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TRADITIONAL DAM CONSTRUCTION IN MODERN IRAQ: A POSSIBLE ANALOGY FOR ANCIENT MESOPOTAMIAN IRRIGATION PRACTICES

by STEPHANIE ROST and ABDULAMIR HAMDANI
with illustrations by STEVEN GEORGE

Lack of archaeological and comparative ethnographic data has limited our ability to interpret textual information that refers to ancient Mesopotamian irrigation works. This paper presents ethnographic data from modern Iraq regarding the construction, use and maintenance of a traditional irrigation system. Because traditional construction methods make use of organic materials similar to those available in the past, the data presented in this paper are considered to provide a set of analogies that can assist the interpretation of textual evidence and hence lead to a better understanding of irrigation practices in ancient Mesopotamia.¹

I. Introduction

The organization of irrigation has often been presented as central to the understanding of early complex societies in Mesopotamia (Adams, Downing and Gibson 1974; Steward 1955; Sanders and Marion 1970: 104–6). Urbanism, full-time labour specialization, state institutions and the status hierarchy associated with early complex societies depended not only on the production of agricultural surpluses but also, more importantly, on the exclusive control of these resources by a centralized group (Butzer 1976: 110–11; Childe 1974: 8–9; Hunt 1987a: 161–63; Millon 1954: 178; Trigger 1993: 28). The demands for surplus production were satisfied through agricultural intensification, which was frequently based on large- and small-scale irrigation (Adams 1966: 12; Jacobsen and Adams 1958: 1251–58, Butzer 1976; Lowdermilk and Wickes 1942: 209; Doolittle 1990; Millon 1954: 177; Park 1983: 155–56; Dales 1965). In southern Mesopotamia the history of irrigation embraces a period of nearly six thousand years. The region has been characterized by a semi-arid climate since the fourth millennium BC and annual precipitation rates amount to less than one hundred millimetres. Thus, without irrigation, agriculture is not possible. Throughout this period, irrigation both provided subsistence for small communities and later became the economic basis of states and empires (Pollock 1999: 32; Pournelle 2003: 96; Verhoeven 1998: 171–73; Wilkinson 2003: 76–79).

Our understanding of ancient irrigation in Mesopotamian is based mainly on two sources: archaeological settlement-survey data from the 1970s and 1980s (Adams 1965, 1974, 1981; Adams and Nissen 1972; Gibson 1972; Jacobsen 1960, 1969; Wright 1981), including the more recent remote-sensing data (Gasche and Tanret 1998; Ur 2005), and administrative documents from different historical periods. The comprehensive settlement surveys of the 1970s provided a description of the main lines of development of irrigation agriculture in Mesopotamia. However, until now, only the location of some primary canals has been detected archaeologically, and these identifications have been made with varying degrees of confidence (Adams 1981; Adams and Nissen 1972; Jacobsen 1960, 1969; see also Gasche and Tanret 1998). In addition, detailed information on the size, layout and construction design of ancient irrigation systems, which would enhance our understanding of how ancient irrigation was practised and organized, is still lacking. Furthermore, with a few exceptions, there is hardly any archaeological evidence for water-control facilities (see regulator(?) of Girsu; Huh 2005: 181–89; Jacobsen 1969: 103–9; Parrot 1948: 216; Pemberton *et al.* 1988: 220).

¹ Acknowledgements: The article in its current form would have not been possible without the great support and substantial editorial help of Jennifer Henecke and Dr D. J. Bernstein. We are also very grateful for valuable input and stimulating suggestions on numerous drafts by Dr R. C.

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As a result of these shortcomings, there has been an over-reliance on the administrative documents for the understanding Mesopotamian irrigation. There are numerous records that document the assignment, execution and remuneration of maintenance and construction within the irrigation system, as well as expenditures of necessary construction materials. Scholars have been concerned with the interpretation and translation of Sumerian and Akkadian terms referring to irrigation practices and irrigation works (see e.g. *Bulletin on Sumerian Agriculture* 4 [1988] and 5 [1990]). However, the lack of archaeological counterparts impacts on our ability to understand and interpret texts that refer to irrigation topics,² and has led to a degree of confusion surrounding the translation of ancient irrigation terminology. In turn, the content of these texts often remains unclear to the point where it is difficult to determine to which specific irrigation-related tasks they refer.

One way of dealing with these difficulties is to make use of ethnographic data as a source of analogies³ for the interpretation of ancient texts. By looking at traditional means of irrigation one has the possibility of understanding what are the tasks involved and how they can be administered. This can serve as a framework within which one can place the written documentation and, equally important, identify areas not reflected in texts that describe the activities of the state.

With a few exceptions (see Fernea 1970; Poyck 1962), there are very few ethnographic data on traditional irrigation (prior to mechanization) in Iraq. Traditional or local knowledge of methods of constructing, maintaining and operating irrigation systems is rapidly disappearing. In recent years, concrete and metal structures have replaced hydraulic devices that were formerly made of less durable organic materials. Thus, any ethnographic documentation of traditional irrigation practices must be done now before traditional knowledge is lost.

The use of ethnographic data as a source of analogies to assist the interpretation of archaeological and textual data is an indispensable tool in investigating the incomplete record of the past. However, which analogies are considered appropriate, relevant and strong, and how they should be employed in the interpretative process, have been the subject of debate (Asher 1961; Binford 1967, 1968, 1977; Freeman 1968; Gould and Watson 1982; Hodder 1982, 1987; Stiles 1977; Wobst 1978). We recognize that the validity of ethno-archaeological comparisons depends on the strength of the links between past and present, and therefore our ethnographic sample was selected for its similarity to ancient environmental conditions, as well as for the availability of similar building materials.

Our study is limited to traditional dam construction prior to the widespread use of mechanized devices and concrete. Dams of different sizes and design are placed at various key points in a traditional Iraqi irrigation system in order to control the amount of water and the water flow within the canals and into different parts of the system. Ancient records make numerous references to the construction and maintenance of dams whose specific function, however, is often difficult to determine (see Civil 1994). Thus, focusing on traditional dam construction might provide the necessary insight needed to understand a major component of the functioning of ancient Mesopotamian irrigation systems. We do not discuss the construction and maintenance of entire irrigation systems, including canals, levees, dikes etc., nor do we discuss all major tasks that are related to the successful operation of every irrigation system. These tasks include distribution of water, resolution of disputes and in some instances accounting (see Hunt 1988a, 1988b). We plan to address these aspects of irrigation in future publications.

II. *Biographical background of informant Abdulamir Hamdani*

Our ethnographic data on modern traditional irrigation are based on the memory of the article's co-author Abdulamir Hamdani. Mr Hamdani grew up in the village of Al-Midaq (also known by the tribal name Abu-Hamdani), and thus had first-hand experience with irrigation-related work. The village of Al-Midaq is located close to the southern bank of the Euphrates river, at the edge of the northern part of the Al-Hammar marsh in southern Iraq (see Fig. 1).

² For details, see Rost (2006, 2011).

³ The term analogy, according to Renfrew and Bahn (2000: 182) is "the belief that where certain processes or materials resemble each other in some respects, they may resemble each other in others ways also. Thus it may be possible to use details from one body of information to fill gaps in another

body of information from which those details are missing." The *Webster's Dictionary* (cited in Binford 1967: 1) puts the emphasis on the similarities and essential resemblance in relation between two situations, contexts or objects in order to distinguish between an "argument from example and that from analogy".

