Recognition criteria for canals and rivers in the Mesopotamian floodplain

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Abstract

The ability to distinguish between the remaining traces of rivers and those of canals would greatly increase our understanding of water history and management within a given area. Such an understanding would lead in turn to a greatly enhanced understanding of the landscape, social structure, political life and economy of that area. For the Mesopotamian floodplain, intensive water-management activities, together with the frequent avulsions of the Euphrates and Tigris rivers, have rendered channel networks complex and interlocked. This complexity has long confused researchers in regard to channel origins, and whether they are natural or anthropogenic, or a combination of the two. It is a challenging task, but the present work proposes and discusses seven key differences between the two types of channels, namely topographical cross-sections, crevasse splays, marshes, meandering, cut-offs and oxbow lakes, channel patterns, and stream directions. The discussion is based on geomorphological, remote-sensing, historical and archaeological data. It is concluded that, for a given channel, these differences may be sufficient to establish its origin.
The floodplains of Mesopotamia

The floodplain of the Tigris and the Euphrates is a relatively flat area with a low topographic relief, occupying a part of the foreland basin of the Zagros fold and thrust belt (Garzanti et al., 2016). On one hand, rivers in this region are unstable as they are commonly laterally shifted, completely or partially avulsed, seasonally flooded and occasionally desiccated (Morozova, 2005; Jotheri et al., 2016). On the other hand, this region is considered one of the origins of complex societies and has been continually occupied from the Mid-Holocene; here, people have relied on natural and constructed canals for life, irrigation, transport and fortification (Wilkinson, 2003).

The origin of the ancient channels, whether natural or anthropogenic, in some cases cannot be determined with absolute confidence. This can occur when a canal has a long history of use and becomes similar to a river. However, in the present study, the focus is on channels that are now abandoned and dry, regardless of their history, in other words on the final condition of the channel when it is dried out and on whether it was modified and shaped by human activity or there are indications that it was a natural river.

There are many types of anthropological activities, but several of them have led to a re-formation of the landscape, including the creation of irrigation and trading canals, the cleaning and maintenance of the channels, the opening of channel levees, the reclamation of marshes and the strengthening of channel levees (Walstra et al., 2010; Heyvaert et al., 2012; Husain, 2016). The idea of human utilisation of surface water in southern Mesopotamia was developed over time. It started as a simple means of irrigation, such as the crevasse splay style of the fourth millennium BC, when canals of a few metres were dug to control water to supply a small farm (Wilkinson et al., 2015). This construction process did not end until large irrigation canals, such as the gigantic Nahrawan Canal, extended for hundreds of kilometres across the floodplain during the early first millennium AD.

State interventions in water and irrigation systems would lead to high levels of water management and, as a result, to the flourishing of the state and of rural communities. The challenges presented by river changes led to the development of water management over time. The three main reasons for state intervention are political, to gain more control and to tackle sudden change in the environment (Rost, 2017).

Previous work has dealt with mapping archaeological sites and ancient channels in southern Mesopotamia. It includes Jotheri and Allen (in press), Hrits and Wilkinson (2006) and Pournelle (2012). Satellite
images (CORONA and DigitalGlop), historical maps and texts, maps and atlases of archaeological data have also been investigated. The present geomorphological properties of the rivers and irrigation systems have been taken into account. Consequently, in the present study several ancient channel parameters have been suggested as reliable for making distinctions between ancient rivers and ancient canals.

Key differences

In the present study, seven key differences between rivers and canals are discussed: channel patterns, topographic cross-sections, crevasse splays, marshes, meandering, cut-offs and oxbow lakes, and stream directions.

Channel patterns

Ancient rivers and canals are completely different in their patterns as a result of the way they are formed. Rivers have developed four main different types of patterns, namely meandering, braiding, anastomosing and anabranching. Ancient canals display, on landscape imagery, mostly herringbone (Figure 6.1) or dendritic (Figure 6.2) patterns. Herringbone irrigation systems are probably the oldest and most common irrigation system in the southern Mesopotamian floodplain (Wilkinson et al., 2015). This system is the most common and functional irrigation system in the present (Figure 6.3) and across floodplains. However, in some locations, people may have dug canal irrigation systems in dendritic (Figure 6.2) patterns. The dendritic pattern might be selected because of the rough topography.
Figure 6.2  Ancient canal in dendritic irrigation system. Source: author

Figure 6.3  Active canal in herringbone irrigation system. Source: author

of the land or because the land is more marshy and frequently flooded; in such places people would have chosen alternative, workable patterns.

