles.

there is also a link between the economy and the landscape, as that is heavily dependent on the landscape's natural resources, as is man's ability to exploit that productivity. Economic prosperity, it has been shown, relied on all these factors, and as a result societies, landscapes and economies became inextricably linked; through the emergence of economic production zones[98] in the Levant, local and regional economies were developed and sustained. Although this is not exclusive to the period of time under study in this work, a brief overview of the zones of production in the *bilād al-shām* and Cyprus between the Crusader and late Ottoman period may further explain the social and economic role of the watermill, and the reasons for its decline, which will be examined more closely in the following chapter.

The economy of the Mediterranean was affected profoundly by the introduction of new types of plants for agriculture during the early Islamic period, and the scientific knowledge of how to cultivate and irrigate these plants- perhaps the most important of which was sugar- was diffused across the Levant by the Muslims. [99] In Cyprus, sugar factories existed at Akhelia, Kouklia, Episkopi and Kolossi, all located in fertile lowlands with mild winters and easy access to the coast for export. In the *bilād al-shām*, the ability to grow sugar cane in soils of high salinity meant that the plantations could be cultivated with relative ease in coastal lowland areas, such as the Dead Sea plain, and the coast of Tyre, thus establishing one of the zones of production on which the economy was based, at least until the $10^{th}/16^{th}$ century. Although irrigation was always a crucial matter to consider, the diffusion of technological innovation mainly in the form of advanced irrigation methods such as waterwheels and *sāqiyah* enabled the survival of valuable crops such as sugar. The construction of sugar installations to process this commodity was thereby inevitable, and their proximity to the plantations as well as shipping ports and major trade routes meant that sugar was a conveniently cultivated, processed and traded item. The ability to exploit the landscape for building materials -wood for fuel, and water for power- hence became crucial; the economy was thus reliant on man's ability to

[98] Given *et al* 2002; Hadjianastasis 2005, 178.
[99] Watson 1981, 42. The idea of an agricultural revolution in Islamic times has been disputed by Wilson, who claims that much of the "revolution" already occurred in the Roman period. See Chapter One; this is also further discussed in the final section of this chapter.

sustain this operation successfully, which as we know in the case of sugar, eventually failed.

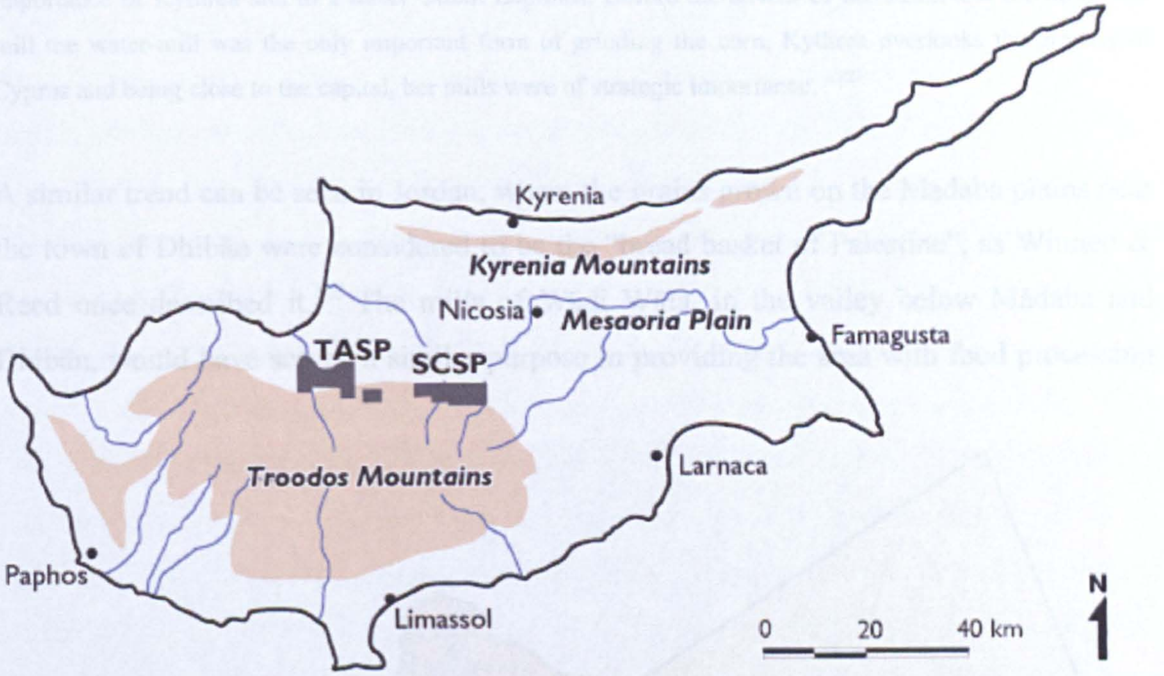


Figure 7.7. Map of Cyprus showing the TAESP and SCSP survey areas. Major towns are shown in relation to production zones, and the highlighted region is land above 500m. (After Given 2000)

Further zones of production, which may show greater variation in the physical landscape, were the highlands and the plains, the main wheat producing areas. As we have established through historical accounts and trade records, cereals formed the basis of not just the Levantine agricultural economy, but the economy as a whole; without it, any medieval and early modern Levantine society would have struggled to exist. In Cyprus, the principal area for producing grain was the Mesaoria plain **(Figure 7.6)**, and the town of Kythrea (Turkish, ***Değirmenlik***)[100] to which travellers refer frequently throughout the Frankish, Venetian and Ottoman periods, was considered to be the main urban milling centre, located to the north east near the island's capital of Nicosia.[101] Once again, one can see the link between the landscape, the economy and the locations of watermills. Although he negates this theory to some extent, in discussing the domestic industries of the island, Christodoulou points out that

[100] ***Değirmen*** (Turkish) means "mill".
[101] Hadjianastasis 2005, 179.

"The distribution of watermills is shown on the map and the pattern is very significant. A comparison with wheat cultivation will show the general maldistribution of the mills and will bring out the immense importance of Kythrea and to a lesser extent Lapithos. Before the advent of the steam-and the oil-driven mill the water-mill was the only important form of grinding the corn. Kythrea overlooks the granary of Cyprus and being close to the capital, her mills were of strategic importance. "[102]

A similar trend can be seen in Jordan, where the grains grown on the Madaba plains near the town of Dhibān were considered to be the "bread basket of Palestine", as Winnett & Reed once described it.[103] The mills of Wādi Wāla, in the valley below Mādaba and Dhibān, would have served a similar purpose in providing the area with food processing

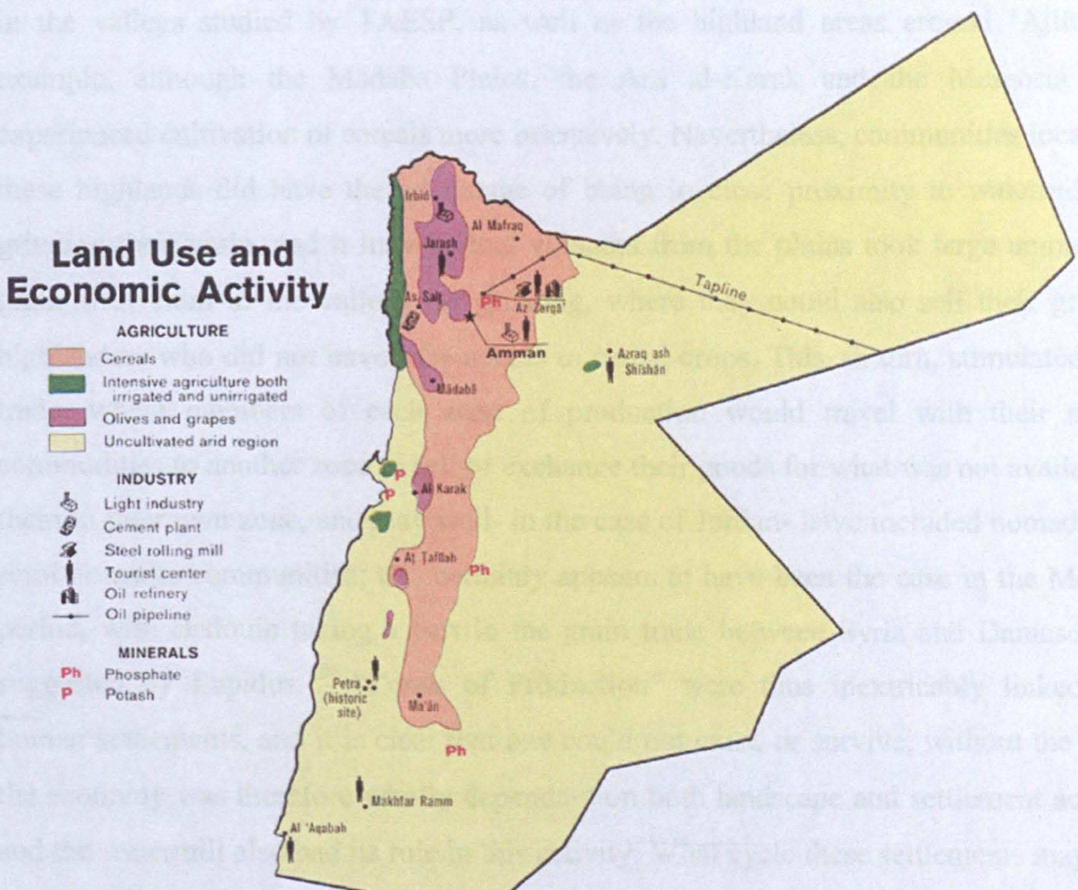


Figure 7.8. Map of Jordan showing modern land use. Zone of cereal production stretches almost the entire length of the country, and is especially wide in the north around al-Ṣalt, Mādaba and al-Karak. (From http://www.lib.utexas.edu/maps/middle_east_and_asia/jordan_land_1986.jpg)

[102] Christodoulou 1959, 103.
[103] Winnett & Reed 1964, 50.

facilities. The Arḍ al-Karak was the other area of grain cultivation in Jordan, with mills to process that grain located in the valleys below the major town of al-Karak, where the local and regional markets were relatively easily accessible.[104] This was also the case for large urban centres, such as Damascus, where the grain was grown in the *Ghūṭa*, the fertile plain surrounding the city; here also, historians already from the time of al-Idrīsī attest to the abundance in crops and the presence of mills for processing cereal.[105] The result of this was economic wealth, and a high population density, furthering productivity and economic growth. **(Fig. 7.7)**

The other zone of production, the mountain area, was considered to be less suitable for growing cereal crops. However, there appears to be a relative abundance in cereal crops in the valleys studied by TAESP, as well as the highland areas around 'Ajlūn, for example, although the Mādaba Plains, the Arḍ al-Karak and the Mesaoria Plain experienced cultivation of cereals more intensively. Nevertheless, communities located in these highlands did have the advantage of being in close proximity to watermills for grinding their grain, and it may be that villagers from the plains took large amounts of grain with them to the valleys for grinding, where they could also sell their grain to highlanders who did not have easy access to cereal crops. This, in turn, stimulated local trade, where members of each zone of production would travel with their special commodities to another zone to sell or exchange their goods for what was not available to them in their own zone, and may well- in the case of Jordan- have included nomadic and semi-nomadic communities; this certainly appears to have been the case in the Mamlūk period, with Bedouin taking a part in the grain trade between Syria and Damascus, as suggested by Lapidus.[106] "Zones of Production" were thus inextricably linked with human settlements, and it is clear that one could not exist, or survive, without the other; the economy was therefore wholly dependant on both landscape and settlement activity, and the watermill also had its role in this activity. What cycle these settlements may have experienced, and how this affected the watermill, is the next topic of discussion.

[104] McQuitty 2005, 330.
[105] Al-Idrīsī 1975, 366.
[106] Hadjianastasis 2005, 182; Jennings 1993, 339; Given 2000, 2002; Glick 2005, 248; McQuitty 2005, 332; Lapidus 1969, 8 n.2.

As mentioned in the previous chapter, human settlement was heavily dependent on the availability of water, as it is today; but, in addition to the constraints imposed by the natural environment, medieval and early modern life in the Levant was much of the time also limited politically and religiously. During the $6^{th}/12^{th}$ and $7^{th}/13^{th}$ century, when the region experienced political as well as economic upheaval primarily through the continuing crusades between Christians and Muslims, contact between different ethnic and religious groups became a part of daily life. In the regions surrounding the major fortifications of al-Karak and Shawbak in Jordan, and Baniyās (Belinas) and Ḥarīm in Syria, for example, what were then frontier societies were faced with the struggles of daily life, as well as the political and religious strife surrounding them, and hence forced to exist accordingly.

Ibn Jubayr, in his travels through the Levant in the late $6^{th}/12^{th}$ century, makes particular mention of a frontier town called Baniyās (North of Lake Tiberias[107]), where Muslim and Crusader populations shared agricultural property seemingly without hostility. Baniyās is used by the $6^{th}/12^{th}$ century chronicler as an example of community inter-dependence between Crusaders and Muslims living in frontier societies, where an attitude of non-interference existed between the two communities. Here, peace was preserved at least with regards to the use of agricultural land and property, which probably also included the use and working of water-driven mills[108].