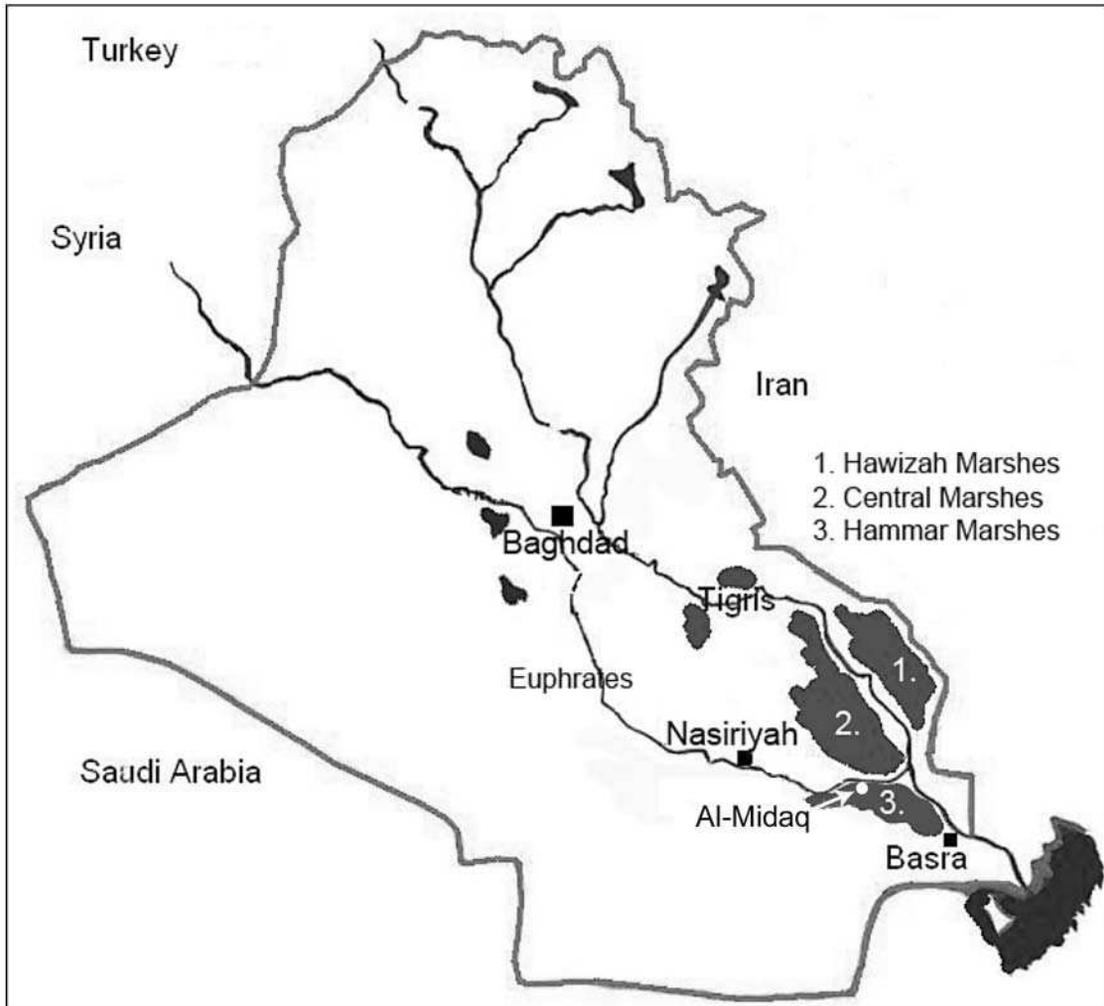


Fig. 1 Map of Iraq showing the location of Al-Midaq village, drawn by Abdulamir Hamdani, 2010.

The village is oval-shaped (800 m long by 150 m wide) and housed approximately eighty families, all members of the Albu-Hamdani tribe. During the winter (December–March) most of the lowlands (*al-tar* or *al-ghamerah*, land which is seasonally flooded) surrounding Al-Midaq village were transformed into a seasonal marsh, while areas of relatively higher ground (*al-hemada*, land that remains dry even at times of flooding) were used to cultivate winter crops (barley and wheat). In late spring (April) the waters retreat until autumn (November), which allows the cultivation of summer crops (rice, corn and summer vegetables) in the lowlands. Winter crops are irrigated, whereas the summer rice crop is grown in standing water on the edge of the marshes and requires no irrigation (see also Wirth 1962: 145). The agricultural land owned by the inhabitants of Al-Midaq equals approximately 1214 ha (3000 *dunums*, دونم) and is located in an area surrounding the village itself. Irrigation in the village remained non-mechanized until 1977, when cousins of Mr Hamdani introduced a water pump. This device became more and more of a necessity as the water levels of the Euphrates began to decrease, following the construction of large dams in Syria, which limited the amount of water reaching this part of the river.

Irrigation work in the village consisted of participating in digging and redigging canals, clearing overgrowth (reed and papyrus) from canal banks in order to ensure unhindered water flow, constructing and maintaining dams of all sizes, making irrigation furrows, and removing dirt clods from the canals. Mr Hamdani's family were farmers, and he also participated in irrigation-related

tasks. The workload and tasks were suited to his age. At twelve, his job consisted mainly in bringing food and supplies to the work parties; by the age of fourteen to fifteen, he began to participate fully in the construction or reconstruction of dams and canals. In the year 1980 (when Mr Hamdani was fifteen), the entire village had to relocate to a small town, Al-Fuhud, which extended from the north edge of the Hammar marsh up to the city of Nasiriyah. The displacement was a result of the Iraq-Iran war (1980–1988). At this point, Mr Hamdani's participation in irrigation-related tasks increased considerably, because all males between the ages of eighteen and forty-five had been drafted into the army. He not only worked for his own father but also for a number of other families from his birth village, as part of a voluntary and reciprocal labour exchange (*‘uona*, عوانة, see V.1.4.2).

In 1983, at the age of eighteen, Mr Hamdani left for Baghdad, where he started his studies in ancient archaeology at Baghdad University (College of Arts). Although he no longer participated in work related to irrigation, he did however still observe ongoing work on the irrigation systems. In addition, Mr Hamdani has paid close attention in the course of his archaeological work (mainly consisting of surveys) to traditional irrigation-agriculture practices and other aspects of contemporary southern Iraqi culture.

III. *Background: irrigation systems*

Before we turn to the specific case of south Iraq, we will discuss the basic components of open-surface canal-irrigation systems in order to familiarize the reader with the relevant technical terminology.⁴ Open-surface canal-irrigation systems are a common means of irrigating fields along rivers and examples are found in regions as far apart as north and south America and China. Despite the topographic and climatic differences of the areas in which they can be found, they are similar in form and function. All open-surface canal-irrigation systems include a facility, such as a head-gate, that guides water away from its natural course toward subsequent water-control facilities (i.e. canals, inlets, distributors, regulators and outlets) that further direct the waters into the fields (Hunt 1988a: 339–40). The size, construction design and technical elaboration of all water-control facilities depend on the availability of construction materials, the local topography, the nature of the original water source and the size of the respective irrigation system.

In a canal-irrigation system, water is distributed beyond the head-gate by a number of canals of differing size (Fig. 2). The system consists of one primary canal and a number of secondary, tertiary and field canals. Their width and length vary according to the size of the command area, the water demands of the cultivated crops and the form of irrigation practised (i.e. basin irrigation, furrow irrigation, border-strip irrigation, see below) (Acht nich 1980: 270–73; Sagardoy 1982: 82–85; Wilkinson 2003: 49–51). The regulation of water flow within the canals and into different parts of the irrigation system is controlled by a number of hydraulic devices. These water-control devices are located both at the intersection of canals of different orders (i.e. primary to secondary canal) and within canals. The most common hydraulic structures are outlets, inlets, distributors and regulators (Acht nich 1980: 276–79; Kraatz and Mahajan 1975: 2; Walker 1989: 14–16).⁵

Inlets are found at the head of canals — both large and small — and can be equipped with flexible gates in order to control the amount of water flowing into different subsections of the irrigation system (see Fig. 2; Acht nich 1980: 279; Kraatz and Mahajan 1975: 33–35; Walker 1989: 16). Outlets discharge water directly from the field canals into the irrigated areas, and they are usually also equipped with gates that regulate the amount of water entering the fields (Kraatz and Mahajan 1975: 235–37).