In the modern geomorphology of the Tigris and the Euphrates inside the Mesopotamian floodplain, there are no natural branches, as all the current branches are human-induced and controlled by dams or barrages (if it was uncontrolled, a single branch would overwhelm the others because of the ‘avulsion’ process).

**Topographic cross-sections**

In general, levees of rivers and canals differ in width and in their degree of slope towards the floodplain. River levees are wider and have a gentle slope, while canal levees are narrower and have a steep slope. These differences between the shapes of the levees mainly depend on how each one was formed.
Natural levees (Figure 6.4) are usually formed as a result of repeated river floods, where the floodwater has loaded more sediment from the river banks and the coarser particles are deposited alongside the channels, forming small elevated banks, while the lighter particles are deposited a long way from the channel that forms the floodplain (see, for example, Mohrig et al., 2000). As this process is repeated, banks (levées) are built up and confine the river.

Canals (Figure 6.5) are usually dug in a relatively flat floodplain area. Water must be confined by levees; otherwise floods will spread across the surrounding area and the purpose of digging the canal will not be served. Therefore, when people dig a canal they normally focus on strengthening the canal sides, including by putting excavated soil along both banks of the canal. They take into account the possibility of
flooding or uncontrolled waves of water by increasing the elevation of the bank levees. In addition, because of the silting-up process, canals are frequently cleaned by removing sediments from the bottom and using them to firm the primary levees, and so canal levees are narrower and steeper.

**Crevasse splays**

One of the clues to recognising an ancient river in the southern Mesopotamian floodplain is crevasse splays, since they are easily recognisable from satellite images (Figure 6.6). Crevasse splays are fan-shaped features formed when the channel levee has been breached during stages of flooding and floodwaters have overflowed the natural levee in the floodplain through swales or breaches (Bristow et al., 1999). They occur close to the channel and in time become a feature of high elevation, but are lower than the channel levees. The flowing stream in a crevasse splay surface forms several small distributaries and braided channels. The formation of crevasse splays depends on flood frequency and the degree of levee strength (that is, they are more likely to be formed when the channel is subjected to flooding and its natural levees have not yet strengthened and become sufficiently elevated). Accordingly, in the past crevasse splays were the location in which people preferred to dig canals and control water in order to create first farms and then settlements.

![Figure 6.6](image.png)  
**Figure 6.6** Crevasse splay associated with river. Source: author
Marshes

Marshy areas are an indication of a natural river, as they are adjacent to the stream channel which forms when water spreads out from natural levees and banks as a result of floodwaters overflowing the banks. The location of ancient marshes cannot be identified from satellite images, because such low land features are easily buried by subsequent sedimentation and there are no surface signs. However, they can easily be revealed by digging several shallow boreholes or augers in the floodplains near ancient rivers, as the marsh faces are composed of silt to sandy silt, which are rich in shells and charcoal (Jotheri et al., 2017).

Meandering

This is a more common feature identifying a river (Figure 6.7), especially in a floodplain, as channels are apt to move from side to side, forming meanders with respect to a straight course, and leaving behind scars of remains where the river channels once were (Hooke et al., 2011). Canals (Figure 6.7) are less likely to form meanders, and therefore leave no scars. However, occasionally, canals form meanders as a result of long-term use and lack of appropriate maintenance (Figure 6.8). In such cases, meanders are small (that is, their wave lengths and wave amplitude are short).

Figure 6.7  Meandering ancient river and straight ancient canal. Source: author
Cut-offs

These features occur close to a main river (Figure 6.9) and are usually characterised by scars or meander scrolls; they are accompanied by levees of high elevation (Hooke et al., 2011). They can be clearly identified in satellite imagery. Cut-offs are old meander loops isolated from the main channel as a result of lateral shifting of the channel; that is, meanders in rivers are separated by deposition, which leaves behind oxbow lakes.