"This city is on the frontier of the Muslim territories. It is small, but has a fortress below the walls of which winds a river that flows out from one of the gates of the city. A canal leading from it turns the mills. The city had been in the lands of the Franks, but Nur al-Din-may God's mercy rest upon his soul- recovered it [in 1165 AD]. It has a wide tillage in a contiguous vale.....The cultivation of the vale is divided between the Franks and the Muslims, and in it there is a boundary known as "The Boundary of the Dividing". They apportion the crops equally, and their animals are mingled together, yet no wrong takes place between them because of it."[109]

[107] Situated on Lake Hule, a smaller lake north of Lake Tiberias.
[108] Conder and Kitchener make a note of working watermills existing in Baniyās during their survey in 1881, and these may be the same that Ibn Jubayr refers to in his travels; see Conder and Kitchener (1881).
[109] Ibn Jubayr 1907, 315

Although Ibn Jubayr does not say whether the agricultural interaction went beyond the "boundary of the Dividing", it would seem feasible to suggest that the management and use of the mills on the river was also shared between the two societies, perhaps in a similar manner that *condominia* were set up between Muslims and Crusaders in their treaties.[110] Indeed, Jonathan Riley-Smith has alluded to the hostilities between groups of Crusaders themselves with regard to the use of water, water conduits and mill sluices within the Kingdom of Jerusalem, and we know of this also in Crusader period Cyprus. It may be equally reasonable for Franks and Muslims to have conducted agricultural practices in harmony as it was, for example, for Templars to be in dispute with the Order of St. John.[111] If such quarrels existed within the Crusader communities on one hand, and a peaceful co-existence between Muslims and Franks in Baniyās took place on the other hand with regards to related issues, perhaps there were similar occurrences in other parts of the Crusader and Muslim lands.

The use of watermills may also have extended to those of moving societies, particularly in Jordan and Syria, and considering the number of watermills located in the 'Ajlūn area for example, one cannot help but pose the question: What would the relationship between watermills and the nomadic or seasonal populations have been, both during Ayyūbid/Mamlūk periods as well as the Ottoman period? Insoll has pointed out the relationship between settler and nomad already in the early Islamic period for the *bilād al-shām*; the fortifications of *al-Risha* in Jordan, and *Qasr al-Hayr al-Sharqi* in eastern Syria are seen as Bedouin stations where "the attempt to ensure a permanent water supply through the use of underground channels....would have become a focal point for periodic gatherings of nomads."[112] A similar, although perhaps more hostile, relationship between settler and nomad is also seen in the Ayyūbid period through the interaction between Bedouin tribes and the Ayyūbid *amīrs* in 'Ajlūn, for example.

The nature of the nomadic population being that of movement and temporary settlement, their reliance on having their grain ground by a watermill would have confined that movement considerably- unless the existence of a state initiative to build watermills for

[110] Perhaps this is where and how customs and laws with regards to water and watermills became adopted and adapted by different groups, to suit their particular needs.
[111] Riley-Smith 1973, 52.
[112] Insoll, T. (1999) *The Archaeology of Islam.* Blackwell Publishers: Oxford ; Malden, Mass, 218.

grain and sugar processing in rural communities during the Ayyūbid, Mamlūk and Ottoman periods extended to include the many Bedouin tribes present in Jordan and Syria. This has been discussed by Sato for Egypt, where settled as well as migrating cultivators of land were subject to irrigation contracts for tax assessments by the Mamlūk government, indicating that state supervised agriculture was not always limited to settled communities.[113]

This appears also to have been the case in 10th/16th century Jerusalem, where there was a continuous struggle between the villages and the officials regarding the water that was brought via an aqueduct. This was also the case between the towns, the villagers and the Bedouin.[114] The system of water division rendered the peasants with a fixed share of water, as was customary by *sharī'a*; however, as it was difficult to keep control over the canals, the water supply was frequently diverted to irrigate canals or to water animals.[115] These offences were usually investigated by a group of officials and adjudicated by a *qādi*.[116] In villages such as Bayt Laḥm, the villagers were forced to pay 25 *Ṣulṭāni* for water in 1554 AD as a charge in case any damage was caused to the pipes, or more than the allotted share was taken.[117] A "guardian of the pipe" (*mashadd qanātt al-sabīl bi-quds-i sharīf*) was sent to oversee the water pipes and supply.[118] However, Singer explains that the rules of the water supply were not an Ottoman development, but rather an ancient local custom that seems to have survived well into Ottoman rule:

"The precise and supervised distribution of water was not a practice introduced by the Ottomans. Within each village, custom dictated the exact apportioning and rotation of the daily flow among the peasants. The Kanun-names for the region do not include details of the arrangements, suggesting that the Ottoman officials did not interfere with local practice at the village level, but rather concerned themselves primarily

[113] Sato 1997, 193.
[114] Singer, A. (1994) *Palestinian peasants and Ottoman officials: rural administration around sixteenth-century Jerusalem*. Cambridge Studies in Islamic Civilisation. Cambridge University Press: Cambridge, 101.
[115] Singer 1994, 102.
[116] Singer 1994, 102.
[117] The *sulṭāni* was the first Ottoman gold struck coin; in 1582 AD it was equivalent to 65-70 *akçe*. See Pamuk 2000, 61-63.
[118] Singer 1994, 102.

with the supply of water to the town. In this context, and at those times when peasants were unable to resolve disputes among themselves, water issues were brought before the qadi."[119]

The 11th/17th and 12th/18th centuries saw considerable abandonment of villages and increased worsening agricultural conditions in the *bilād al-shām*, which caused the widespread distribution of pastoral nomads.[120] This is described by Hourani as "both the cause and the effect of decay in settled agriculture"[121]; in fact, during the 10th/16th century, approximately 40% of the population in the *liwā'* of 'Ajlūn was nomadic[122], and perhaps the disappearance of these nomadic tribes from this area by the 14th/20th century factored in the neglect and abandonment of the watermill there, or in the changing function of the watermill with the introduction of more modern industrial technologies such as the diesel powered mill. This could suggest that the survival of the watermill did not depend as much on the survival of nearby settlements and towns as previously considered, but was rather dependant on the introduction of more efficient technologies. Dalman has already pointed out that the Bedouin tribes of Palestine agreed to ceasefires and offered free escorts to anyone who carried grain to a watermill through their territories[123]; there was clearly an awareness of the necessity that the watermill posed for both their own survival as well as that of the settled population. The watermills, in areas like 'Ajlūn and Ḥisbān, may have been as much utilised by Bedouin as by people who had settled there[124].

Cyprus had no nomadic population, although a number of seasonal settlements were discovered during the TAESP survey in the Troodos region. An examination of these settlements has shown that there is a strong link between seasonal movement, pastoralism

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[119] Singer 1994, 103. Although these peasants were not necessarily Bedouin, it implies that ancient customs and traditions with regard to water were commonly practiced in agricultural communities during the Ottoman period. The fact that Ottoman officials did not interfere in Jerusalem may also suggest that the lack of such interference in Transjordan, as indicated by Fischbach, was not indeliberate there either, at least until the start of the Bedouin rebellions which forced the Ottoman government to exercise direct control; see Fischbach 2000.

[120] Wagstaff 1985, Hütteroth & Abdelfatteh 1977.

[121] Hourani, A. (1957) "The Changing Face of the Fertile Crescent in the Eighteenth Century". *SI* 8, 89-122, in Wagstaff 1985, 199.

[122] Wagstaff 1985, 191.

[123] Dalman 1964; see also Chapter Six.

[124] Glick and Kirchener have indicated that watermills were controlled by tribal groups in Islamic Spain, but whether these were nomadic is unclear; Glick, T.F. & Kirchener, H. (2000) "Hydraulic Systems and Technologies of Islamic Spain: History and Archaeology", in P. Sqatriti (ed), *Working with Water in Medieval Europe. Technology and Resource Use.* Brill: Leiden, Boston & Köln, 268-329; 309.

and cereal production, such as it was in Jordan; the number of threshing floors in a seasonal settlement is the main indicator, as it is much higher than those found in permanently settled villages. [125] Seasonal settlements, such as those at *Mandres* (Kato Koutraphas), located near the town of Nikitari, may have been taking their grain to be ground at the mill on the nearby site of Pano Koutraphas, as discussed in the previous chapter. However, this is still uncertain, as oral histories have also related that seasonal settlements in the Asinou valley took their grain to be ground not in the nearby area of Lagoudhera, but in areas such as Petra, in the Karkotis Valley. This indicates perhaps that certain seasonal communities were obliged to grind their grain at the mills belonging to the person they worked for, rather than the mills that were in physical proximity to their own seasonal settlement. It may also suggest, as has been established in other areas of the Levant, that they had to pay a tithe in flour to the individual they worked for, which could only be reasonably controlled by forcing the seasonal workers to grind the grain at the mill of their lord or employer. [126]

Over time, of course, as landscapes and settlements undergo a series of transformations, buildings become abandoned and fall into disuse, as has been established in the many case studies in this work. For the Troodos region, seasonal settlements are significant not only from the aspect of migrating populations within a rural economy, but also because these settlements changed their status; this can be seen in Aspri, as well as Nikitari *Khalospitiaes*, which in the Ottoman period turned from permanent to seasonal settlements. [127] This transformation of settlements was also common for medieval and Ottoman sites in Jordan, and to simplify the perspective on the transitional use of rural buildings, Alison McQuitty provided an interesting parallel in her study of Khirbat Fāris. [128]

Khirbat Fāris is a multi-period site located on the Karak Plateau near the town of al-Karak in southern Jordan. It is surrounded by vast agricultural plains where wheat and barley are grown; the *wādi* below which drains into the Dead Sea has plenty of water

[125] Given 2000, 217.
[126] Oral information, TAESP survey, 2004.
[127] Given *et al* 2002.
[128] McQuitty 2005, 327-339.

throughout the year.[129] The site itself has been settled since pre-Islamic times, but settlement was at its most intense from the 1st/7th to the 7th/14th centuries; this changed from seasonal settlements to permanent settlements in the early 20th century, and that indicates that different agricultural communities, making use of different types of agriculture, existed here. Again, there is a pattern of settlement located higher up in the valleys or on the plateau, with watermills located in the lower parts of the valleys. McQuitty's study of the recent use of the buildings has revealed that this site was used as a pastoral nomadic settlement, where the people chose to use the stone houses as storage areas for crop harvests, while they themselves lived in their tents for parts of the year. Threshing floors being located on the plains, above the valleys, where the majority of crops were also located, as well as the location of grain stores there, indicates a similar pattern of land use and settlement for Jordan and Cyprus[130]; grain was taken to the valleys to be ground by both seasonal and permanent settlements. The watermills in the valley below Khirbat Fāris, in Wādi Ibn Ḥammād, would have been ideally located for this kind of agricultural regime. A similar example of building use was found in one of the mills in Wādi Wāla, where the recently restored mill house was now being used for storage of farm equipment as well as for storing grain[131].

Any building in a rural setting has the potential of being used for a number of purposes, but once they are derelict in their primary function, they are usually used either as dwellings, sheep/goat pens, or storage facilities. However, the water mill had a function undeniably important in the rural landscape in that it provided it with a mark of civilisation in marginal societies. As Timothy Insoll writes:

"Physical links between settlements and surrounding areas will exist in many instances, providing a body of material for the archaeologist. These can range from irrigation and water supply systems to field systems, nomad, trade and pilgrimage routes, and fortifications. All mechanisms by which the landscape can be tied together, settlement to settlement, nomads to sedentaries, feature to feature deserve study. Connecting landscape features are many, and we can look at water supply as an example. It is important as

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[129] McQuitty, A. (2005) "The rural landscape of Jordan in the seventh-nineteenth centuries AD: the Kerak Plateau." (FOCUS ON ISLAM II). *Antiquity* Vol.79/304, 327-339,332.
[130] Lancaster & Lancaster 1999.
[131] See Chapter Five, *Wādi Wāla*, pp.130-142.

a necessity to life, subject to much technical ingenuity in its provision, as a 'landscape element' and also because it has a significance beyond the purely practical in Islam...."[132]

From a purely anthropological point of view, it is interesting to note that most of the watermills in Jordan either show signs of some modern occupation- either as goat pens or storage units (and sometimes even toilets)- or are still visibly occupied by people, implying perhaps a long-standing traditional use which may have originated earlier on in history when the watermill was a point of social gathering as suggested by Ibn al-ʿAdīm for Syria[133], and by Given for Cyprus.[134] Lancaster & Lancaster suggest for Jordan that agricultural land and its associated water supply has been used to mark territory by Bedouin tribes[135], and although no such markings have been discovered directly on any watermills in these case studies[136], they would be an ideal territorial marker within an agricultural landscape, and Bedouin tents have frequently been found in the near vicinity of watermills in Jordan.[137] Particularly for Jordan, this could suggest a bridge between nomadic and settled life through the existence of a necessary communal building, such as the watermill.