⁴ We follow the definition of irrigation systems given by Hunt 1988a: 339–40: “A canal irrigation system is composed of (1) a facility (gate, offtake) which takes water from a natural channel and moves it away from its natural downhill course and (2) the subsequent control works (canal, gates, fields) that guide the water flowing on the surface to the agricultural plants until that water either soaks into the earth or flows on the surface out of the control works.” Hunt (1988a: 351 n. 3) further points out one problematic aspect about his definition: the fact that irrigation

systems can have multiple head-gates.

⁵ Inlets, outlets and regulators are frequently referred to as sluices and weirs in the irrigation literature. However, the term “weir” is often employed for both barrages and regulators, so in this article we prefer “regulator” in order to avoid ambiguity. The term “sluice” frequently denotes a structure which allows the transportation of ships over cataracts, so here, for the sake of clarity, the terms “inlet” and “outlet” are used instead.

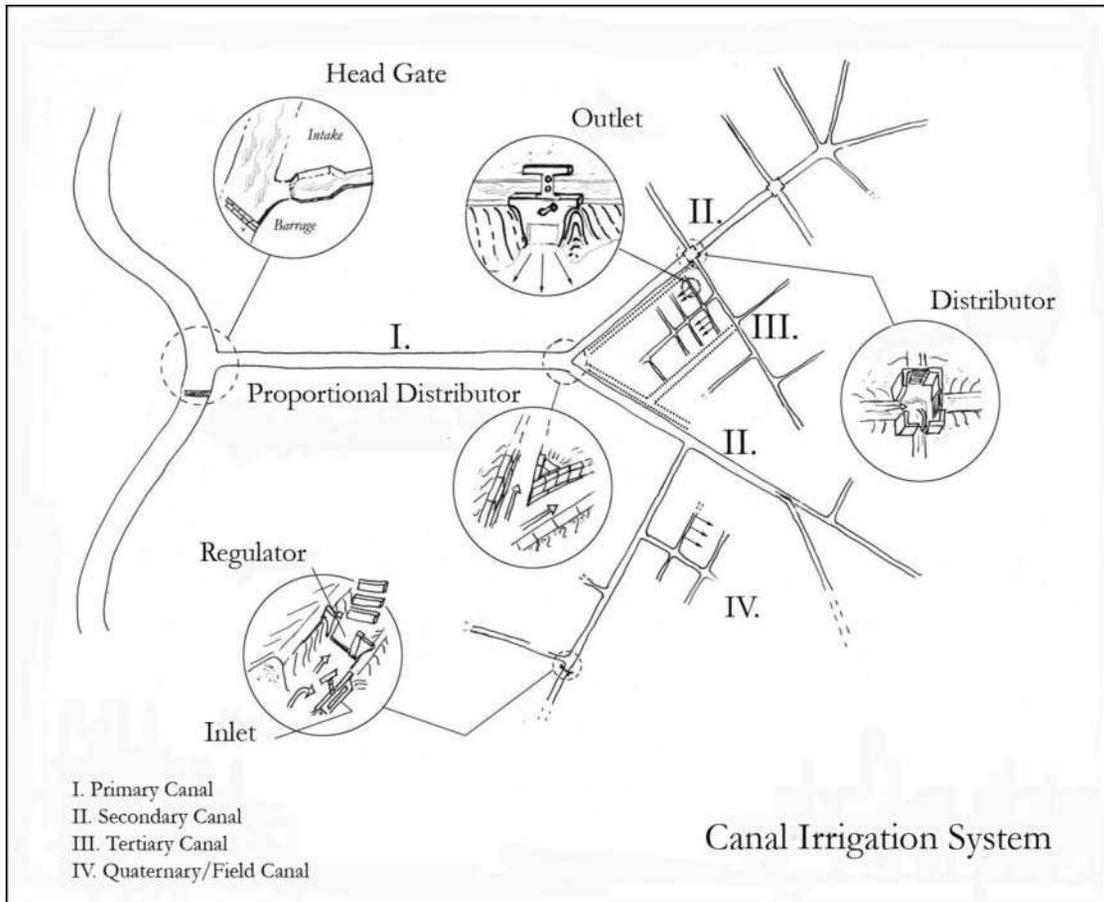


Fig. 2 Schematic map of a canal-irrigation system, drawn by Stephanie Rost, 2006.

Distributors are responsible for distributing water conveyed by a canal into two or more lower-order canals (Fig. 2). Distributors that divide water proportionally are usually not equipped with gates, but those that allow for the systematic conveyance of water into different parts of the irrigation system are equipped with gates (Achnich 1980: 278–79; Kraatz and Mahajan 1975: 2–3, 183 ff.; Walker 1989: 15).

Regulators are important for the control of water flow within an irrigation system, as well as for the maintenance of the water level within a particular canal. Regulators are constructed across a canal and can temporarily block water flow. Damming up water is necessary when the water level in the canal is low and water needs to be directed into a particular canal with a higher inlet and/or when a certain amount of water needs to be deflected during a certain period of time. Therefore, regulators are usually placed slightly downstream from canal inlets (see Fig. 2), and there are usually as many regulators as there are canals. A regulator is also used to drain a canal for major maintenance work (Achnich 1980: 278–79; Kraatz and Mahajan 1975: 3; Walker 1989: 15–16).

The shape of agricultural fields varies depending on the irrigation method practised. In basin irrigation, the entire field is flooded, and thus fields are usually square and enclosed by low dikes to hold in the water (Achnich 1980: 302; 314–20; Charles 1988: 17; Walker 1989: 9–10). Border-strip irrigation calls for long, narrow field strips (ideal width of 10–20 m and length of 400 m) that are also enclosed by low dikes. A gradient of 0.2–4.0 per cent is needed so that the water can pass from one end of the field to the other (Achnich 1980: 322–28). In furrow irrigation, the field shape is variable but generally consists of a number of parallel running furrows. The usual distance between two furrows is 75–150 cm. Crops are cultivated on the furrow ridge, while the field is watered along the parallel running furrows (Achnich 1980: 332–46; Walker 1989: 10–11).

Every irrigation system has a built-in mechanism for draining excess water to prevent the water-table from rising. The uncontrolled rise of the water-table can result in waterlogging of the soil, which will kill dry-foot crops (Hunt 1987: 1–2). If the water-table rises to one or two metres below the surface it may also cause salinization of the soil. Particularly in semi-arid climate zones, the evaporation of irrigation water on the surface can cause a capillary effect by which saline minerals are transported through the root zone and on to the surface. The water-table can be controlled either by means of drainage canals or through a fallow system that leads to a natural decline in water levels (Achtlich 1980: 199, 202–3; Fernea 1970: 38; Hunt 1987: 1–2; Nützel 2004: 26–27; Tanji and Kielen 2002: 3–4).

Flood control is particularly important when a regularly flooding water source is utilized. In Iraq, where the annual flood of the Euphrates and Tigris occurs right before the harvest (see below), flood control is necessary for protecting fields and the ripening crops. Flood control can be accomplished in various ways, such as by building dikes along the river to contain the rising water levels or by installing devices that deflect or release excess water. In some cases, head-gates are equipped with a special canal or an opening that releases and diverts excess water if necessary (Brunner 2000: 8; Vischer und Huber 1985: 62). Another way to control excess flood water is to cause an artificial breach in the river levee at a location where diverted water cannot cause harm to the irrigation system or the agricultural fields (Hunt 1988b: 192–93). In this article, we only discuss flood-damage interventions.