Stream direction

This characteristic can be used as an indication of a canal rather than of a river, as rivers always follow the general slope direction of the floodplain (Figure 6.10). In several cases, people have dug canal extensions in an area and in a direction that, to some extent, is not parallel to the general gradient of the area (Figure 6.10).
A case study

A case study has been selected to evaluate the key differences between natural rivers and anthropogenic canals discussed earlier. The selected area is located between Diwaniyah and Kufa (Figure 6.11) in the centre of southern Iraq, where the branches of the Euphrates are and were the main factor controlling the hydraulic landscape (Figures 6.11 and 6.12). One of the main reasons for selecting this area as a case study is that changes in the river and irrigation systems in this area are widely described in Ottoman texts and maps. Therefore the natural rivers and canals have already been mentioned in such works. If we tried to classify the channels in this area without looking at texts and maps, it would not
Figure 6.11  The rivers and canals in the case study. A. Satellite image of the area. B. The reconstructed rivers and canals of the area. C. The River Ramahiya and its branches (canals) that were active from the thirteenth century until 1700. D. The River Diwaniyah and its branches (canals) that were active from 1700 until 1905. E. The Kufa and Shamiya canals and their branches (canals) that were active since 1905, and the Shafiyah canal that was dug to irrigate the town of Diwaniyah. F. The current rivers and canal after the construction of the Hindiya barrier upstream of Euphrates. Source: author
be easy to distinguish between natural and anthropogenic origins. However, the key differences described help to distinguish them.

For the purposes of this chapter, only river changes in the Euphrates from the late Islamic period until the present day are taken into account, because the palaeo-channels, avulsions and hydraulic landscape of this area before the late Islamic period are discussed in detail elsewhere (Jotheri et al., 2016).

In this case study, archaeological sites and palaeo-channels have been identified and traced (Figure 6.11B) using SRTM, CORONA and QuickBirds satellite imagery and data, in addition to ground truthing carried out at several locations in the area. Historical, mainly Ottoman, texts and maps have also been reviewed.

During the Ottoman period, the agricultural and irrigation systems in the Mesopotamian floodplain were controlled by low-skilled rural community leaders such as the heads of tribes (sheikhs), peasants and local cultivators. These rural people were the most active of the players who triggered river avulsion in this part of the Euphrates. In fact, the Ottoman central bureaucratic administration had no plans or rules for irrigation systems but relied on these people’s knowledge of irrigation. For example, the Ottomans gave power to tribal heads to organise labour and to suggest irrigation plans to cultivate their land, without questioning or supervising the plans.

Although it was up to rural communities to manage their water systems, the Ottoman administration encouraged peasants and sheikhs to focus on the irrigation system, which would lead to an increase in the area of cultivated land, in cases where the latter would raise tax revenues. Conversely, any work (digging or maintenance) on a waterway system that only led to villages or cities being fed was not a priority. For this reason, rivers or canals that were not used mainly for irrigation were more likely to be subject to silting up with sand and reeds. People often complained about this to the Ottoman administration, but rarely received a reply.

One of the most significant causes of conflict among ordinary farmers was the downstream flow of a canal becoming too slow and therefore incapable of supplying enough water to farms, because of excessive consumption of water upstream. Another common reason for complaint was the canal becoming silted up as a result of not having been cleaned for two or three years or more, which would lead to flooding of the upstream land and desiccation of the downstream land.

Every tribe that benefited in one way or another from a canal would be responsible for digging, cleaning and reinforcing the canal’s banks along a given section. In the summer the regular water-work of a rural
Community was the construction of weirs across the channels to raise the water level and then the digging of canals to irrigate crops. In winter, strengthening channel levees and damming the river crevasse splay to prevent flooding were paramount.