Although it may be true in many cases that "physical environments do not determine use"[138], as with any building within any landscape, it has a significance that goes deeper than its physical role; the presence of a water mill in, for example, the hills of northern Jordan or the Troodos mountains in Cyprus, alters the landscape to such a considerable degree by imposing a social role on it. The primary cause of this is without doubt the availability of a water supply. Thus, the idea of settlement has been totally transformed[139]; nomadic settlements are drawn to bodies of running water for their own survival as well as that of their animals in the same way that settled communities are. The presence of watermills along streams and rivers thus make settlement in their vicinity

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[132] Insoll 1999, 219.
[133] Ibn al-ʿAdīm 1990, 337.
[134] Given 2000, 227.
[135] Lancaster & Lancaster 1999, 125.
[136] The aqueduct leading to the water mill in Wādi Faynān in Southern Jordan has some markings which may be "territorial", although this is still speculative.
[137] Whether this is because of the proximity to water, or whether there is an inherent instinct to settle near a building- perhaps for social reasons- is not certain, but it would make an interesting study in the near future considering the number of instances nomadic tents are found in the vicinity of mills.
[138] Lancaster & Lancaster 1999, 98.
[139] Insoll 1999.

desirable, as there is not only the availability of water to consider, but also the opportunity to have grain ground in the near vicinity of that temporary settlement. In addition, the location of wheat fields may also be a determining factor; Bedouin migration involves the territory of that particular tribe, and permission is needed to migrate across another tribe's land[140], and presumably this also includes taking grain against payment. This, in turn, may lead to semi-nomadic and nomadic communities becoming settled over time, as was the case in Khirbat Fāris[141]; the incentive to stay on one's own land is therefore probably greater than migrating onto someone else's territory, and there is thus an added incentive for having one's own facilities to grind the grain; the ownership of mills is discussed in more details in the following chapter.

Dating and Chronology

The dating of the mills in this study is difficult due to lack of historical and archaeological evidence, both in Jordan and in Cyprus[142]. For Jordan, the archaeological evidence is sparse, as there have as of yet been few published reports of excavated water mills, and indeed excavation may not always help. Survey finds, although helpful in determining human activity around the watermill, do not yield enough reliable evidence to suggest a chronological framework with which historians and archaeologists can work. However, a combination of archaeological finds and historical records may provide more information regarding the use and dating of watermills. This can also be problematic, as the reliability of early historical records can be questionable in addition to the scattered information that does exist. Where documentary sources exist they can be combined with the survey data, but they are rare, and not usually specific enough to provide adequate chronological control.

It may be possible that dates for the watermills can be arrived at through the use of a comparative typology in both Cyprus and Jordan, and perhaps other countries of the Levant such as Syria and Lebanon. The comparative typology and classification set out in

[140] Jabbur, J. (1995) *The Bedouins and the desert : aspects of nomadic life in the Arab East.* Translated from the Arabic by Lawrence I. Conrad ; edited by Suhayl J. Jabbur and Lawrence I. Conrad. Albany : State University of New York Press, 304.
[141] McQuitty 2005, 332.
[142] This is further discussed in *Technological Diffusion* in Chapter Eight of this work.

this work may be helpful not only in terms of determining the use and function of watermills in different regions, but also in mapping technological changes and innovations over time. The similarities and differences between the water mills of Jordan, Syria and Cyprus may provide useful clues in their dating and their roles in the historical environment of the Levant. Political and economic activity in and between these countries, particularly during the $7^{th}/13^{th}$-$9^{th}/15^{th}$ centuries, was such that it almost certainly encouraged the diffusion of technological ideas and inventions through contact and interaction with each other. These ideas and interactions in turn shaped contemporary thought and society, despite the general instability created by constant warfare and religious bloodshed.

Medieval and early modern accounts of the history and landscape of Jordan and human activity during this period correlate frequently with modern archaeological discoveries. For example, the East Jordan Valley Survey, conducted in 1975 by members of the Department of Antiquities, the American Centre of Oriental Research (ACOR) and Jordan University, showed that the most frequently represented period in the Middle Islamic Period were the Ayūbbid and Mamlūk periods.[143] Vast amounts of pottery attributed to these periods, as well as remains of large water-driven mills frequently with *in situ* mill stones, were discovered during this survey. The survey area covered the northern half of the East Jordan Valley, and included the Yarmūk, 'Arab, Ziqlāb, Rayyān, Kufranja, Zarqa', Shu'ayb, Kafrayn and Ḥisbān valleys, in all of which there are still remains of water-driven mills today. Although the dating of these mills is questionable, and cannot be definitive, the finds collected around the remains of these mills (such as sugar pot fragments and millstones) at least provide the basis of a chronological framework for dating of the mills.

As to the dating of the water mills of North Jordan, the difficulty caused by lack of archaeological evidence still remains. In the Wādi al-Yābis (now the Wādi al-Rayyān) preliminary survey report, all the mills were classified as Ottoman-period constructions, which is in keeping with the general assumption about the majority of the watermills that have been studied in Jordan so far.[144] However, it is curious that all of the watermills in

[143] Ibrahim *et al* 1976.
[144] Mabry *et al* 1988; Gardiner & McQuitty 1987; Rogan 1995.

this survey were classified as Ottoman, despite many of the surrounding settlements dating back to the Ayyūbid and Mamlūk periods; in a few cases, these settlements even dated to the early Islamic periods.

Scientific dating conducted on watermills thus far has also proven inconclusive. The attempts made by McQuitty and Gardiner to date the construction of some mills from the Wādi al-'Arab in North Jordan through the analysis of tufaceous deposits[145] present in the plaster lining of the mill leats are still awaiting results. The difficulty with such a method would be that it does not successfully date the whole structure, but rather the specific part of a structure which is probably most likely to undergo restoration and rebuilding in relation to the rest of the building. The water leat is probably most prone to weathering through the force of the water flowing through it, in addition to exposure to other natural elements such as wind and sandblasting. Other proposed methods of scientific dating include the measurement of *rhizocarpon* growth curves, types of lichen found on rock, which grow at a certain rate over time; this may help to determine a *terminus ante quem* for some masonry, although this dating method has not been tested yet.[146] Equally, dendrochronology may also help to determine the date of some structures; however, this is heavily dependent on a reliable sample of wood, and some cases in this study point to the reconstruction of watermill structures using wooden beams which would not be helpful in determining the original construction date of the mill, but again may provide a *terminus ante quem*, as with lichenometry.[147] New methods in thermo-luminescence (TL) dating of plaster samples have also been developed, although these may not be helpful in dating for the medieval and Ottoman periods as the date ranges are too broad to provide any helpful information on determining the date of construction for a mill. The mill on the Crocodile River, discussed briefly in Chapter One, has been dated to the mid-fourth

[145] These are mineral deposits caused by weathering due to exposure to the elements. The effectiveness of this dating method has yet to be established as it is still being tested.
[146] Jay Noller pers.comm. 2002; see also www.geo.arizona.edu/palynology/geos462/13lichenometry.html for more information; Noller, J. & Locke, W. (1998) Lichenometry. In *Dating and earthquakes: review of quarternary geochronology and its application to paleoseismology*. J.M. Sowers, J.S. Noller, and W.R. Lettis, eds 417-433. Washington D.C.: U.S. Nuclear Regulatory Commission, NUREG/CR 5562.
[147] Kuniholm, P.I. (2000) Dendrochronologically dated Ottoman monuments. In *A historical archaeology of the Ottoman Empire: breaking new ground.* U. Baram and L. Carroll, eds. 203-217. New York: Kluwer Academic/Plenum.

century AD by C14 dating, but this date is also provisional, and further proves the general unreliability of dating the water mills by these scientific methods.[148]

Dating through architectural features may also be a possible avenue to explore. The varying sizes of penstock chutes, for example, may be an indication of when the mills were built, although this would be difficult to determine because of the factors that landscape and climate may have played in determining the size of the chute. The size of the mill as a whole may be another way to determine its period of construction; for example, it could be that earlier mills were smaller in size, because of the smaller number of people present in the Levant, and the mills increased in size with the increase in population. It could, however, also be the other way around; the mill decreased in size with the introduction of more efficient technologies, particularly in recent times. This would particularly apply to the rural areas of the Levant.

Conclusion

For the majority of the watermills in the Levant it has been difficult to place them in a historical context without conducting detailed analyses of historical texts, such as church records, *defters* (Ottoman tax records) and accounts of travellers over the last millennium. The archaeological evidence gathered from Jordan, Syria and Cyprus, combined with the historical information, suggests that watermills were a fundamental and important part of rural and urban agricultural communities already from early medieval times throughout the Ottoman period. While the archaeological context may not always be clear or appear significant to the watermills within the individual valleys that were discussed in the case studies in Chapter Five, the pattern of settlements interpreted through the archaeological material is indicative of a continuous utilisation of the natural resources available within the landscape. This also suggests that where watermills have been assumed to date from the Ottoman period, in many cases the archaeological and historical evidence, as well as the building style, actually indicates differently. This does not imply that the Ottoman period saw no construction of watermills- we know this is not the case from the few dated examples that exist- but rather proves that there is as much reason to believe the mills

[148] Oleson 1984; Schiøler 1989; see Chapter One, p.9.

were built before the Ottoman period as there is to assume they were built during that period, as has frequently been suggested in previous studies.

In addition, the agricultural landscape has shown to be directly linked with the presence of watermills, where cereal production tended to occur in the high plains, and the cereals were taken down into the valleys below for processing. The system for sugar cultivation was slightly different, as sugar was grown in the immediate vicinity of the mill factories, where the crops were easily watered, harvested and processed in one area; these areas were generally coastal as they offered easy access to shipping ports for export. Zones of production, trade routes, and cereal and sugar crops were thus linked to sustain both a local and a regional economy.

CHAPTER EIGHT

Economies, People & Watermills

This work has intended to shed light on some of the many issues surrounding the water mill in the Levant, and to draw attention to its importance in the region's agricultural as well as social history, as such a study has not been attempted until now. The historical record has revealed that there were laws and regulations governing the construction and use of watermills across the Islamic world throughout the period of time studied; these did not change significantly over time despite the turbulent political events that occurred frequently across the Levant. Agricultural, government and *ḥisba* manuals, as well as *waqf* documents, treaties and charters have all provided information which is relevant to both the economic and social aspects of the study of watermills. In addition, the people who travelled this region have added invaluable information regarding the social and environmental conditions during the medieval and early modern periods, particularly paying attention to the importance of water and its uses in areas with an arid climate, such as Jordan, Syria and Cyprus.

Not always complementing the historical record, the archaeological record has none the less also provided important information; it has shown that there are significant patterns of settlement which enable us to determine rural and urban agricultural activities over time. For the Levant, settlement and agricultural activity have proven to be reliable, if characterised by interspersed periods of peaks and troughs. Excavations and surveys in various areas- such as the Mamlūk settlement in Ḥisbān, Jordan or the village Ottoman estate at Xyliatos, Cyprus- have revealed significant settlement and agricultural activity in areas where watermills are frequently found nearby, indicating a link between the locations of settlements and watermills, as well as bodies of water for water supply.

This brings us to the landscape record, which is perhaps less easy to study in some ways because of the sometimes changeable, or even ephemeral, nature of many landscape features. Nevertheless, landscape use has been shown to go hand in hand with settlement patterns over the centuries studied, indicating that what the landscape can yield, or has been able to yield in the past, has shaped the agricultural economy of the Levant, and thereby society itself has taken the shifting shapes and forms that can be seen in historical records and archaeological investigations so far.

The architectural documentation in this study has shown that despite regional variations in construction of the watermill (grain mills in particular), there is an emergent Near Eastern/Mediterranean/Levantine building pattern, perhaps similar to that proposed by McQuitty for the rural dwellings across the Eastern Mediterranean.[1] Although this can not be determined for urban mills on a wider Levantine scale, as Damascus was the only urban area studied in detail in this work, the architecture for the rural mill remained consistent, as did the basic technology.

When this information is combined, what can be interpreted with regards to the role of the mill in economy and society in the medieval and early modern Levant? This final chapter hopes to illuminate some important economic and social issues concerning these topics through a combined analysis of the information provided in the previous chapters.

The Economy of the Mill

The Crusader and Ottoman periods in the Levant were eventful on many levels, particularly economically and socially. Trade and trade embargoes, as well as natural disasters and depopulation, affected contact between regional societies both positively and negatively. Despite the sometimes complex administrative systems during the Crusader period and Ottoman rule, the watermill remained an important part of the physical and social Levantine landscape, until very recently. It has been suggested that, unlike the sugar mills, the water-driven grain mills were not a part of the market economy, but rather played a part in the subsistence economy of the region, supplying flour and other processed grain products to the armies and local villages. The following section will examine the role of the mill in the economy, in particular grain mills, to determine whether, like sugar mills, they also played their part in the wider economic context of the Levantine region through history, and affected the changes in technology that accompanied the changing economies and societies.

[1] McQuitty 2005, 330; see her discussion about the 'Late Antique House' with regards to techniques in construction of houses in this region.