IV. *Traditional irrigation in Iraq: environmental background*

Southern Iraq is located on an alluvial plain in a semi-arid zone with an annual precipitation rate of less than one hundred millimetres (see Table 1). The Euphrates and Tigris rivers are the major water sources in the region, especially for irrigation. The topography of Iraq's alluvial plain, while appearing flat, actually consists of a diverse landscape of high ground and low depressions. The deposition of sediments during the annual flooding of the Euphrates and Tigris has led to the formation of massive levee systems, elevated two to four metres above the floodplain. These levee systems create arable ground and provide a well-suited relief for irrigation. The back slopes of these levee systems ensure adequate flow velocity within canals located on them and on to agricultural fields (Pollock 1999: 32; Pournelle 2003: 96; Verhoeven 1998: 171–73; Wilkinson 2003: 76–79).

The water regimes of the Tigris and Euphrates rivers are characterized by strong and often unpredictable fluctuations that do not coincide with the water demands of winter crops (barley and wheat). During the sowing of winter grain in September/November, the water level is low and the availability of water five times less than during the flood season in April and May (see Table 2; Fernea 1970: 158; Ionides 1937; Postgate 1992: 181–83; Pournelle 2003: Table 6; Verhoeven 1998: 199, 201–3). It should be noted that the Tigris floods approximately one month earlier than the Euphrates because it is considerably shorter. However, the flood of the Euphrates is generally more severe because of its

TABLE 1: Monthly precipitation rates (in millimetres), Nasiriyah 1950–1958; source: Minister of Development, Development Board and Ministry of Development, Baghdad Iraq 1959, http://docs.lib.noaa.gov/rescue/data_rescue_iraq.html, accessed April 2010.
Legend: T = trace of rain; 0.0 = no rain; — no measurement.

Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1950	0.0	T	53.9	32.6	10.3	4.2	11.1	5.1	6.0	0.0	0.0	0.0
1951	0.2	T	5.1	25.1	32.9	13.5	17.3	2.3	0.0	T	0.0	0.0
1952	0.0	0.0	69.8	49.4	11.4	12.2	3.7	17.2	T	0.0	0.0	0.0
1953	0.0	10.8	32.4	21.2	12.6	19.4	30.6	51.7	—	0.0	0.0	0.0
1954	0.0	8.5	54.7	55.5	2.4	23.6	27.3	05.0	0.7	0.0	T	0.0
1955	0.0	T	12.3	23.0	14.6	0.4	12.7	7.9	7.5	0.0	0.0	0.0
1956	T	T	T	35.7	2.4	28.1	10.1	4.4	0.0	0.0	0.0	0.0
1957	0.0	0.9	35.1	5.3	19.1	48.5	23.7	59.0	13.8	T	0.0	0.0
1958	0.0	T	6.4	28.2	39.0	T	T	0.2	0.7	0.0	0.0	0.0

TABLE 2: Euphrates mean monthly discharge (CUMECs), 1931–66; source: Ubell 1971.

<i>Euphrates</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>
<i>minimum</i>	100	190	240	260	280	310	460	500	1200	490	200	80
<i>average</i>	295	420	670	390	1340	1205	1630	2650	3350	1695	600	310
<i>maximum</i>	490	650	1100	1600	2400	2100	2800	4800	5500	2900	1000	540

greater water volume (Ionides 1937: 247–59). The flood peaks just prior to harvest in April/May (see Table 2) and, consequently, flood control is crucial for the cultivation of winter crops. As we show below, the timing of the flood requires close monitoring of, and potentially immediate intervention with, both the rivers' water levels and the adjacent dikes.

Because of Iraq's environmental and climatic conditions, its agricultural production was, and still is, heavily focused on the cultivation of the winter crops, barley and wheat. Summer crops, such as rice, corn, cotton, sesame, millet and pulses (lentils, beans, peas etc.), have always played a minor role in Iraqi agricultural production.⁶ Water availability declines after the flood waters recede, at the same time as the water needs of summer crops drastically increase. Evaporation rates double during the hot summers (forty per cent in summer versus twenty in winter; see Table 3). In July and August, the *daily* evaporation rate amounts to ten millimetres in comparison with an average *monthly* evaporation rate of 45–160 mm between November and April (Charles 1988: 4–5). Thus, the cultivation of summer crops in Iraq was, until recently, exclusively small-scale and orientated toward household production.

Barley and wheat must be planted by mid-November or the crop will not have enough time to germinate before the first frost (first week of January).⁷ The initial irrigation of winter crops takes place one week after they have been planted (mid-November to early December), and they are irrigated again in the first week of January. The crops are irrigated for a third time before 21 March. The timing of this event depends greatly on the amount of precipitation during that particular year. Precipitation is distributed unevenly over a period from October to the beginning of June and peaks from February until May. The crops are irrigated for a final time in early April. If this takes place after 10 April, the soil and crops will not have enough time to dry out before harvest occurs at the end of April to mid-May.

The summer rice crop is sown in late May and harvested in November. Fruits and vegetables are grown in orchards close to settlements, next to a river or canal. Since vegetables can require up to

TABLE 3: Monthly temperatures in degrees Fahrenheit, Nasiriyah 1940–1952; source: Government of Iraq, Ministry of Communication and Works, Meteorological Department, Climatological Means of Iraq, Publication No. 10 (Baghdad: Government Press, 1954) http://docs.lib.noaa.gov/rescue/data_rescue_iraq.html, accessed April 2010.

<i>Temperature</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>
<i>3 G.M.T.</i>	73.2	64.2	55.6	47.8	44.5	47.2	53.6	63.1	74.5	78.7	79.6	78.0
<i>6 G.M.T.</i>	88.8	79.2	65.0	53.1	48.8	53.4	62.5	74.4	86.1	89.7	92.0	93.3
<i>12 G.M.T.</i>	105.3	94.5	79.1	65.4	62	67.0	74.1	85.7	95.4	101.2	105.8	109.1
<i>mean</i>	88.8	79.3	66.6	55.4	51.8	55.9	63.4	74.4	85.3	89.9	92.5	93.5
<i>mean max.</i>	106.7	96.1	80.2	66.3	63.0	68.1	74.5	87.0	98.6	103.1	111.2	111.3
<i>mean min.</i>	70.3	61.3	52.9	45.4	40.9	44.6	51.4	60.7	72.3	76.1	77.1	75.6
<i>highest max.</i>	120	111	98	80	80	90	93	109	113	118	120	121

⁶ For example, rice cultivation in 1953 occupied only 2.5% of the total agricultural area of Iraq, while all summer crops together occupied only 15% of the total cultivated land (Wirth 1962: 47–48).

⁷ In southern Iraq one distinguishes between two periods

of frost. The so called *chilla saghira* “small frost” is in the first week of January, while the second and longer one *chilla kabira* (الجملة الكبيرة) “big frost” or *al-azraq* (الأزرق, blue, referring to the colour of cold skin of the hand), lasts from 7 January until 1 February.

forty irrigations in a growing season, they are usually irrigated using water-lifting devices such as the *dalia* (دلایة),⁸ a *noriasaqia* (ناعور),⁹ or the *cherd* (چرد).¹⁰

V. Traditional southern Iraqi irrigation systems

Traditional irrigation systems in southern Iraq consist of a primary canal, secondary canals and tertiary canals (Fig. 3). Primary canals (*jadwal*, جدول) usually draw water from either the tributaries of the Euphrates and Tigris or the rivers themselves (Fig. 3, I). They are eight to twelve metres in width and about ten to fifteen kilometres in length. Secondary canals (*bada*, بدعة) branch off from the primary canals at regular intervals (Fig. 3, II). They are four to six metres wide and five kilometres or less long. Tertiary canals (*naharan*, نهران) draw water from specific secondary canals (Fig. 3, III). They measure about two metres wide and are between one and one-and-a-half kilometres long.