In 1687, a farmer called Dhiyab dug a canal from the eastern bank of the River Hilla in Ciniyah village to irrigate his land, and the river began to avulse as a new channel had started to form, taking water from the main river. The new branch was called ‘the Dhiyab’, ‘the Rashadi’, ‘the Hasaka’, ‘the Hilla’ and ‘the Diwaniyah’, while the original channel was called ‘the Ramahiyah’ or ‘the Ciniyah’ (Husain, 2014; Jotheri et al., 2016). The avulsion was completed in 1700; the Ramahiyah dried out, while the Diwaniyah branch flooded and its floodplain became extensive marshes covering both sides of the new branch (Husain, 2016).

The main consequence of this avulsion was that the tribes that were living on the River Ramahiyah and its canal branches migrated from their farms and towns (Figures 6.11C, 6.12 and 6.13) and settled in three

Figure 6.12 Ramahiyah archaeological sites and the River Ramahiyah. See Figure 6.11C for location. Source: author
areas: upstream of the avulsion node (i.e. to the north of Ciniyah village), near the new Diwaniyah branch and marshes (i.e. around Hasaka and Lamloom villages (Figures 6.11C and 6.11D), and around Kufa (Figure 6.11D).

In 1701–2, the Ottoman authority ordered the restoration of the avulsion through the cleaning of the abandoned Ramahiyah branch and the damming of the new Diwaniyah branch and its marshes, in order to keep Ramahiyah and its branches active. The other purpose of restoring
the avulsion was to eliminate tribal people who constantly protested against Ottoman authority and settled in these marshes (Husain, 2014). For such water-work, the Ottoman authority ordered the local people to use large rolls of reeds and heavy pieces of palm-tree trunk, and they dumped sandbags to block the head of new channel. However, all their efforts failed to prevent the new river from continuing its ongoing avulsion and feeding the marshes. Therefore, the Ottoman authority ordered the people to block the head of the crevasse splay and all the canals taking water from the Diwaniyah branch to its floodplain. Several drain canals were dug parallel to the Diwaniyah and across to the crevasse splays and the irrigation canal to siphon water off the marshes. However, these efforts were not enough to dry out the wide marsh area rapidly and were also hampered by the frequent flooding of the River Hilla, the main branch of the Euphrates at that time. Therefore, the Ottomans continued with the same type of water-work, which led to a reduction in the discharge of water, and then the silting up the river. As a result, water diverted from upstream of Hilla started to form the Kufa and Shamiya branches. Since that time, no floods have been recorded in any season of the year, and the Hilla branch discharge has reached its lowest level. Consequently, the country-dwellers and the marsh community who had been living and thriving around Diwaniyah, Hamzah and Rumaytha for a decade downstream from the Hilla began to leave the area and spread out in other areas within southern Mesopotamia.

According to the historical texts and maps studied by Husain (2014, 2016) and Jotheri et al. (2016), including this present study, the natural channels are:

1. the main channel of the Ramahiyah (Figure 6.11C)
2. the main channel of the Diwaniyah (Figure 6.11D)

while the canals are:

1. the branches of the Ramahiyah (Figure 6.11C)
2. the branches of the Diwaniyah (Figure 6.11D)
3. the main channel of the Euphrates at Kufa and Shamiya, and its branches (Figure 6.11E, F)
4. the Shafiyah Canal (Figure 6.11E).

Having examined the key differences between naturally occurring rivers and canals, we have found that the channel patterns of the canals mentioned are herringbone and dendritic, with narrow topographical
cross-sections, a lack of associated crevasse splays and a lack of adjacent marshes; they generally show a low rate of meandering and a lack of associated cut-offs or oxbow lakes, and some of the streams do not flow with the general gradient. In contrast, the natural rivers mentioned have no specific channel pattern, wide topographical cross-sections; associated with them are crevasse splays and marshes, meandering, and frequent cut-offs or oxbow lakes, and their stream directions are normally in line with the general gradient.

Conclusions

As the present study has demonstrated, the process of distinguishing between rivers and canals may require a closer consideration of geomorphological features and surface properties. From an examination of key differences in channel patterns, topographical cross-sections, crevasse splays, marshes, meandering, cut-offs and oxbow lakes, and the directions of streams, it does appear to be possible to determine whether the origin of a channel is natural or anthropogenic. An additional conclusion is that these key differences can be applied to any area within the Mesopotamian floodplain for the purpose of distinguishing between these features.

References


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