Jordan is often considered to be an area remote in both political and economic significance from the central governments of both Cairo and Damascus until the late Ottoman period, and it has therefore been difficult to establish what role, particularly economically, this part of the ***bilād al-shām*** played in these periods. The historical records and archaeological material gathered so far intimate a period of reasonable prosperity for Jordan throughout the medieval and Ottoman periods. The number of settlements of the Ayyūbid and Mamlūk periods is not insignificant; larger cities, such as Aleppo and Damascus, of course have no equivalent in Jordan, but they also have a history that stretches long before the emergence of Islam. That is not to say that Jordan did not have urban settlements of equal significance- one needs only to look at the Classical metropolises of Jarash and Philadelphia ('Ammān) - but they lessened in significance even before the advent of Islam in many of these areas, due to various factors such as natural disasters and widespread political conflict. The wider region of northern Jordan around 'Ajlūn suggests not only the area's importance in a political context, with fortified outposts between Damascus and the estates of Montrèal and al-Karak, as well as Belvoir (*Kawkab*) to the east, but the steady occupation for the Ayyūbid and Mamlūk periods across the region also hints at consistent agricultural activity, by both settled, semi-nomadic and nomadic communities.[2]

Despite the sense of remoteness one may gain from a relative lack of substantial monumental archaeology or detailed historical information, the early Mamlūk period in Jordan appears to have been a time of moderate economic activity, with sugarcane production in the central and southern parts of the country for trade, prompting the need to construct water-driven sugar mills, as those for example found in *Ṭawāḥīn al-Sukkar* and Kurdāna.[3] This economic activity may also have resulted in the building of water-driven grain mills such as those found in Northern Jordan, as economic growth- though

[2] McQuitty 2005.

[3] See Pringle's list of mills in his work on secular buildings in Palestine, in Chapter Six of this work, Table 1, pp. 216-218. See also Chapter Two for historical sources on mills in Palestine.

modest- also led to increased populations which called for increased availability of grain to feed that population, and thereby the necessary means for food processing.

Trade was, of course, also a mainstay of the Ayyūbid and Mamlūk economies; for the Mamlūk period in particular urban centres such as Cairo, and to a lesser degree Syria, experienced profitable trade particularly through the export of sugar. This was frequently taken advantage of by various *ṣulṭāns*, who imposed monopolies on sugar to stabilise and improve the economy, but also to increase their own wealth and that of their soldiers.[4] Particularly notorious for this in Egypt was Ṣulṭān Barsbay (825/1422-842/1438), who controlled the production of sugar by his subjects only to force them to buy the product back from him at extortionate prices.[5] Grain monopolies were also a relatively frequent occurrence, and these had a greater impact on merchants and millers, who were compelled to purchase grain from the warehouses of *amīrs* and *ṣulṭāns* at elevated prices; this also had an adverse effect on the peasantry, who not only had to pay tithes on their crop yields, but were also forced to put up with the increase in the price of flour.[6]

The Mamlūk state's grain economy, which will be discussed further in the following section, also involved keeping warehouses to store large provisions of grain in the empire's provinces, in particular at the citadels of Damascus, al-Karak and Shawbak, to be used for necessary payments and as a stock of food for military campaigns.[7] These warehouses- called *al-shūwān-* often had mills and bakeries attached to them to dispense bread and grain to those in need.[8] Thus, despite the state control over grain, individual "entrepreneurism" was encouraged in mills and bakeries, where the miller would purchase grain to process, and then sell it on to the baker, who made the bread; needless to say, this also prompted monopolies and price-fixing by these respective tradesmen.[9] These activities were not limited to Egypt; according to Lapidus, "peasants from the Hawran brought wheat to Damascus and Bedouins had some part in grain marketing as caravaners between Egypt and Syria and around Damascus".[10] The discovery of a store

[4] Sobernheim, M. (1914) "Das Zuckermonopol unter Sultan Barsbai." *Zeitschrift der Assyriologie* XXVII-XXVIII, 75-85; 75.
[5] Sobernheim 1914.
[6] Lapidus 1969, 10.
[7] Ibn Mammāti 1943, 305.
[8] Lapidus 1969, 6.
[9] Lapidus 1969, 11.
[10] Lapidus 1969, 8 n.2.

room at the Mamlūk palace complex in Ḥisbān, which was supposedly used for sugar, also indicates that the storage of food provisions was a common occurrence in the Mamlūk period; the presence of watermills around all these towns additionally suggest there was a system of food storage and processing in the provincial centres of the government, keeping alive both local and wider regional economies.[11]

Trade with surrounding Levantine states was also prolific, despite the Papal embargo imposed in the 8th/14th century. Products such as pepper, cinnamon, ginger and cotton were traded freely between the Levantine states, although the import of sugar from the Islamic territories was fervently discouraged.[12] Although this may have prompted the Syrian sugar industry to decline, Crusader charters from Cyprus still record the purchase of Syrian sugar cane in the late 15th century.[13] The overall economic portrait emerging from this brief review of the state of the Ayyūbid and Mamlūk economies does allude to a period of moderate wealth, not only for the empire's centre- Cairo- but also for its provinces; trade relations within and outside of the empire also indicate there was a steady economic activity, prompted both by profitable enterprises such as the sugar industry, as well as the production and distribution of grain.

The economic history of medieval Cyprus is, like the rest of the Levant, turbulent, as is often reflected in 14th and 15th century Venetian archives and Ottoman documents. The island underwent phases of economic prosperity with intermittent phases of plague and locust infestations that destroyed crops and caused a decline in population, as attested to by several travellers to the island during those times.[14] The Crusader period was often a chaotic, though usually prosperous, time for the island of Cyprus, both politically and economically. Sugar cane production was prolific during the 13th, 14th and 15th centuries, like it was in Syria[15], and refined sugar from Cyprus was known for its excellent quality. Evidence for sugar production, and trade, can be found at the still extant remains of the

[11] Walker 2003.

[12] Coureas, N. (2005) "Economy", in A. Nicolaou-Konnari and C. Schabel (eds.) *Cyprus: Society and Culture 1191-1374.* The Medieval Mediterranean. Brill: Leiden and Boston, 111.

[13] Von Wartburg, L. (2001) "The Archaeology of Cane Sugar Production: a Survey of Twenty Years of Research in Cyprus." *The Antiquaries Journal* 81, 305-335 2001.

[14] Jennings 1993; Hadjianastasis, M. (2005) *Bishops, Ağas and Dragomans: A Social and Economic History of Ottoman Cyprus, 1640-1704.* Unpublished PhD thesis submitted to the University of Birmingham.

[15] Ashtor, E. (1992) *Technology, industry, and trade : the Levant versus Europe, 1250-1500. Edited* by B.Z. Kedar. Variorum: Hampshire, Great Britain ; Brookfield, Vt., USA.

water powered sugar mill of the Crusader castle of Kolossi, discussed briefly in Chapter Five, as well as in Kouklia, among other places.[16]

The widespread cultivation of sugarcane during the Venetian period came to an end by the early 17th century, when it was replaced by more profitable export commercial crops such as cotton. Reasons for the disappearance of sugar cane from the commercial market are still speculative, although production may have been affected by the disputes that frequently arose between different institutions regarding water supply and rights. Until that time, however, sugar was a main item for export during this period, and its profitability was well understood by the Crusader rulers, who took advantage of the opportunity to gain wealth through exporting this luxury commodity throughout the Levant. Its high commercial value is attested to in the need to transport sugar products for export on armed vessels.[17]

Grain was also grown in fluctuating abundance in Cyprus during the Lusignan and Venetian periods, as historical accounts have confirmed.[18] Like Mamlūk Egypt, the feudal lords and the crown were the main landowners, and thus had control over the sale of grain and sugar, of which they profited relatively heavily by trade with Genoese merchants, as well as on the wider international market. Like sugar, grain was also an export product in times when the island experienced a surplus, but unlike its luxury opponent, it was not deemed necessary to transport grain on armed galleys.[19] Trade between Cyprus and the surrounding Levantine states was vigorous until the 16th century, although the intermittent papal embargos on trade with the Islamic empire frequently forced the island to act as an intermediary stopping point between the Eastern and Western Mediterranean, rather than an official trading point. However, the colonies of Venetian and Genoese merchants that were allowed to remain in Cyprus helped to promote Cypriot products in the international market, at the same time as encouraging the local economy through purchasing goods from the crown and the feudal lords, who frequently also had monopolies on commodities, as the Mamlūk ṣulṭāns of Egypt did.[20] This local and international economic growth was such that it could sustain, and be

[16] Ashtor 1992; Aristidiou 1983; see in particular von Wartburg 2001; Coureas 2005, 112-113.
[17] Coureas 2005, 145.
[18] See Chapter Two, pp. 40-45.
[19] Coureas 2005, 145.
[20] Coureas 2005, 156.

sustained by, advantageous technology for food processing, such as water-powered mills; an example of many is the Cistercian monks' development of a complete hydraulic system, including a mill, at Pyrgos.[21]

The economic activity of the island during this period is also reflected in the historical and the archaeological study of the TAESP survey area, discussed in Chapter Seven. Boustronios' account of the estate at Vyzakia and the 14th century royal charter regarding properties at Athassi (Athasy)[22] and Vyzakia, both villages located in the TAESP survey area, are two of many indications that the Troodos region was agriculturally and economically active, if not prosperous, during the Frankish and Venetian periods, and played a part in the local and regional economy. The existence of watermills in these areas (although their dating is still uncertain) may also imply that this economy depended on these food processing facilities to sustain itself through the encouragement of local agricultural productivity and profitability.

The Ottoman Period

In addition to the Ottoman *waqf* documents related to Damascus and Ḥoms, discussed in Chapter Three, documents from Ottoman period Palestine have also brought to light some of the financial matters concerning watermills present in the relevant areas of this study. Hütteroth and Abdelfatteh provide a detailed study of the tax registers for Palestine and Transjordan at the end of the 16th century.[23] The *taḥrīr* registers reveal several areas in Transjordan where water mills were taxed at various rates. Although the reasons for the different levels of taxation are unclear, the fact that hand mills were not taxed suggests that the use of water may have played a role in determining the tax rate, probably because the amount of grain processed by a water-driven mill was much higher than that of a hand mill. The water powering the mill enabled it to produce a larger volume of flour which could be sold on a local or state level, depending on the capacity of the mill; thus, indirectly, the tax charged for the millstones is also related to its capacity, which is dependent on water power for energy.

[21] Coureas 2005, 112-113.
[22] See Chapter Two, Dawkins 1964, and Chapter Seven, Richard 1962.
[23] Hütteroth & Abdelfatteh 1977; Hütteroth 1978.

Mills were taxed either as individual fiscal units, or included among items in village taxes. This was known as the *rasm ṭaḥūn*, and the determining factor for the tax rate was the number of millstones the mill contained. As previously established, the mill was also taxed according to the amount of time it was in operation during a whole year. There is no mention of the tax being based on the amount of water needed to power the mill, and there is no mention by the fiscal registers surveyed by Hütteroth and Abdelfatteh of any tax on irrigation or water supply works; however, as al-Māwardi states, the allotment of water through time-shares, or by other systems according to *sharī'a*, suggests there were at least legal implications for operating a mill out of turn, as well as fiscal implications. The water powering the mill enabled it to produce a larger volume of flour which could be sold on a local or state level, depending on the capacity of the mill; thus, indirectly, the tax charged for the millstones was also related to its capacity.

Town	*Tax Paid*	*Population (per hāne)*
'Ajlūn	300 *akçe* (5 watermills working all year)	364
Kufranja	140 *akçe* (2 watermills working all year)	10
Al-Karak	240 *akçe* (4 watermills working all year)	191
Nā'ūr (Ḥisbān)	90 *akçe* (3 mills working half a year)	62
Shawbak	120 *akçe* (2 mills working all year)	70

Table 2. Tax figures for the *liwā'* of Ajlūn in 1596 AD.

Table 2 shows a list of places mentioned in the tax registers of 1596 AD, which are still thriving rural communities in Jordan today; they include the amount of tax charged on water mills, and although some of these figures are obscure, as they do not add up to multiples of 15 (60 *akçe* for one year; 30 for half; 15 for 3 months, according to the tax fixed in the Ottoman *kanūn-nāme*), they are indicative of moderately consistent agricultural activity across the region. The figures provided are from the *liwā'* 'Ajlūn, which stretched from Northern Jordan beyond the Sharāt region to Shawbak. The number of watermills in brackets is a calculation based on the tax for one year, and is speculatively based on the number of mills that still exist in these towns today. For example, 'Ajlūn and Kufranja paid 440 *akçe* in total, presumably for the whole of the year 1596 AD. This indicates that there may have been at least a total of 7 mills in this area at the time running all year, despite the fact that the figures do not work out correctly in multiples of 15, as mentioned previously, even when figures are calculated per half or quarter year. (Hütteroth & Abdelfatteh do not provide any explanation for this, and I have also been unable to find a pattern.)

It is also interesting to observe that there is no mention of the town of al-Ṣalt, which was considered to be the chief town of the *liwā'* 'Ajlūn during the late Ottoman period and has a number of watermills located south of it; another town where watermills are abundant today is Ḥisbān, and this is listed as *hāli*, or empty, in 1596 AD. However, the area containing the watermills and irrigation systems- Sayl Ḥisbān- may have been included in the town of Nā'ūr, which is located approximately 5 km north east of Ḥisbān. The mills of Wādi Ibn Ḥammād and Sayl Karak may be included in the tax register for al-Karak, and the tax charged for Shawbak is probably for the mills discovered at the foot of Shawbak castle, and along the *wādi* to Abu Makhtūb, and may be those remaining from the time of the Mamlūks when Shawbak was used as a *shūwān*.[24] This is not only indicative of a functioning rural economic community at the start of the Ottoman period in Jordan, but also that many of the mills in the areas mentioned above still extant today may be dated, at the very latest, to the early Ottoman period.