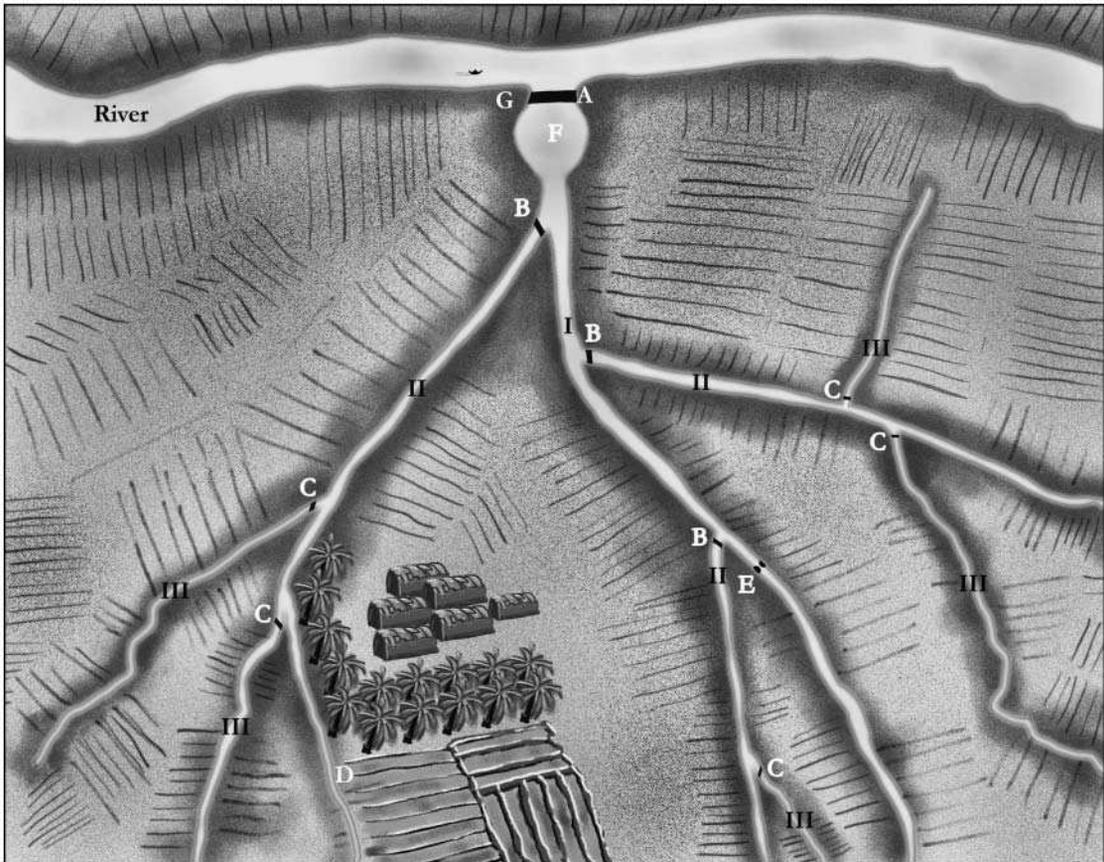


Fig. 3 Topview of a traditional Iraqi irrigation system, drawn by Steven George, 2010.

⁸ The water-lifting device called *dalia* in Iraq is better known in the west by the Egyptian term *shaduf*; it consists of a support structure on which a movable pole is placed. The pole has a weight on one end and a rope with a bucket on the other. The bucket is pulled down into the canal, filled with water and lifted by means of the weight on the other end of the pole (Bagg 2005: 75).

⁹ The *norja* or *saqia* is a water-wheel on to which vessels are fixed. The wheel is placed at the water source and as it turns the vessels automatically fill with water. Once the individual vessels reach the top of the wheel, the water contained in them is discharged into a basin or a small canal. In most cases, these water-lifting devices are powered by animals,

such as donkeys and camels (Rifai 1990: 314–19). However, some water-wheels are powered by the current alone, like those on the river bank at Hama in Syria (Girard, Roumi and Robine 1990: 368).

¹⁰ The *cherd* is an animal-powered (donkey, ox or camel) water-lifting device consisting of a vertically placed pole to which a pulley is fixed. A rope running through the pulley is connected at one end to a leather bucket and at the other to the draft animal. By the forward and backward movement of the animal the bucket is sunk into the water and then lifted to the point where the water is discharged into a basin or canal (Hamidé 1990: 31; Oleson 2000: 222–22; Rifai 1990: 314).

Although the length of primary canals can vary, on average one primary canal provides water for approximately five thousand to seven-and-a-half thousand hectares of agricultural land belonging to an irrigation community of approximately five to six villages, each of which might consist of ten to fifteen households.¹¹ Secondary canals may irrigate the land of two or three villages, while a tertiary canal may serve only one village.

Canals in the recent past were simple earthen constructions whose embankments were usually reinforced. During canal maintenance, accumulated sediments would be piled up on either side of the canal and compressed to form a strong embankment. Once the embankment became too high to allow for the removal of sediment, the canal would be abandoned and a new one built parallel to the pre-existing one (see also Fernea 1970: 120–22; Koldewey 1990: 19–21).

In the following, we discuss a variety of “dam” water-control facilities within a traditional Iraqi irrigation system, including their construction design and material, and associated forms of labour organization. Constructed of organic materials, such as mud, reed and palm-trunks, dams are placed at various key points within the irrigation system and differ therefore in function, size and construction design (Fig. 3, A–D). We organize the information by following the physical layout of the irrigation system, starting with the head-gate and ending at the outlets of field canals. The term “dam”¹² is somewhat misleading when referring to various water-control facilities which have been defined in the literature on the basis of their function, by terms such as canal, weir, regulator, barrage etc. In order to distinguish between water-control facilities of different functions while at the same time recognizing the fact that they all resemble the shape of a dam, we refer to them as a “head-dam” instead of a “head-gate”, “regulator-dam” instead of “regulator”, etc. Unless otherwise noted, all ethnographic data come from Mr Hamdani’s personal experiences and observations.

V.1. *Head-dam: location*

The head-dam is at the head of the primary canal and controls the timing and the amount of water entering the irrigation system (Fig. 3, A). The location of the head-dam is determined by the gradient of the river in respect to the location of the irrigated fields and may or may not be close to agricultural land. A further consideration for choosing the location of the head-dam is the degree of hydraulic pressure which will allow the withdrawal of water. Hydraulic pressure along a river is higher where the river is narrower and at the outer bank of a river meander. Placing a head-dam at the outer bank of a river meander will take advantage not only of greater hydraulic pressure but also of the availability of large quantities of water at flow velocity.

V.1.1. *Head-dam: construction*

The head-dam is built at the final stage of the construction of the primary canal, which is dug from tail to head toward the water source. Therefore, the size of the head-dam depends on the width of the primary canal, which, as noted above, can vary between eight and twelve metres. The head-dam may reach a height of three to five metres, depending on the size of the primary canal and the difference in elevation between the canal bed and the river. The construction of a head-dam usually takes place between July and September, during the agricultural off-season and when water levels in the rivers are generally low. This allows for the construction of the dam to take place on relatively dry ground. However, depending on the location, the head-dam literally has to be built in the water. In this case, a palm-trunk (*ca* 60–75 cm in diameter) is placed parallel to the river bank in order to deflect water and reduce flow velocity at the location where the dam is to be constructed.

Prior to construction, any loose silt and/or organic material is removed from the canal bed in order to provide a firm foundation for the dam. The foundation for the mud and reed part of the

¹¹ We follow Hunt *et al.* (2005: 44) who define the irrigation community as a “corporate group of all and only the users” of one irrigation system. Membership of the irrigation community can be based on membership of settlements located along or within irrigation systems. There are ethnographic cases where membership of an irrigation community is separate from membership of a settlement and based only on water rights (Hunt *et al.* 2005: 442).

¹² The *Multilingual Technical Dictionary on Irrigation and*

Drainage defines the term “dam” as follows: “Dam: 1. A barrier usually on an important scale, across a watercourse, for the purpose of impounding water or creating a reservoir (i) to raise water level, (ii) to divert therefrom into a conduit or channel, (iii) to create a hydraulic head which be used to generate power, (iv) to improve river navigability by means of regulated releases of stored water, and (v) to retain debris. 2. to provide a dam; to obstruct the flow” (Anon 1967: no. 5248).



Fig. 4 Cross-section of a head-dam, drawn by Steven George, 2010.

head-dam is built adjoining the horizontally placed tree-trunks. This foundation (ca 0.5–1 m height and ca 2 m wide) can be made of different materials, such as baked bricks (*sakhar*, صخر), unbaked bricks (*libin*, لبن), dried clay blocks (*chirmed*, جريميد), and compressed mud layers (*tof*, طوف) forming a pisé foundation. A locally available stone (*jalmood*, جلمود), which is a type of gypsum or chlorite, may also be used. If the foundation is built of baked bricks, bitumen is usually used as a mortar, while unbaked bricks and dried clay blocks are simply placed next to one another. A wooden frame is often needed to compress and stabilize the mud layers. Foundations constructed of *tof* are normally no higher than thirty centimetres and usually compressed by hand.

On top of the foundation, a number of terracotta pipes are put in place to serve as the water inlet (Fig. 4, A). The number of pipes can vary but usually does not exceed three. If one large pipe is used, the diameter is generally about fifty centimetres, but if three smaller pipes are used then the diameters are about thirty centimetres. The amount of water entering the primary canals can be regulated by closing the pipes with clay on either side. The pipes are fixed by placing mud or dried clay blocks between and on top of them. Several rows of palm-trunks or fruit-tree trunks are placed on top of the terracotta pipes in a criss-cross fashion (see Fig. 4, B). Depending on the length of the head-dam, a number of palm-trunks are sunk vertically into deep holes. More tree-trunks are then placed horizontally against the row of standing logs. The layer of horizontally placed tree-trunks may

be up to three rows high. Alternating layers of mud (see Fig. 4, C), reed bundles¹³ and reed mats (Fig. 4, D) and occasionally stones are placed on top of the rows of tree-trunks. The reed bundles, thinner at one end, are woven together to increase the head-dam's stability.

The head-dam is coated with a special lining made of a mixture of mud, straw and/or the flower crowns of reed (*ethab*, عذب) or papyrus (*neffash*, نفاش) (Fig. 4, E). The choice of straw versus reed or papyrus depends on availability. Reed and papyrus are available in April and May, while straw is available shortly after the harvest in April and May. Straw is also more likely to be stored and thus more readily available.

V.1.2. Maintenance and duration of use of head-dams

There are several significant causes of damage to head-dams, with the most common being water erosion. However, since the head-dam also functions as a bridge over the primary canal, this traffic can cause large cracks along the top. Moreover, hostile parties may intentionally destroy head-dams in order to cause major damage to their opponents' fields, irrigation systems and settlement. Major maintenance work is performed annually during the agricultural off-season, but running repairs are also often needed. If, for whatever reason, a breach in the head-dam occurs, the entire population will turn out immediately to fix the damage (see paragraph V.1.4.4). These spur-of-the-moment repairs tend to be fairly localized but, every two or three years, the head-dam will be completely rebuilt in order to replace its organic components.

V.1.3. Tools

In addition to a transport vehicle for the construction materials, there are three tools necessary for head-dam construction: a sort of spade (*misha*, مسحاة),¹⁴ a long steel stick (*heem*, هيم),¹⁵ and a large pick (*qazma*, قزمة). Every family purchases a few tools and every participant in the dam construction brings his own tools or borrows them from a neighbour or relative. All metal tools can be acquired in a blacksmith shop in the nearby town. These blacksmith shops were owned and run until the recent past (ca 1970) by the Sabian or Mandaean ethnic group,¹⁶ who make and repair tools. The blacksmith is paid both in agricultural products and in money (see also Fernea 1970: 42).

V.1.4. Labour organization

The construction and maintenance of head-dams is usually undertaken between July and September. This period is most suitable for these tasks because the water level in the rivers is low and materials, such as dry reeds and dry soil, are readily available. This period is also the agricultural off-season, in which little work needs to be done in the fields. The tasks related to the construction of the head-dam comprise preparing and providing construction materials, participating in the construction itself and providing food for the labourers. These tasks are usually distributed amongst those members of the irrigation community who profit from the construction of the head-dam. However, as is shown below, neighbouring villages or certain families who are not members of the irrigation community may also participate on a voluntary basis.

V.1.4.1. The importance of the *mudhif* in the organization of labour

The division and assignment of different tasks require management and the construction and maintenance projects need supervision. The tribal leader, or *sheikh*, assumes the key role of

¹³ One reed bundle consists of 12–14 single reed poles.

¹⁴ A *misha* is a spade with a very sharp blade. The pole of the spade is made of hard wood imported from Java (Indonesia). The pole is further equipped with a step device which allows the user to increase the force on the spade's blade by stepping on it.

¹⁵ A *heem* is a steel stick about 1.20–1.50 m in length and 0.08–0.12 m in diameter, with one pointed end and the other end closely resembling the edge of an axe. The pointed end is used to drill holes in very dry and hard soil (*silsal*) to

loosen the ground, and the soil is further broken up with the axe-like end. Grooving placed on the middle of the stick prevents the user's hand from sliding.

¹⁶ Sabians or Mandaeans are an ethnic minority settled until recently in the marshes of south Iraq near Al-Amara, Qal'at-Salih, Nasiriya, Suq ash-Shuyukh and Qurna. They practise a religion called *sabba* (صَبَّة), meaning literally "one who knows the right way to God", that retains elements of ancient Mesopotamian religion and Christianity.

manager and mediator.¹⁷ He does not, however, make unilateral decisions; instead, these are generally made through a consensus of the adult males. These men are visitors to the sheikh's *mudhif* (مضيف), which is the public meeting or guest house of the local sheikh.

The *mudhif* is an impressive reed structure, made of reed-pole arches (0.5–1 m in diameter), which can reach fifteen metres from the ground (Fig. 5; Fernea 1970: 91–93; Ochsenschlager 2004: 145–49; Thesiger 1964). The arches are covered with reed mats, and the front and rear ends of the structure consist of elaborate latticework (Ochsenschlager 2004: 150). The atmosphere in the *mudhif* is serious and a formal social etiquette is followed. Violation of the etiquette is a direct offence against the sheikh. Thus, a guest can only speak when asked, and each matter brought up for discussion has to be presented with precision, clarity and calmness, no matter how emotional the issue may be. Black coffee is usually served to the guests (Ochsenschlager 2004: 145–49; Thesiger 1964). Wealthy and influential members of a village may also own a *mudhif*, and if more than one *mudhif* is present in a single village, the daily visits made by adult males alternate among them.

The *mudhif* plays an important role in labour organization since a majority of male adult members gather there daily. Thus, plans, decisions on labour division, and progress reports can easily be exchanged and subsequently the news can spread throughout the rest of the community. If a decision is made to construct a new head-dam, the male heads of each family of the village are invited for dinner at the *mudhif*, to be followed by a discussion of the upcoming project. After the assessment of the work, tasks like the provision of labour, material or food are divided up among the different families.