Although the countryside around Jordan had during this period a law of its own, being ruled chiefly by Bedouin tribes, Damascus was in the 18th century ruled by a series of semi-independent governors; one of these was As'ad Pāsha, who controlled wheat prices by enticing the *shaykhs* of wheat millers to hoard grain, thus causing the price of wheat to rise. Wheat millers (*taḥḥanīn*) also carried a monopoly on various commodities of which they gained more wealth; the situation had clearly not changed a great deal since the Mamlūk period.[25] It is no wonder, then, that the peasantry during this period was pushed into poverty, as milling became an increasingly expensive endeavour due to the monopolies held by the wealthier classes, which may have ultimately led to the

[24] See this chapter, p.266.

[25] Rafeq, A.K. (1981) "Economic Relations between Damascus and the Dependent Countryside, 1743-71", in Udovitch (ed), *The Islamic Middle East*, 653-687; 657. This was also the case in Mamlūk Egypt, as discussed earlier in this chapter, in *The Medieval Economy*.

abandonment and ruination of watermills in many areas, especially the remote rural areas. In addition, the wheat millers of the city were probably exempt thereby from paying the fixed dues, unlike those of the countryside, which were taxed at various rates.[26] This was the case even though wheat mills were usually- at least in part- *waqf* property.[27] This is also apparent in the relationship between Damascus and the peripheral countryside. The Ottoman government realised that the availability of inexpensive grain for the city in times of dearth was not only in the interest of its inhabitants but also for the government itself; this monopolisation, of sorts, led to an influx of people from the countryside "where the authorities cared less about such matters".[28] Depopulation of rural areas as the masses flocked to the cities no doubt also had an effect on the demise of the rural watermill.

The 13th/19th century also saw a number of changes in the relationship between Damascus and the peripheral countryside. Transjordan, for instance, had been controlled locally by various tribes, but by 1851 a *qadā'* (subgovernorate) was established in 'Ajlūn in an attempt by the Ottomans to regain control of the area. This control expanded south to include al-Karak and the Balqa' by the end of the 13th/19th century. All of these regions had good water supplies and irrigation works to promote a thriving agriculture and rural economy; however, each of these areas had its own agricultural system until the arrival of the Ottoman administrators.[29] Although court records have already established that the Ottomans included the watermill as a taxable item, and therefore a source of revenue for the failing economy, across all of Syria, as established by Mantran & Sauvaget, and Pascual[30], the existence of localised agricultural communities suggests that mills were being used extensively before the arrival of the Ottomans. This is perhaps not a surprise, but it indicates an initiative by both nomadic and settled communities to act without the aid of a centralised government, probably unlike the Ayyūbid and Mamlūk periods, where government control on agriculture appears to have been more wide spread, at least in Egypt. A decline over the centuries of agricultural activity may therefore not have been

[26] Hütteroth & Abdelfatteh 1977.
[27] Rafeq 1981, 669.
[28] Schechter, R. (2005) "Market Welfare in the Early-Modern Ottoman Economy- A Historiographic Overview with Many Questions". *JESHO* 48 (2), 253-276; 267.
[29] Fischbach, M.R. (2000) *State, Society and Land in Jordan.* Social, Economic and Political Studies of the Middle East and Asia 75. Brill: Leiden.
[30] Mantran & Sauvaget 1951; Pascual 1983.

quite as dramatic on the small scale as previously believed, and the watermill, although abandoned in many cases, kept its place in the rural economy until relatively recently.

Cereal	*15th Century*	*1540s*	*1850s*	*1870s*
Wheat	999 290	1 400 000	412 500	560 000
Barley	1 254 907	1 600 000	962 500	1 200 000
Oats	20 000	34 000	-	-

Table 3. Cereal productivity in Cyprus from the Medieval to the late Ottoman period (in bushels). (After Christodolou 1959)

The decline and ruin of the Cypriot grain mill may be attributed to the decrease in cereal production between the end of the 16th century and the middle of the 19th century. (Table 2) There are a number of reasons for this; like Syria and Egypt, Cyprus was plagued by drought, famine and the Black Death throughout the Lusignan, Venetian and early Ottoman periods, at least until the beginning of the 18th century. As a result, the island was burdened with severe bouts of depopulation, as well as extreme agricultural poverty. The accounts given by some travellers to the island during this time period attest to this, and although it is difficult to determine the severity of the situation at times, there is little doubt that an economy based almost solely on agriculture would have been profoundly affected by such events. The price of wheat fluctuated heavily during the late 16th and 17th century, sometimes even doubling in the same year.[31] Trade declined, taxes increased and the export of grain diminished in the 17th century due to strict regulations by the Porte, who deemed it necessary to ban exports of grain to keep the prices low, and thus prevent social dissent[32]; a similar fate fell on the sugar industry, when sugar from the New World began to be imported to the island in the 17th century, and the sugar plantations and factories fell into ruin as a result.[33]

Around this somewhat bleak picture of agricultural and economic decline, there nevertheless were initiatives on a government level to improve the state of agriculture on

[31] Jennings 1993, 314; the price of wheat in 1593 is here shown as ranging from 21 ⅓ *akçe* and 50 *akçe* for one *kile* of wheat. (A *kile* is roughly equivalent to one bushel.)
[32] Jennings 1993, 315.
[33] Hadjianastasis 2005, 169.

the island. Despite the at times severe fluctuations in agricultural, economic and climate activity between the start of the Venetian period and the middle of the Ottoman period, as frequently described by 16th and 17th century visitors to the island, the idea by the governor Bekir Pasha, for example, in 1747 AD to improve agriculture by constructing mills and irrigation channels suggests that there was an awareness of the necessity to keep agriculture a main priority. Such an initiative may in return imply that the watermills were seen as a part of an industry whose purpose was not merely to serve or sustain the rural populace, but that they were also a part of a wider island- or even regional- economy. This was certainly the case in Ottoman Anatolia; Ottoman tax registers from 1500-1501 AD are the only documentary evidence surviving regarding the watermills in the Sagalassos and Burdur regions, and both the municipality and the Ministry of Finance still tax any operational watermills today.[34]

Monasteries continued to be influential economic instruments in the countryside throughout the Ottoman period, mainly due to the Ottoman's policy of leniency towards the empire's many religious groups. As in the medieval period, these monasteries were often the owners of mills.[35] Estates (Turkish, *çiftlik*), also similar to those found in the Lusignan and Venetian periods, contributed heavily to the existing rural agricultural economy; several such estates, located in the North Troodos area as well as the TAESP survey area, were large-scale producers of grain, as attested to by the size of the threshing floors found next to these.[36] An economy so reliant on agriculture was thereby dependant on the efficient and continued output of the rural countryside, in which the watermill, as a food processing facility, had a necessary role.

Sugar and Grain: The Economies of Trade

It is generally assumed that flour was not an export product, as it did not keep as well as grain. This would make the purpose and function of the water-driven grain mill as that of a small-scale agricultural device used by local farmers in the rural areas of the eastern

[34] Donners *et al*, 2002.
[35] See pp.291-299 in this chapter for a brief discussion on mill ownership.
[36] Given 2000, 219; Given *et al* 2002.

Levant.[37] But how do we explain the initiatives by the Mamlūk and Crusader Empires to import grain from neighbouring areas in times when there was a local surplus, and how could this have affected the role of the watermills? Although the questions of the Mamlūk wheat supply have been dealt with in some depth[38], perhaps comparing grain and sugar exports would clarify the issue.

Sugar cultivation and processing has nearly always been seen as a part of the market economy, meaning that its cultivation was largely for the purpose of export, or as a commercial product; this explains perhaps the fortified nature of the sugar mill at Kurdāna, over which numerous disputes and confrontations took place, as also attested to in the treaties and charters of the time.[39] Grain, on the other hand, has generally been seen as a part of a smaller scale subsistence economy, mostly benefiting smaller local communities in a relatively concentrated area. However, the expense involved in building and maintaining a water-driven mill would have been great, indicating either that they were a part of a government initiative to further agricultural activity in the region, or that they were a *waqf*, or religious endowment, belonging to a mosque, for example. The grain mill may have played a role in the import of grain, where during times of higher demand, such as plague or famine, it may have been deemed necessary to increase flour productivity. After all, economic activity during the 13th century in the Levant was such that, "...Technological and social innovations produced surpluses, which were in turn traded internationally to further intensify development. Parallel advances in navigation and statecraft facilitated contact among distant societies, which generated even more surpluses."[40]

Lapidus suggests the Mamlūk period was a time of economic wealth as well as poverty-grain was sometimes exported to help areas in need suffering from famine, such as Cyprus; in times of crop failure, the Mamlūks would import it for their needy populations.[41] Ashtor has argued that

[37] McQuitty 2005.

[38] Lapidus 1969; Ashtor, E. (1986) "The Wheat Supply of the Mamlūk Kingdom", in B. Kedar (ed), *East-West Trade in the Medieval Mediterranean*. Variorum Reprints: London, IX, 283-295.

[39] See Chapter Three for information on treaties between Muslims and Crusaders.

[40] Abu Lughod, J. (1989) *Before European Hegemony: The World System A.D. 1250-1350*. Oxford University Press: New York/Oxford, 4.

[41] Lapidus 1969.

"the import of wheat into Syria had begun at the end of the 13th century during the frequent campaigns of the Mamlūks against the remnants of the Crusader principalities, a long war of attrition which probably was connected with much pillaging and devastation; and it may have continued into the beginning of the fourteenth century."[42]

This is a plausible explanation, but as he also admits himself, there were imports of grain in times when grain prices were low, indicating a surplus; this is less readily explained. The early 7th/13th to the first half of the 9th/15th centuries were periods of fluctuating stability, both economically, environmentally and politically[43], and this no doubt had a profound effect on the grain provisions, perhaps causing the Mamlūk administration to recognise the need to import grain in order to avoid a dearth and keep the population- and the troops- with a constant and reliable supply of food. This has also been discussed by Lapidus, who has indicated that grain was exported from Egypt to Syria to feed the ṣulṭān's armies on campaign there, as well as "to meet regional needs in times of crises".[44] However, Lapidus also recognises the difficulty with speculating on the supply of grain to rural areas, as information regarding this appears to be practically non-existent. Another factor that played a part in this was the climate. Agriculture in Egypt was totally dependent on climate activity, particularly in Ethiopia, as the Nile floods depended mostly on the rainfall there. A year without rainfall in Ethiopia meant a year of drought in Egypt; this not being the case in Syria, however, as agriculture there was affected by a different climate system, meant that the two regions could depend on each other in need, but also that in case of drought in both areas, that they had to look elsewhere for grain. This without doubt also had an effect on the fluctuating grain prices of the time.

Although it is difficult to establish any correlation between the construction (or existence) of watermills (as there has been little or no documentation of this for the Ayyūbid or Mamlūk periods) with the rise and fall of wheat prices, and the occurrence of famines, it is almost certain that environmental, social and economic factors affected their existence, much as these same factors affected the rise and fall of the sugar industries in the *bilād al-shām* and Cyprus. Thus, grain being used both for commercial as well as subsistence purposes, survived longer as a commodity, necessitating the construction and upkeep of

[42] Ashtor 1986, IX 283-295, 285.
[43] Ashtor 1986 IX, 292-293.
[44] Lapidus 1969.

food processing means, such as watermills, depending mainly on demands of both local and foreign populations. The presence of mills in the ‘Ajlūn, Ḥisbān and Troodos regions, for example, may not indicate a highly commercial enterprise, such as the sugar mills in the Jordan valley or the coastal sugar mills of Cyprus, but a necessary tool to enable basic human subsistence to maintain a steady local economy, and aiding indirectly the wider economy of the Levant, their importance cannot be ignored.

This brings us to the question of the export of processed grain. Although it is generally believed that grain was exported wholly unprocessed, its purpose as a relief supply for a besieged population in times of war may suggest that this food needed to be processed before it came to the aid of those who were in need, particularly the troops who were fighting for the empire. The issue of trade of certain commodities has been discussed by Li Guo, who refers to some 7th/13th century shipping documents from the Red Sea port of Quseir. Here, there are numerous documents which frequently mention the shipment of flour (as well as wheat, but the two are referred to as clearly distinct commodities in the shipping notes) to and from various individuals.[45] Li emphasises the importance of Quseir as a gateway to trade routes both to the Arabian Peninsula as well as the Indian Ocean, meaning that these were long distance shipments. This contradicts the usual assumption that flour was not shipped over long distances, if at all, as it did not keep as well as grain, and suggests further that flour was indeed exported, as well as imported, during this period. Therefore, the role of the watermill, as indicated previously, was not always limited to a local area. As a food staple necessary for survival flour gained its value from that, and this is reflected in the relatively high price of flour listed in the shipping notes found in Quseir.[46]

Grain was plentiful in Cyprus during the Venetian period, and there was often talk of grain surpluses, rather than a dearth.[47] Although there are as of yet no known documents regarding the import of flour into Cyprus during the Venetian and Ottoman periods, Venetian trade documents have shown that perishable foods such as cheese and lard were

[45] Li, G. (2001) “Arabic Documents from the Red Sea Port of Quseir from the 7th/13th century, Part 2: Shipping Notes and Account Records.” *JNES* 60:2, 81-116; Ashtor also claims that “Egypt and Syria imported flour” although he does not specify a source for this information; Ashtor, E. (1983) *Levant trade in the later Middle Ages.* Princeton University Press: Princeton, 465.

[46] Li 2001, 23.

[47] Hadjianastasis 2005, 169; Coureas 2005, 156.

frequently imported from other areas of the Mediterranean.[48] Trade with the Muslim lands also flourished; the import and export of refined sugar products in the 14th century[49] kept alive the island's own prosperous sugar industry. The import of refined sugar products may seem superfluous, yet it is registered in the Venetian trade archives as being a popular product for import into Cyprus from Egypt.[50] Flour may, similarly, have been imported from surrounding countries which had a wheat surplus (such as Syria) during times of famine, as was the case with the *bilād al-shām* and Egypt, as well as exported as a processed grain product. This would have given the role of the watermills in the Troodos region, for example, not only the role of supplementing a subsistence existence, but also a role in the wider economy of the Levant.

It has been suggested that economic activity in the Ayyūbid and Mamlūk periods was, at least in the early periods of the Mamlūk era, flourishing in the *bilād al-shām*.[51] Although the lands east of the Jordan are generally thought of as having played a small role in the politics and economics of the greater *bilād al-shām,* the presence of the Crusader-period fortifications in 'Ajlūn, al-Karak and Shawbak point to some political and economic significance. There is a possibility that 'Ajlūn was used as a major supply region for Ayyūbid and Mamlūk military efforts against the Crusaders; Johns mentions the role of 'Ajlūn in the siege of Damietta in 617/1217.[52] Although he mentions mainly iron and timber supplies, it is not improbable that basic foodstuffs such as flour were also a part of such relief efforts, as the *shūwān* of al-Karak and Shawbak were, discussed earlier. This would, of course, imply a necessary presence of grain mills in the area during that time. 'Ajlūn's rich iron ore was mined and smelted since that time until relatively recently, and at the time of Johns' study of 'Ajlūn, "a small knife making industry was still carried on in Kafrinji"[53]; a similar continuity of local socio-economic custom could be applied to the use of grain mills and grain processing.

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[48] Coureas 2005, 144.
[49] Ashtor 1986; Lapidus 1969; Coureas 2005, 139.
[50] Coureas 2005, 139.
[51] Abu Lughod 1989; Irwin, R. (1986) *The Middle East in the Early Middle Ages: The Early Mamlūk Sultanate 1250-1382.* Croom Helm: London & Sydney; Holt, P.M. (1986) *The Age of the Crusades. The Near East from the Eleventh Century to 1517.* A History of the Near East. Longman: London and New York.
[52] Johns 1931, 30.
[53] Johns 1931, 30.

This has also been suggested in recent studies of the Ottoman period in Cyprus. Although other industries prospered, along with cotton, wine, honey and other products, it has often been debated whether grain consumption was sufficiently high to merit the construction of mills, particularly in the Troodos region. However, agricultural activity – including the cultivation of grain crops- has proven to be high in this area for more than the last 1000 years. During Ottoman times, the economy was mainly supported by agriculture, on both a local and state level, particularly with the cultivation of cereals.[54] Given has suggested that "the sophisticated technology of water mills and threshing sledges and a complex and intense system of labour meant that the rural economic system was capable of rising above the subsistence level; pressure from the tax-levying authorities meant that it had to do so."[55] Perhaps, as grain and sugar were both major agricultural products traded between the medieval Levantine states, it is not impossible that some of the grain mills here too sustained and were sustained by, at least in part, an export economy.

The Question of Ownership

Ownership of mills has in this study in most cases been very difficult to establish, particularly for the pre-Ottoman periods. The meticulously collected records which are at hand from the Crusader and Ottoman periods outnumber the archival sources that are available for the Ayyūbid and Mamlūk periods. In addition, the lack of translated sources makes for limited, as well as time-consuming, work. The information presented in the following paragraphs comes from material published from various parts of the Islamic world, including interesting and valuable information from medieval Spain, as well as oral historical information from Cyprus.

The Lord's Mill

In general terms, there seems to be no consistent pattern of ownership of mills for the Levant across the time period studied. Records from the medieval period (6th/12th-

[54] Given 2000, 212.
[55] Given 2000, 227.

$10^{th}/16^{th}$ centuries) have shown that ownership was mostly seigniorial, with mills being constructed by wealthy lords who either leased them out to his wealthier subjects, or compelled them to grind their grain there in return for tithes, known as 'banal' mills.[56] Although the evidence is vague regarding whether this was also the case in Egypt, Sato's study has revealed a similar arrangement there in that mills were frequently owned by Mamlūk lords,[57] and Glick's claim that "mills.....constituted one of the classical seigniorial monopolies of feudal Europe..." has also proven true in some areas in Spain, such as Catalonia and Valencia. State economic investment into rural areas of Jordan was also common in the Mamlūk period, as shown by Walker for Ḥisbān,[58] and this also included mills. The case for sugar mills was different, where these were owned by large powerful families, such as the Cornaros in Cyprus, or by religious orders, such as the sugar mill at Kolossi which was owned by the Hospitallers, who could afford substantial investment in the construction and upkeep of mills and related water works. Additionally, sugar cane factories in the *bilād al-shām* were almost always in the possession of a Ṣulṭān due to the lucrative economic nature of sugar, which the ordinary peasantry rarely had a chance to afford except in times of illness when sugar was used as a restorative treatment for various diseases.[59]

This may point to a state initiative of constructing mills for economic purposes, although this initiative probably changed with the fluctuating needs of the economy and society, perhaps along with an increasingly private character of irrigation administration as was the case in Egypt, and also in Iran until the $8^{th}/14^{th}$ century[60]; this could also indicate that mills and other hydraulic machinery in Jordan and Syria were leased out to peasants by large estates who were then effectively in charge of them.[61] As Cooper states concerning the construction of *sāqiyah* in Egypt during the time of Ibn Mammāti:

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[56] Glick, T.F. (1995) *From Muslim Fortress to Christian Castle. Social and cultural change in medieval Spain.* Manchester University Press: Manchester and New York, 120.

[57] Sato 1997.

[58] Walker 2003.

[59] Sobernheim 1914.

[60] Beazley & Harverson 1982, 83.

[61] Cooper, R.S. (1973) *Ibn Mammati's rules for the ministries : translation with commentary of the Qawānīn al-Dawāwīn.* Thesis submitted to the University of California at Berkeley, 58.

"Because of the large investment involved in setting up a sāqiyah, this was undertaken by the large, powerful estates which leased them to less powerful villages and individuals. Basin irrigation, which required centralised decision making, remained in the control of the government, but the installation of the sāqiyah was a matter of individual initiative."[62]

The Mamlūks levied taxes on watermills from their serfs, while in Egypt there was a tax for the annual repair of the irrigation canals and dams[63]; in addition, yearly rents were paid at a fixed rate by tenants of perpetually irrigated lands, on top of which a tax on sugar-cane plantation was levied by the feudal lords.[64]The cultivators who owned these perpetually irrigated lands individually had the power to pass them on to their heirs. With regards to the common land, the lords often divided it into several sections that were irrigated by particular irrigation networks, and it was the responsibility of each peasant to supervise the designated irrigating channel, each division being taxed separately. This changed during the Ottoman period:

"Whereas under the Mamlūks the fief-holder was responsible for the annual repairs of the local irrigating dams and canals, under the Ottomans the responsibility was imposed on the peasants themselves."[65]

This appears also to have been the case for Jordan as late as the 18th century. Conder suggests that some of the mills in the Ḥisbān area were built under the patronage of the 'Adwān *shaykh*, Dhiyāb, in the late 18th century[66], and Lancaster & Lancaster have suggested that the Wādi Ibn Ḥammād mills were owned mostly by the Majāli tribe.[67]This, on the other hand, would cast doubt on the idea that there was any official administrative endeavour to provide the countryside with irrigation and food processing facilities, but rather that it was an effort of the local peasant or tribal lords to improve agricultural facilities such as irrigation to maximise their use of the landscape. In rural

[62] Cooper 1973.
[63] Poliak 1939; Sato 1997.
[64] Poliak 1939; Sato 1997; Frantz-Murphy, G. (1986) *The Agrarian Administration of Egypt from the Arabs to the Ottomans.* Supplément aux Annales Islamologiques, cahier n° 9. Institut Français d'Archéologie Orientale: Cairo.
[65] Poliak 1939, 69-70.
[66] Conder 1889, 126.
[67] Lancaster & Lancaster 1999, 278.

Ottoman Jordan, this clearly included the improvement of grinding facilities, in the form of watermills.

The tax registers dating from the Ottoman period mentioned previously have listed several watermills as taxable items in Jordan from the end of the 10th/16th century, which perhaps indicates that individuals owned the mills, and were taxed by the state accordingly. This was no longer the case in the late 13th/19th century, when the Ottoman *wazīr* Muhammad Rashīd Pāsha decided to try to end the internal tribal disputes in Jordan by stationing Ottoman troops in al-Ṣalt, al-Karak and southern Transjordan. This sparked a substantial increase in agricultural activity in the 1860s and 70s[68], when the various tribes began to take a greater interest in cultivating land, prompting the Ottoman administration to restore and renovate many of the water mills present in these areas, causing their rebirth as a significant economic tool, as suggested by Rogan.[69] In Cyprus the mills of Kythrea were also owned by the state during the 18th century,[70] and the Ottoman initiative to restore derelict agricultural buildings was also common in Jerusalem :

> "Building new mills and ovens, or re-activating old ones that had been derelict and unused for many years, was an outstanding characteristic of the first century of Ottoman rule in Jerusalem."[71]

Lordly and state ownership did not seem to have changed a great deal between the medieval and Ottoman periods, particularly with regards to irrigation and administration of watermills, except perhaps that the peasant suffered at the hands of a policy of increased taxation and expenditure by the ruling lords and ṣulṭāns, or in later times, the centralised state. The taxation of irrigated land, as well as the taxation of mills, continued to be a policy to the end of the Ottoman Empire across the Levant in the 19th and early 20th centuries, as it indeed still is in some parts of modern Turkey where watermills are still in operation and subject to tax by the government.[72] The imposition of responsibility

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[68] Lewis, N.N. (1987) *Nomads and Settlers in Syria and Jordan, 1800-1980*. Cambridge Middle East Library. Cambridge University Press: Cambridge, 127.
[69] Rogan 1995, 753-757.
[70] Given 2000, 227.
[71] Cohen, A. (1989) *Economic Life in Ottoman Jerusalem*. Cambridge studies in Islamic civilization. Cambridge University Press: Cambridge, 114.
[72] Danişman 1978.

upon the peasantry of repairing irrigation canals may explain the decline in their maintenance, as well as in the watermills, as the peasants were already lumbered with other financial burdens by the Ottoman regime. Perhaps this is one of the reasons for the establishment of shareholders' mills, to ease the burden of expense in maintenance.

The Shareholder's Mill

The Islamic legal documents discussed in Chapter Three suggests that there were frequently multiple individuals who owned an agricultural building; in the case of irrigation channels, for example, ownership belonged to the people who constructed the channels according to regulations stipulated in the *sharī'a*, and the same kind of system may have been in place when it came to constructing watermills which were fed by these channels. The frequent occurrence of mills in clusters, rather than as individual, unconnected buildings, perhaps substantiates that theory, as they appear within the landscape as a succession of functioning agricultural buildings frequently located on land owned by different groups of people.

Glick's study on mills in medieval al-Andalus has also shown that there was a collective ownership of mills, and attributes this to the social organisation of milling as a result of the cultural attitude towards the use of mills. While the mills of Christian Spain were seen as a seigniorial monopoly, as discussed earlier, mills in al-Andalus were "a business enterprise like any other in or near cities, while in the *alquerías*[73] they provided a service and were typically owned collectively by up to a dozen partners."[74] This suggests that there was a social or religious factor affecting the construction and control of mills, and not a political factor as with the banal mills of feudal Europe. This social regime extended to Berber and Arab tribal groups, which built and owned mills in al-Andalus after the conquest of Spain by the Muslims in 711 AD[75]; it appears thus that mill ownership was not exclusive to settled communities in this part of the Muslim world either. After the *repartimientos*, however, this changed, and mills formerly belonging to

[73] (Spanish) *Farmstead or hamlet..*
[74] Glick 1995, 161.
[75] Glick & Kirchener 2000, 309.

Muslims were controlled by the new Crusader rulers, as explained in the work carried out by Glick and Burns, discussed in Chapter Three of this work.[76]

In Jordan and Syria, there can be little doubt that the Bedouin system of allotting land- and therefore by law including what was on the land in form of trees and irrigation systems- would also have stretched to the presence of watermills on any parcel of land. The priority of upstream irrigators over those further downstream, as stipulated in the *sharī'a* as well as in documents from medieval al-Andalus[77], suggests for rural areas that there had to be a system of mill ownership using shareholders to avoid any conflict over water distribution, or an agreement between individual mill owners regarding water supply for the mill. However, mill ownership by individual families was not common, in Cyprus or Jordan, as the day-to-day running and maintenance of the mill was too costly, as were the rights to water.[78] Mills here were often owned by a particularly wealthy *shaykh*, or as in medieval Spain, by a kind of consortium of shareholders, as has also been discovered by Rogan for the Ottoman period in al-Ṣalt.[79] In addition, tax registers have shown that 'Ajlūn was populated by both farmers and Bedouin tribes in the 16th century, and the Bedouin were assigned to a particular *nāhiye* so they also would be officially liable to pay taxes. How much, or even if, this influenced their movements or their use of the landscape and the buildings within it, is impossible to determine, but their need to rent land for grazing their herds may have extended to renting the use of watermills, as settled communities also would do frequently.[80] Lancaster & Lancaster have pointed out that shares in the Wādi Ibn Ḥammād mills were "bought and sold all the time"[81], indicating that shareholding in mills also clearly extended to Bedouin tribes.