If more than one village belongs to an irrigation community (which is a likely situation), the sheikhs of each village meet in one of the *mudhifs* and assign workloads and various other tasks to the individual villages. The division of the village's assigned work load among different families is then done by each sheikh individually, following the process described in the previous paragraph.



Fig. 5 *Mudhif* at Al-Diwaniyah, photographed by Abdulamir Hamdani, 2009.

¹⁷ The title “sheikh” is used for leaders of different degrees of political authority within the tribal organization of south Iraq, from the head of a single tribe (*ashira*, عشيرة) to the

leader of an entire tribal confederation (*sillif*, سلائف) (Fernea 1970: 69, 86, 105–17, 133–36).

During the construction of the dam, food is provided for the workers at the construction site. The workers are either provided with food by their own families individually or else this responsibility is shared by a number of families. In this case, one family bears the responsibility for feeding the workers on one day, another family on the next. The size of the labour force determines how the provisioning of food is organized. At the end of the construction process, a big feast or ceremony is held, and all contributing families are invited. Large amounts of food are prepared in a quickly assembled reed house, and the group will eat while watching the men perform the traditional war dance (*hosa*, هوسة).¹⁸

V.1.4.2. *Reciprocal labour exchange*

If the labour needed for constructing the head-dam is greater than the parties involved can provide, they can fall back on an informal system of reciprocal labour exchange with nearby communities. This system of reciprocal labour exchange is called *uona* (عونة, “help”). If the labour needed is greater than a single family or village can provide, they call for external help consisting of *awwana* (عوانة, “helpers”). These groups volunteer their labour freely with the condition that help will be returned when needed (see also Fernea 1970: 130–32). The *awwana* workers are provided with food during the time they help out.

V.1.4.3. *Supervision of the construction*

The construction of the head-dam is overseen by a person called *estad* or *ustadh* (إستاد/أسطة), usually an elderly man who has expertise in organizing the construction of dams, mud/reed houses or *mudhifs*. If such a man does not exist in the village, he is brought in from another village or town. He is considered a guest and stays in the sheikh’s *mudhif* for the duration of the project. Depending on the kind of relationship the *estad* has with the irrigation community, he either works under a contract, which specifies the payment he will receive after the job’s completion, or he agrees to help out as part of the *uona*. The *estad* may be paid in money or in kind, and he usually also receives gifts, such as livestock, boats, barley or new clothing. He is respected, even by the sheikh, because of his expertise and experience. The role of the *estad* is limited to supervision of the construction, and he is not usually involved in the recruitment of labour and material. He supervises and controls the workers and determines how much and what kind of construction materials are needed. Since the *estad* lodges at the *mudhif*, he reports to the sheikh on daily progress and consults with him on the work plan for the following day. The *estad* assumes temporary leadership based on his abilities and is very strict in the exercise of his authority. It is in his interest to build a durable and functional dam and to accomplish it in a reasonable amount of time; otherwise his reputation will suffer and he will not be employed by other villages. The irrigation community, on the other hand, has a vested interest in keeping him happy so that he does not leave the project. The position of *estad* is seasonal, and thus these individuals work as farmers or in some other occupation during the rest of the year.

V.1.4.4. *Guarding the head-dam*

Guarding the dam and checking it for damage are done year round. This task is divided among all the families making use of a single irrigation system. Every family is given a *nawba* (نوبة), a specific date and time slot when the family must guard the dam and, if needed, do minor repairs. The person guarding the dam is called *nātoor* (ناطور). The dam is guarded day and night during the “dangerous” times, which are the flood season from late February until the beginning of June. During the flood season even tiny cracks can rapidly turn into a major breach, potentially flooding fields or entire villages. Another danger is posed by rising river levels, in particular those occurring at night due to tidal forces. The tide affects the water levels of both the Euphrates and the Tigris, but the effect on the Euphrates is greater due to its lower bed gradient and can be felt as far upstream as the town of Suq ash-Shuyukh. Since the tide is related to the lunar cycle, the difference between high and low tide is greatest at night when the moon is waxing. A rising tide can cause waves that slam against the dam, potentially causing major damage. Another danger to the dam is posed by hostile

¹⁸ For more detailed information on the institution of the *hosa* see Fernea (1970: 87–88).

tribal groups. Before water distribution from the primary canal was regulated by the Iraqi state, every tribal group could take water as they needed. This led to frequent disputes and attempts to destroy other groups' head-dams (Fernea 1970: 120). Such attacks would usually have been carried out at night — another reason why guarding the dam at night was of major importance.

During these dangerous periods, one to three mature male members of the family usually stood guard at the head-dam day and night. They were normally equipped with guns and would fire one to three shots into the air to signal the status of the dam. In case of an emergency (i.e. a major breach in the dam), every single able-bodied member of the community would rush to the head-dam in order to repair it. The women of the villages would make a specific yelling sound called *halāhel* (هلاهل) in order to alert everybody. This type of emergency situation is called *faza'a* (فزة). The importance of an individual's obligation to participate in the *faza'a* is expressed in a *hosa* song, which states *elmaiefza'a nakhith gā'a* (الميفزع ناخذ كاعة) "the one who is not joining us in the *faza'a*, we will take his land."

During times when the river's water level is low and there is no immediate danger, the guards check the dam from time to time, once at night and once during the day. In addition, passing motorists or pedestrians will alert the irrigation community to any damage. The guards are expected to give reports on the state of the dam during the daily meeting at the *mudhif*.

V.2. Sediment pond

A pond forms naturally beyond the head-dam due to the erosion of the banks of the primary canal (Fig. 3, F). These ponds are encouraged by the local people and, once they acquire the desired size (about five to seven metres in diameter), they serve as water-collection basins (*al-meīāh*, المياه; *tajmie*, تجمع; *hawedh*, حوض) at times of low water levels in the river, and as sedimentation basins to slow the build-up of sediments in the canals. Due to their capacity to hold a large amount of water they also function as inbuilt flood protection for the irrigation system in case of a breach in the head-dam or in times of great water surplus. These ponds are also used for watering animals, washing clothes and dishes, and provide a habitat for different kinds of fish, which are caught by members of the irrigation community. When such a pond is full of fish it is called *michmān* (مجمان) "the place with more fishes", and nets are sometimes placed at the inlet of the primary canal in order to catch them.

Another important function of these ponds is as harbours for small boats, which transport commodities from the countryside to the markets of the nearby towns and/or cities. Irrigation canals (primary and secondary) are used as waterways for the transportation of people and goods. Head-dams and inlet-dams form obstacles for boats that can only be bypassed by using boats of different sizes that remain in the respective canal or river.¹⁹ While the boats remain in the sediment pond, the cargo is off-loaded on to the bank. The cargo is then transported to a dock made of baked bricks with bitumen or stone masonry and located on the river bank next to the head-dam (Fig. 3, G). From there the cargo is loaded on to larger boats which commute between the countryside and the towns and cities. If the riverbank is not reinforced with a wall but consists instead of a simple sand bay it is called *sheri'a* (شريعة). The stone or brick-walled dock and platform in the pond are both called *mesanaya* (مسناية). The length of these platforms is dependent on the amount of traffic as well as the size of the boats (on which see fn. 19).