Although archival sources for Cyprus have not been studied sufficiently enough to determine whether grain mills were owned by individuals other than those of the upper ruling class in the pre-Ottoman period, it appears that power was not always rendered in total to the lord during the Crusader occupation of the island. A record from 1317 AD

[76] See Chapter Three, pp. 73-79.
[77] Ibn Baṣṣal 1955, 228;Glick 1995, 81.
[78] Given 2000; Rogan 1995.
[79] Rogan 1995.
[80] Beaumont *et al* 1976, 157.
[81] Lancaster & Lancaster 1999, 228.

indicates that in Psimolophou the lord had to pay "damage expenses to the *apauteur* [82]of the mills of the village for the time they remain inactive for repairs"[83]. This suggests that although the mill was leased to the village, the lord was not absolved completely from financial responsibility toward his subjects, as it was his responsibility to keep the mill properly maintained, being obliged to offer recompense if he was unable to fulfil this obligation. Unfortunately, other than the feudal aspect of ownership of the medieval Cypriot mill, little else is known regarding this subject, although a Venetian record of 1243AD shows that Venetians- who did not formally take over the island until the 1489 AD- were allowed to own some property on the island, and this also included flourmills, suggesting that foreign ownership of mills was also acceptable.[84]

For the Ottoman period, the information is still sparse, but through oral histories it has been established that some mills in the Troodos area have been linked to individual owners; for the TAESP area, a major mill owner was Ahmed Agha, who owned mills in Linou and Katydhata (BU002, 003, 004, 0044), and also Krommidhos, who owned mills in Phlasou (BU0062, 0075, 0076)[85]; in these cases, there appears to be clear distinctions between Turkish and Greek ownership of the mills.[86] Collective ownership was also common, as the oral histories have also shown; mills such as the Rotsos mill in Tembria (BU0064) were owned by three Greek families.[87] Owning shares in a mill, in the form of a specific amount of time allotted at periodic intervals, was also not unusual; the daughter of a priest was allowed "the use of a mill at Evrykhou for three days and three nights every 30 days".[88]

[82] (French), tenant who leased land at a fixed sum; also known as a *francomati*.
[83] Nicolaou-Konnari, A. (2005) "Greeks", in Nicolaou-Konnari & Schabel (eds.), *Cyprus: Society and Culture 1191-1374*, 13-62; 35.
[84] Coureas 2005, 116.
[85] Oral information, TAESP survey project.
[86] Oral history gathered by various members of the survey teams during the TAESP survey, 2001-2004.
[87] Oral history, TAESP, 2001-2004.
[88] Given 2000, 225, from Theocharides, I.P. (1993) *Othomanika Engrafa 1572-1839*. 5 volumes. Kykko Monastery Research Centre: Nicosia, 447.

In medieval Cyprus, watermills were often a part of large monasteries, or provided with equipment by churches in return for a fee.[89] In 1220 AD, Queen Alice granted the cathedral of St. Sophia free rights to use the mills at Kythrea, and the Cistercian monks at Pyrgos "developed extremely advanced hydraulic and sanitation systems for supplying piped water to their monasteries and the mills and fishponds pertaining to them..."[90]. Associations between mills and religious institutions in Jordan and Syria are more difficult to establish, although Elisseeff frequently places the mills of Damascus near mosques and monasteries.[91] Here, names of buildings also allude to ownership by religious institutions, such as the *Khanqa al-Ṭāḥūn*, or the "Convent of the Mill", located outside the old city walls and attributed to Nūr al-Dīn, who is said to have built it in 563/1165-66.[92] In Ḥisbān, sugar mills were endowments belonging to a *sulṭān* resident there, and although it is unlikely that these mills were in fact sugar rather than grain mills, it appears that *waqf* properties in the form of watermills belonging to Egyptian Mamlūk *sulṭāns* were a common occurrence in Jordan during the 7th/13th and 8th/14th centuries.[93] Equally, in the Kingdom of Jerusalem, mills were often a part of property donations to abbeys and other religious institutions.[94] Mills in Spain also frequently belonged to churches, but here they were usually acquired through a process of investment, where the church or monastery would buy shares in a mill from lay lords or groups of allodial

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89 Given 2000, 226.

90 Coureas 2005, 112; Schabel, C. (2000) Frankish Pyrgos and the Cistercians. *RDAC*, Cyprus, 349-360..

91 Elisseeff 1956, 77-79.

92 Elisseeff, N. (1951) "Les Monuments de Nūr al-Dīn: Inventaire, Notes Archéologiques et Bibliographiques." *BÉO* XIII, 5-43; 24.

93 Although it has been suggested that water mills were often used for more than just one purpose- such as paper and textile- it is unlikely that the same set of millstones would have served all purposes; more likely is the suggestion, as stated by Pascual above, that a mill would have housed several separate milling devices for different purposes, the only shared implement being the water-power they received, using one or more wheels to turn the millstones. A single-penstock mill with one set of millstones could theoretically have been used for several purposes, but the maintenance would have been very high, as cleaning, repair and alterations would have been costly as well as time consuming. For many single-chute mills in Jordan- and all the mills in the TAESP survey area in Cyprus- this means that they could only have been used for one purpose, and that was in all likelihood to grind either grain or sugar.

94 Delaborde, H. (1880) *Chartes de Terre Sainte : provenant de l'Abbaye de N.-D. de Josaphat.* E. Thorin: Paris.

peasants who had built the mills[95], and used the mills to further the economic potential of their institution.

For the Ottoman period there is also some information concerning the mill as a part of religious institutions; for Syria, this can be seen in the *waqf* of Selim II, discussed in Chapter Three, where the mills and *nawā'ir* were religious endowments left by the owner during his lifetime or upon his death.[96] This was also the case in Cyprus, where mills were *waqf* properties as part of monasteries, as seen in the 11th/17th century donation deeds of the Kanakaria Monastery, which also include grain mills.[97] Additionally, individuals frequently endowed property to support religious institutions; the *awqāf* of Selim and Cafer Pasha, set up in the 10th/16th century, shortly after the Ottoman conquest, provided income from mills and water distribution to maintain the Aya Sofya mosque in Nicosia.[98] Turner tells of his visit to the Kykkos Monastery, and the mill which the monks used there, and Barsky tells of a monastery near Paphos which gained income from two mills grinding corn there in the mid-18th century.[99]

All aspects of ownership had effects on the construction and continued existence of the mill; while seigniorial mills had the advantage of substantial financial backing, the shareholder's mill appears to have functioned equally efficiently as a collective of farmers, as was the case in medieval al-Andalus prior to the *repartimientos* of 13th century Spain. The greatest impact on society as a whole came, perhaps, from the monastic patronage of watermills; wheat being the prime form of payment for rents particularly in rural areas in the medieval period and early Ottoman periods, the expansion of cereal crops thus became inevitable, and with that the expansion and further development of mills and milling technology.

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95 Glick 1995, 121.
96 See Chapter Three, p.64-69.
97 Chapter Three, pp. 66-67.
98 Yıldız, N. (2005) "Wakfs in Ottoman Cyprus", in C. Imber *et al* (eds.) *Frontier of Ottoman Studies: State, Province and the West.* Vol. II. IB Tauris: London/New York, 179-196; 184-185.
99 Cobham 1909, 439; Barsky 1996, 59.

The relationship between the physical, the economic and the social landscape thus encouraged the survival of, to a greater or lesser extent, the local and regional Levantine economy; the advantage of exploitable natural resources, and technological expertise to further the economic market, became fundamental to the growth of society as a whole, across a local and regional scale. However, this growth also perpetrated a greater need for industrialisation to sustain population demands, which inevitably led to the innovation of new technologies, and the decline of less effective technological traditions, such as the water-driven grain and sugar mills.

With the political, economic and social transformations that accompanied these changing times, the decline and loss of technological traditions were, as suggested above, inevitable. As mentioned earlier, the debated "agricultural revolution"[100] sparked by the Islamic conquests in the early 1st/7th century introduced a large variety of new plants, and ancient irrigation systems underwent restoration and improvement during this period, providing the necessary basis for the "green revolution" that would continue for centuries to come.[101] This revolution thus, in many respects, went hand in hand with a change in attitude toward technological innovation, sparking the development of new techniques in irrigation and food processing, as Watson suggests.[102]

This has been a heavily debated issue; there has been a wealth of discussion over the past decades about the possibility of an "industrial revolution" in the Middle Ages as a result of the application of water power, with particular focus on Europe.[103] In his work, Lucas discusses this issue in some detail, focussing on the work of previous scholars.[104] He concludes that the theory of the industrial revolution being present in the middle ages is

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[100] Al-Hassan & Hill; Watson 1981.
[101] Watson, 1981
[102] Watson 1981, 46.
[103] Lucas 2006.
[104] For reading on the role of the watermill in a possible "industrial revolution of the middle ages", or IRMA, see White, L. (1964) *Medieval Technology and Social Change*. Oxford: OUP; Mumford, L. (1963) *Technics and Civlisation*. Harcourt Brace: Orlando; Bloch, M. (1967) *Land and Work in Medieval Europe*. Routledge & Kegan Paul: London; Langdon, J. (2004) *Mills in the Medieval Economy: England 1300-1450*. OUP: Oxford; Carus-Wilson, E.M. (1941) "An Industrial Revolution in the Thirteenth Century". *EHR* 11, 39-60; Bautier, A.-M. (1960) "Les plus anciennes mentions de moulins hydrauliques industriels et de moulins à vent." *Bulletin philologique et Historique* 2, 567-626; Holt, R. (1988) *The Mills of Medieval England*. Blackwell: Oxford.

"on shaky foundations", as there were several earlier societies in which the use of the watermill was already prevalent, such as those of China and in the Islamic societies of Spain and the Middle East.[105] Instead, he believes that

> "those regions of medieval Europe that were engaged in industrial milling appear to have been geographical pockets of technological innovation within a broader environment of technological incrementation." [106]

The main idea behind this, according to Lucas, is that these "centres of innovation" were linked to centres of trade and commerce with large populations, where resources were plentiful and industries had already been developed; in addition, they were strategically positioned geographically to supply local, regional and international markets, particularly taking advantage of the "zones of production" discussed earlier in this chapter.[107]

The findings in this study point to a similar pattern of technological progress for the Levant. Although regional variations in technology and architecture are subtle in the case studies provided here, it appears that sugar and grain mills were built according to these precepts. The locality of watermills is therefore important in this study, not only in a local sense, but also in a wider socio-economic sense. While the profitability of sugar in the commercial market is undeniably high and thus reflects its situation in the physical and economic environments, this is not immediately apparent with the grain mills. However, the location of grain mills studied in Jordan, for example, point to a similar pattern; grain mills were clustered around or near major towns in every case, such as Ḥisbān, al-Ṣalt, al-Karak and al-Shawbak. These major towns were also on major trade and pilgrimage routes, where the local grain mill was frequently not only supplying the immediate population, but also reached communities further away through its link with the trade network. As Lapidus pointed out earlier, these local centres of government were also major grain supply centres that frequently had mills attached to them. The Quseir shipping notes, discussed earlier, emphasise the importance of an efficient trade system,

[105] Lucas 2006, 230.
[106] Lucas 2006, 231.
[107] Lucas 2006, 231.

both for short and long distance shipments, and has shown that the import and export of flour was also a part of this system.

In addition to the availability of a well-structured trade network in the Levant, which clearly had its effects on the construction and development of milling technology there, population shifts and transfers certainly would also have had an impact on the medieval and early modern societies of the Levant. For example, the transfer of a dispossessed population as suggested by Maier for Shawbak during the reign of Baldwin I[108], may suggest, amongst other things, the transfer of scientific knowledge and technology, and help to indicate that ideas regarding water and sugar mills passed from further East in the Holy Land west to the island of Cyprus. Although it is easy to speculate on this matter, particularly as conquest and reclamation of lost land- not just in the middle medieval period but in earlier times as well- has considerably blurred the evolution and transmission of scientific knowledge, there are certain technological attributes which can be found in some regions, such as the vertical wheel in Syria, but are mainly absent in other areas of the Levant. Political and economic activity in and between both regions, particularly during the 12th-13th centuries, was such that it almost certainly provided government and society with technological ideas and inventions through contact and interaction with each other.[109]

This has certainly been a possibility for Europe, where horizontal wheeled mills were in operation as early as the 7th century AD. With particular reference to an example from Ireland, Lucas further attributes this phenomenon to cultural links between Ireland and the Mediterranean world, suggested through " finds in Ireland of certain types of exotic Mediterranean pottery from the late Roman period and early middle ages, as well as the establishment of Egyptian monasticism in Ireland via direct contacts with Gallic monasteries from the Loire valley as early as the sixth century."[110] The case for technological diffusion through cultural exchange is therefore very strong, although the existence of both vertical and horizontal wheeled mills suggests that there was perhaps

[108] See Chapter Seven of this work, p.245.
[109] Abu Lughod 1989; Lucas 2006; Glick 1995.
[110] Lucas 2006, 40.

not a strong evolution from horizontal to vertical wheel as often thought, or even vice versa.

Pringle indicates that the presence of a vertical wheel, such as may have been the case at Kurdāna, points to the introduction of a Frankish technology from Europe into the Holy Land. By this, Pringle suggests that the introduction of the vertical wheel- which replaced the horizontal wheel in the West in the early 14th century- took place after this time; this could mean that the horizontal mills found in Jordan and Cyprus, for example, date to a time before the 14th century. This idea is also supported by the presence of the series of vertical wheeled mills in the Wādi Zerqa in Jordan, which have been dated to the late Ottoman period.[111]

Technological diffusion and innovation had clear links with initiatives by society to improve the economy. Lucas has debated the issue of mills in Europe having "politics"[112], and at least with regards to the sugar mills, this certainly seems to have been the case in the Levant, and does not rule out the possibility of technological competition furthering the economy through technological change and diffusion. This technological innovation may also have been fuelled by religious factors, and in considering the question of the *religion* of the mill, Glick perhaps indirectly proposes further ideas regarding the diffusion of mill technology. With regards to this issue, Glick has called attention to some interesting points regarding watermills in Christian and Muslim societies in medieval Spain:

"The relationship between mills and irrigation, as noted in the case of the huerta of Valencia, is obvious. Nevertheless, the spatial relations between the two functions were different in Muslim and Christian societies. In rural al-Andalus horizontal grist-mills were sited at the ends of water systems or outside them completely (as when mounted directly on a stream). Mills so located do not require monitoring by irrigators. In feudal Catalonia the priorities were inverted because gristmills were a seigniorial monopoly. There the mills were preferentially located at the heads of systems, near to the water source. Once used for milling, the water was distributed through the *subtus rego*- mill race- to irrigated fields below."[113]

[111] McQuitty 2004.
[112] Lucas 2006, 326-334.
[113] Glick 2005, 276 n.59.

It is interesting to note that the case was similar in Jordan, where mills were constructed along the lines of a canal (as far as can be discerned from the remaining channels), usually close to the river bed, with the water exiting the mill to return to the river, or irrigate the surrounding lands. However, that does not necessarily imply a "Muslim" technology; both al-Andalus and the *bilād al-shām* have water systems dating as far back as the Roman period (Jordan even earlier), and may indicate that climate was the main factor behind the construction of this type of mill, rather than any cultural factors. Rather than being influenced purely by religion, perhaps the combination of climate and the implementation of separate laws regarding milling and irrigation, as were present in medieval Spain, were the prime factors in siting the mills in Muslim and Christian communities. It may also indicate that rules regarding the siting of the mill prompted the development of a new technology, such as the vertical wheel.

The case for technological diffusion becomes even more confusing when looking further east. Harverson's work on the mills in Iran, discussed briefly in Chapter Six, alludes to the existence of both vertical and horizontal mills in Fars already in the time of al-Muqaddasī, in the 4th/10th century:

"By a mighty dam the water was raised into a lake. On both sides of the lake he set up draw-wheels driven by the water; there were ten of these; under each was a mill. He thus irrigated 800 villages by the aid of pipes."[114]

The presence of both technologies contemporaneously could suggest that different technological innovations occurred simultaneously, rather than one type of technology leading to the development and introduction of another technology. This could also be substantiated when one takes into consideration the role of the landscape and the development of milling technology, as discussed earlier. Mitterauer, when discussing the idea of three agrarian revolutions occurring simultaneously in the West, the Islamic world and China in the medieval period, has, in contradiction, suggested that there was no impact on the development of the water-driven grain mill as a result of these revolutions, with the exception of the sugar mill, which was a direct result of the extensive cultivation

[114] Beazley & Harverson 1982, 83; the "draw-wheel" is a *nā'ūra*, demonstrating the use of *nā'ūra*-mill complexes already in the 10th century Islamic world.

of sugar brought from the East.[115] Considering the plethora of theories and ideas regarding technological diffusion between East and West, the diplomatic proposal would seem to be that both horizontal and vertical water-driven grain mills developed alongside each other, along with the *nā'ūra*, and whether an agricultural "revolution" took place or not, the discovery of sugar cane as a valuable commodity undoubtedly prompted the technological adaptation of the grain mill to process sugar subsequently.

Conclusion

History, landscape, architecture and archaeology- these have been the main points of focus in this study on watermills in the Levant, and this study has revealed that the watermill had its place in all these worldly aspects to a greater or lesser extent. The undeniable link between watermills, archaeology, settlement and landscape has shown the rural and urban Levant as a productive and technologically enterprising area that formed the basis of a fluctuating, yet continuously prolific, economy. While I am aware that the study is a broad one- encompassing not only a wide time span, but an equally wide range of disciplines- I hope, at least, that a glimpse of the "life" of the watermill from the medieval to the Ottoman period has been conveyed to the reader.

Although much of this work was based on previous studies conducted in the field of watermill research within the Levant, the work undertaken here aimed to steer away from localised studies to provide a picture of the watermill in the wider Levantine region. That by no means suggests that the results of this study include every building in every region, but rather that as great a representative sample from each area was chosen to provide the necessary basis for the resulting study and interpretation. This has previously not been achieved, and while that is not to suggest that previous studies are less important- in fact, much of the work conducted here could not have been achieved without these studies- the point here was to provide a regional, rather than a local, picture; while for example previously, one could perhaps provide a detailed record of a certain mill, or the status of mills, in the Ottoman period, this study has enabled us to understand the role of the mill

[115] Mitterauer, M. (2001) "Roggen, Reis und Zuckerrohr. Drei Agrarrevolutionen des Mittelalters in Vergleich." *Saeculum* 52/II: 245-265, 256.

in general, as well as that of specific mills, not only from the Ottoman period, but also from pervious times, and within various aspects of society and economy. This has been provided across no less than three different countries that share cultural as well as historical ties.

Linked to these studies have also been brief comparisons to the architectural features of watermills from further surrounding countries touched by Islam at some point over the last 1300 years, which have provided an even wider area of focus on the study of molinology in the Mediterranean and Middle East. The continuity of the watermill's importance from as far back as the 10^{th} century AD until recent times has thus been demonstrated through this multi-disciplinary and multi-regional approach, and it is now possible to better understand the role, and impact, a relatively simple agricultural implement has had in the Islamic world, and how its role there may have differed, or compared, to watermills in the West. In addition to this wealth of information, a record of watermills, including details of their state of preservation as well as their location, now exists for future reference, in case these buildings disappear over time due to urban encroachment and agricultural expansion.

The broad nature of this study has, a result, no doubt left many questions unanswered; however, one of the main purposes of this study was that of documenting a rapidly disappearing historical feature of the rural Levantine countryside, and having accomplished this for a number of areas in the Levant, either as a part of a project (as with Cyprus) or with the help of friends and work colleagues- is an achievement in itself. The resulting interpretation of the watermill in the historical, environmental, archaeological and social contexts is therefore inevitably broad in focus; however, if one individual is able to achieve a solid multi-disciplinary basis for a study single-handedly, it is hoped that this may provide an encouragement for other individuals or groups to undertake future studies, which may have a narrower regional or disciplinary focus, and may thus provide more detailed studies regarding the specific case studies of watermills presented in this work, as well as new ones, and their roles in the social, historical and environmental landscapes of the Levant.

Appendix: Abbreviations for Building Materials and Study Areas

The following abbreviations for **building materials** will be used:

- Limestone: LMS
- Basalt : BAS
- Rubble masonry (rubble & mortar): RM

The abbreviations for **study areas in Jordan** are as follows:

- Wādi Kufranja: KFR
- Wādi Rayyān: RAY
- Wādi Rājib: RJB
- Wādi Ḥisbān: ḤSB
- Wādi Wāla: WĀL
- Wādi Haydān WH
- Wādi Ibn Ḥammād: ḤAM
- Wādi Shawbak: SBK
- Sayl al-Karak: SK
- Wādi Shu'ayb: SHU
- Wādi al-Sīr: SĪR

The abbreviations for **study areas in Syria** are as follows:

- Damascus: DAM
- Aleppo: ALO
- Misyāf: MIS

Glossary of Mill Terms

Arḫiya	literally, something that turns. Usually used for rotary hand quern, but is also referred to mills turned by water or driven by animals.
Axonas	Greek-Cypriot term for the axle attached to the mill wheel and mill stones.
Bed stone	lower grinding stone; see also *katolitharon.*
Bi'r	see *chute*.
Boiling hall	large room adjacent to the mill room(s) of a sugar-mill, where the sugar product was boiled in numerous vats to avoid fermentation. The products were boiled in large copper cauldrons above circular openings over the stoking room.
Chute or shute	the deep opening in the penstock, attached to the leat, through which the water flows into the mill chamber through the outflow at the bottom of the shute.
Dawlab	Water wheel; see also *nā'ūra.*
Drop-tower	see penstock, also *arūbah* penstock. 4-10m high stone tower containing a circular "well" at the end of the mill race.
Edge runner stone	vertical millstone found in sugar mills, placed at the edge of horizontal millstone, and attached with necessary gearing to the water wheel. It crushes the sugar cane by moving along the edge of the bed stone, which is where it gets its name.

Floating mill	also boat mills.
Gearing	mechanism that operates the mill-wheel and mill stone; usually made up of the lightening rod and the vertical shaft.
Hopper	funnel-shaped device through which grain is fed to the millstones, probably suspended from the ceiling of the mill house; see also *kofinia.*
Iron spindle	vertical shaft attaching the lower mill stone to the upper stone in the vertically wheeled mill. This controlled the distance between the upper and lower stones depending on the desired grinding quality.
Katolitharon	Greek-Cypriot term for bed stone.
Kofinia	Greek-Cypriot term for grain hopper.
Leat	water channel running into the penstock along the top. See also *mill-race.*
Lightening rod	this is a long pole attached to the center of the mill wheel, and reaches through a small fitted circular opening in the ceiling of the wheel chamber, to attach to the mill-stones. The miller can use this rod to control the movement of the wheel.
Maʿāsir	A press, usually used as a term for a sugar or olive mill.
Madār	A mill, usually animal drawn
Massecuit	purified mixture of crystals and syrup in the sugar-milling process

Methāne	see *mill house.*
Mill race	see leat
Mill-room	room located above the wheel house, adjacent to the penstock. This is where the grain was processed, and housed the mill-stones and the hopper.
Mill-stone	grinding stones, for grinding the grain or other crop (except for sugar). Usually large, heavy circular stones, one on top of the other; the distance between them can be adjusted by the lightening rod. The lower stone would probably have had a rough surface against which the smooth upper stone would have turned to grind the product.
Mill-wheel	wheel that turns the mill-stones, located in the wheel room. The wheel was usually made of wood, with slanted paddle-shaped panels against which the water coming from the outflow would hit, causing the wheel to turn in a propeller- like manner.
Mindar	see *wheel room.*
Misrāf	see outflow.
Nā'ūra	vertical waterwheel, driven by the flow of the river (undershot wheel). See also *dawlab.*
Outflow	located at the bottom of the penstock or drop-tower; usually a small circular opening through which the water flows into the wheel chamber.

Penstock	tower-like structure part of a water mill, housing a deep opening through which the water flows into the wheel room of the mill.
Pivot stone	square masoned block of stone on which the vertical shaft of the mill wheel rested below the wheel.
Poupanalitharon	Greek-Cypriot term for upper mill stone.
Qadāḥ	See Hopper.
Qanawāt al-Ṭāḥūne	channel for conducting water, commonly found running alongside or in the vicinity of a mill. The term is used to refer to any open channelling device for water, whether near a mill or as a part of an older water system, such as that of Aleppo or Damascus.
Raḥā	Vertical or horizontal water mill.
Runner stone	upper grinding stone; see also *poupanalitharon.*
Sāqiyah	term with several meanings; it can refer to an animal powered mill, or an animal driven water-lifting device; sometimes also interchangeable with *nā'ūra.*
Shadūf	a water raising device particular to Egypt.
Ṣidd	dam
Lūḥ	adjustable opening on the mill-race to control the flow of water into the penstock.

Stoking room	subterranean chamber containing furnaces which provided heat for the boiling room, located below the boiling hall.
Ṭāḥūna	Any kind of mill.
Vanes	oblique panels that make up the mill wheel against which the water bounces as it enters the wheel chamber, causing the wheel to turn and beginning the grinding mechanism above.
Vertical mill	this is the most common type of mill in the western world. There are 3 different types of vertical mills: undershot, where the mill wheel is turned by the a water power from underneath; overshot, where the mill wheel is turned by a source coming from above, such as an aqueduct; and breastshot, where the mill wheel is turned by water that hits it from a source mid-way.
Weir	a small dam-like structure used to raise water level of the stream or river on which mill is located, to allow sufficient water to run into the mill race to keep the mill-wheel moving at optimum speed.
Wheel shaft	horizontal axle of the water-wheel; see also *axonas*.
Wheel-room	room adjacent to the lower part of the penstock, which houses the wheel that turns the mill stones.

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