V.3. Inlet-dams on secondary canals

The construction of inlet-dams on secondary canals is similar to that of the head-dam in respect to materials and design, although since they are smaller and exposed to less hydraulic stress, they tend to be less substantial (Fig. 3, B). The length of these inlet dams can vary between three and six

¹⁹ Four kinds of boats travel on the rivers, primary canals and secondary canals in southern Iraq. The smallest craft is called *mašhoof* (مشحوف), which is 2–3 m long and mainly used for fishing and collecting reeds. A little larger boat, called *ke'ad* (كعد), is 4–6 m long and used to transport people and luggage. *Mašhoof* and *ke'ad* are used only within the

irrigation system. Larger still is the *balam* (بلم) (6–8 m), which is employed for moving animals, goods and people between the city and villages. The largest vessel, the *mehaila* (مهيلة), is 8 m or more and used only for the transport of cargo for trade. The *balam* and *mehaila* boats are sailed only on rivers like the Euphrates.

metres, depending on the width of the secondary canal, and they may achieve a height of about one or one-and-a-half metres. The major difference between the head-dam and inlet-dam of secondary canals is that the latter are built only of mud, reed bundles and reed mats. Although the foundation for inlet-dams is identical to that of head-dams, tree-trunks are not used in their construction. Inlet-dams are also equipped with one or two pipes in order to control the timing and quantity of water released into the secondary canals. These dams are also maintained and repaired each season. An inlet-dam has a lifespan of two or three years.

Labour is recruited from those villages or families that make direct use of the secondary canal and managed in a very similar way as for the head-dam, although the project is much smaller in scale. The *mudhif* functions here also as an important venue for planning, decision-making and discussion of the project's progress. The construction of the inlet-dam may or may not require the supervision of an *estad* and/or the voluntary participation of additional workers. Inlet-dams also need guarding, however less frequently than the head-dam, since they are not at immediate risk.

V.4. *Inlet-dams at tertiary canals and outlet-dams for field canals*

The inlet-dams of tertiary canals are even less substantial than those of secondary canals (Fig. 3, C). Since they do not exceed two metres in length they are constructed of densely packed mud. When water is drawn from the secondary canal, a small opening is dug in the mud dam, close to the canal bank, and closed and opened by means of a large stone (Fig. 6).

These dams have to be rebuilt every season, since the hot and dry summers dry out the mud completely, thus destroying the dam. The responsibility of maintaining these dams is shared among families using the tertiary canal. Outlet-dams for field canals are also made of densely packed mud and do not exceed one metre in length. The construction and maintenance of these outlet-dams are a matter for the individual farmer.

V.5. *Regulator-dams*

Regulator-dams are placed on canals in order to control water flow as well as water level. Water availability decreases around July and August when the water level in the rivers and canals is low. Since the outlet-dams of primary, secondary and tertiary canals are fixed at a certain height, regulator-dams are placed slightly downstream of the inlet-dams in order to raise the water level and increase the hydraulic head that accelerates water withdrawal (for location of regulators, see Fig. 3, E). Regulator-dams in southern Iraqi irrigation systems are mainly found in secondary canals, but depending on water availability and the height of water levels, they can also be found in rivers,



Fig. 6 Inlet-dam from a secondary to a tertiary canal, at Baidha west of Ar-Rifa'i, photographed by Abdulamir Hamdani, 2010.

tributaries and primary and tertiary canals. Regulator-dams are placed at varying intervals along several kilometres of the river or canal. Regulators are made of two dams, placed facing each other on opposite banks, leaving an opening of one or two metres. When water levels are low, the opening can be closed and the water dammed. The regulators are closed with soil and palm-trunks or tree branches.

The regulator-dams resemble very closely the head-dam in construction. Palm-trunks are fixed on each side of the river or canal bank and covered with alternating layers of mud, reed mats and reed bundles. In addition to being water-control facilities, regulator-dams also function as bridges, palm-trunks being placed on top of the two opposing dams (Fig. 7). The size of these regulators depends on the size of the canal or river they are placed in, and just as is the case for the inlet-dams of secondary canals, they are maintained every season and need to be replaced every two or three years.

V.6. Flood-damage intervention

Another aspect of irrigation management that does not strictly fall under “traditional dam-construction” is the measures taken in case of a dam’s failure. When a breach occurs a cylindrical roll, called *durbayah/badkha* (درباية / بطخة) (Fernea 1970: 199 n. 21), is used to close the breach. The roll is made of ropes spread out on the ground with a reed mat placed on top of them. A palm-trunk and/or reed bundles are placed on the reed mat in addition to a thick rope, 40–60 cm in diameter, made of crushed reed or palm-leaf fibres, which is placed in the centre with its ends sticking out. The reed mat, palm-trunk, central rope and reed bundles are then rolled into a large cylinder and bound together with the rope. The length and diameter of this roll depends on the size of the breach. In one historically documented case such a roll had a diameter of close to 2.5 m and a length of *ca* 20 m (Great Britain Admiralty 1944). Large sticks are placed underneath the roll in order to lift and transport it to where it is needed. The roll is then placed in the breach and fixed by anchoring the



Fig. 7 Regulator/palm-tree bridge at the Umma Nakhlah canal (a side branch of the Euphrates river) south of Suq ash-Shuyukh, photographed by Abdulamir Hamdani, 2010.

ends of the central rope in excavated shafts along the still-intact river or canal bank. These shafts are filled with earth after the ropes have been anchored. Alternatively, the central rope may be fixed to a pole which is hammered into the ground. Fernea (1970: 199 n. 21 citing Ionides) also mentions that in some cases several rolls are needed in order to close the breach. In such a case, those placed first have to be weighed down with mud or tree-trunks in order for them to sink to the bottom. Once the first roll is at the bottom of the breach, a second is placed on top of it, and so forth. As mentioned earlier, when a breach occurs everyone is responsible for helping out. This also applies to providing the materials needed for the roll's construction.

VI. *Discussion and conclusion*

In this paper, we have described the construction design of various dams of different functions in a traditional Iraqi irrigation system. We explained the ways they were traditionally built prior to the use of concrete and metal as construction materials and prior to the use of machines such as water pumps. By focusing on traditional construction methods, we hope to provide ethnographic data which can function as valid and relevant analogies to assist in the interpretation of textual information referring to similar irrigation practices in the past. Conducting a comprehensive analysis of the archaeological and philological implications of these particular ethnographic data is beyond the scope of this article. One limitation in the use of these data as a source of analogies is that it is still unclear how representative these data are for southern Iraq as a whole. In the ethnographic case-study presented above, the proximity to the marshes provided abundant access to construction materials such as reeds, flower crowns and palm trees. Access to construction materials certainly varies in different areas of southern Iraq, and it is possible that as a consequence the construction of water-control facilities differed in terms of construction design and materials used.

The information presented here, however, has wider implications for the theoretical consideration of centralized versus decentralized irrigation management. Our data demonstrate that major hydraulic structures, such as head-dams (8–12 m in length, 3–5 m in height and 2–3 m in width), may be constructed and maintained on a local cooperative basis. As we have shown, the construction of the head-dam may require the cooperation of several villages, but this cooperation is organized in an informal and consensual manner without the involvement of any central authority. Instead the organization of such a large project relies on local authority structures, as represented by the *ustadh* — whose temporary leadership is based on his competence — and the sheikh, whose authority is decentralized and based on the consensus of his fellow tribesmen. In addition, the concept of *uona* is part of a system of labour organization that is common to many peasant societies, but is often neglected in historical reconstructions of ancient Mesopotamia.

The problem, of course, is that practices such as these would hardly be reflected in ancient documents. Indeed, the lack of textual evidence for cooperative labour organization is probably the reason why most scholars tend to argue for a centralized management. However, as our example shows, labour organization on a cooperative basis is effective even beyond a single village community. We are not suggesting that the organization of irrigation in ancient Mesopotamia was mainly a cooperative effort but rather that it was not entirely state-run. We hope that by presenting these data we will provoke a reconsideration of both the textual record left by the central authority and the possibility of unrecorded cooperative behaviour as an important feature of the management of Mesopotamian irrigation systems.

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