CHAPTER 4:

LAND USE OF THE MODEL COMMUNITIES

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LAND USE IN NORTHERN MESOPOTAMIA

The ways in which past communities exploited their surrounding territories is a crucial question for reconstructing ancient society and economy, but one that is particularly challenging to address through archaeology (Morrison 1994; Earle 2000). Excavation yields a rich dataset for a variety of intra-site activities, which can be interpreted further for various socioeconomic aspects; however, with the exception of some classes of environmental data (see below), this dataset cannot speak directly to past engagement with the broader landscape. Nonetheless, Near Eastern archaeologists have adopted four main approaches for reconstructing past land use.

On the assumption that the same physical landscape will often result in similar land use decisions, it is a common archaeological practice to reconstruct past land use via analogy with traditional agro-pastoral practices found in the same region in the recent and ethno-historical past. Such an approach is risky in the Upper Khabur basin, the part of northern Mesopotamia that serves as the empirical basis for the model. Despite its present productivity and the high populations it supported in the Early Bronze Age, this region has been largely depopulated by sedentary agriculturalists since the end of the sixteenth century AD in favor of Kurdish semi-nomads and Arab camel nomads (Glubb 1942; Göyünç and Hütteroth 1997; Lewis 1987, reviewed in Ur 2010b: 5-18). Full agricultural resettlement came only in the 1940s; this was characterized by capitalist investment and modern mechanical methods, and included a high proportion of irrigated cotton for export (Boghossian 1952; Gibert & Fevret 1953; Mehner 1983; Wirth 1964). None of these aspects would have characterized land use in the third millennium BC. As a result, analogies with recent land use must be used with extreme caution or not at all. Rather than specific circumstances in the basin, it is preferable to invoke general principles of traditional agricultural movement and land use (e.g., Chisholm 1962) together with off-site landscape data (see below).

The most prominent landscape features in northern Mesopotamia are of course the remains of the settlements themselves, now in the form of mounds that can stand as high as 40m above the plain. Building on some assumptions about population density and dietary needs, archaeologists have used the sites themselves to propose minimum agricultural areas required to sustain settlements. Such simulations were undertaken by Adams (1981: 90-94) for the earliest urban settlement patterns in southern Iraq, and have also been applied in northern Mesopotamia around Tell Leilan (Stein 1994) and Tell Beydar (Wilkinson et al. 2007: 56-57; Ur & Wilkinson 2008; Deckers & Riehl 2008). These methods make simplistic assumptions about the uniformity of population densities and productivity of the surrounding terrain, and do not incorporate factors such as the movement of agricultural produce or the needs for social surplus for feasting and for non-human consumption (i.e. foddering; see Danti 2000). Sustaining areas based on site size can, however, be checked against further off-site evidence from field scatters and hollow ways.

Ideally, a land use reconstruction could draw on a range of off-site features that bear direct witness to past activities beyond the settlement, including roads, tracks, field boundaries, canals, terraces, check dams, and many others (reviewed in Wilkinson 2003: 44-70). In practice, however, many such features are ephemeral and are lost to cultural and environmental taphonomic processes. In northern Mesopotamia the smallest features have suffered from significant attrition because intensified agriculture have completely covered the alluvial plains since the mid-twentieth century AD. Nevertheless, large accretional features have survived and can be documented using a combination of field survey, geoarchaeological, and remote sensing methods. These features allow for a vivid reconstruction of northern Mesopotamian land use in the EBA.

The most prominent features are broad and shallow linear depressions that radiate outward from sites of EBA date, variously called hollow ways, linear hollows, or routes rayonnantes. Hollow ways form as human and animal feet disturb the ground surface, causing sediments either to be removed by wind or by surface runoff. They were recognized in the aerial photographs of Poidebard (1934) and mapped systematically across the Hassake province of northeastern Syria by van Liere and Lauffray (1954-55). Using aerial photographs and ground observation, Wilkinson mapped a broad network throughout the Iraqi North Jazira and along the Syrian Euphrates (1993, 2004). CORONA satellite photographs preserve traces of over 6000km of pre-modern hollow ways in the Upper Khabur basin (Ur 2003, 2009 and 2010; Wilkinson et al. 2010; see Chapter 9), and have also been used to map communication routes in adjacent areas of northern Iraq (Altaweel 2003) and elsewhere in the Middle East (Casana 2013).

Hollow way features are most obviously significant for reconstructing the movements of people and animals, but they can also serve as a proxy indicator for land use in the areas through which they pass. To understand why this is so, it is important to recognize the role that constraint plays in the formation of these features: hollow ways form because people and animals are constrained to walk along them (Wilkinson 1994: 492-493; for European analogies see Hindle 1982: 21 and Muir 2000: 113). At certain times of the year, particularly the rainy season, traffic would certainly avoid these low areas unless some external constraint held it within these spaces. It can be assumed, therefore, that where hollow ways formed they ran between agricultural fields, and where they did not the landscape was characterized by pasture, open steppe or low-intensity agriculture. The point at which radiating hollow ways fade out can be interpreted as the interface between the settlement’s agricultural sustaining area and the pastoral zone beyond it (Wilkinson 1994: 482-493; Ur & Wilkinson 2008: 312-314). The monumental scale of hollow ways, and their ubiquity in the EBA but not in subsequent periods, suggests not only that traffic was great at this time, but also that fields were intensively cultivated; indeed it may be that the radial patterns of hollow ways are indicative of fallow reduction (Ur 2009), the classic form of agricultural intensification (Boserup 1982), but one that has proven difficult to document archaeologically (Morrison 1994). The most typical pattern of hollow ways is a spoke-like arrangement in which most of the tracks simply fade out at a distance of 3-5km from the population center. Since the majority of the inhabitants of third millennium BC towns and cities were largely concerned with subsistence activities within their daily routines, it is not surprising that a majority of the hollow ways fall within this category. Such roads apparently 'going nowhere' are, in fact, rather common in ancient landscapes. In Britain such routes linking long-term zones of settlement with pastoral and other common resources have been termed ‘resource linkage routes’ (Harrison 2005; Williamson 2008). In the case of the radial hollow ways, their terminal ends often represent the boundary between cultivation (where movement was constrained and tracks became depressed) and land used for pasture (where movement was unconstrained and hollow ways did not form). It is therefore possible to use them to reconstruct the long-term average sustaining areas for the central settlements (Ur & Wilkinson 2008). Additional evidence of hollow ways as route networks is provided in Chapter 9.

A more direct measure for intensification comes from the interpretation of off-site scatters of small and abraded artifacts, predominantly sherds, that cover the alluvial plains in a continuous but variable carpet. Wilkinson’s interpretation of these scatters as the product of manuring with settlement-derived debris (1982, 1989) is supported by evidence from elsewhere in the Old World (Gaffney, Gaffney & Tingle 1985; Bintliff & Snodgrass 1988; Ault 1999; Alcock, Cherry & Davis 1994: 145-157). The pattern found in northern Mesopotamia is one in which the densest scatters are found in proximity to the major EBA towns and cities, such as Tell al-Hawa, Hamoukar, and Tell es-Sweyhat, but smaller scatters also characterize the landscape around their satellites (Wilkinson 1994: 491-92; Ur 2010: 65-76). These crop amendments would have reintroduced nutrients that were being removed from soils via intensive cultivation, and add further support to the theory of an intensive EBA agricultural economy.

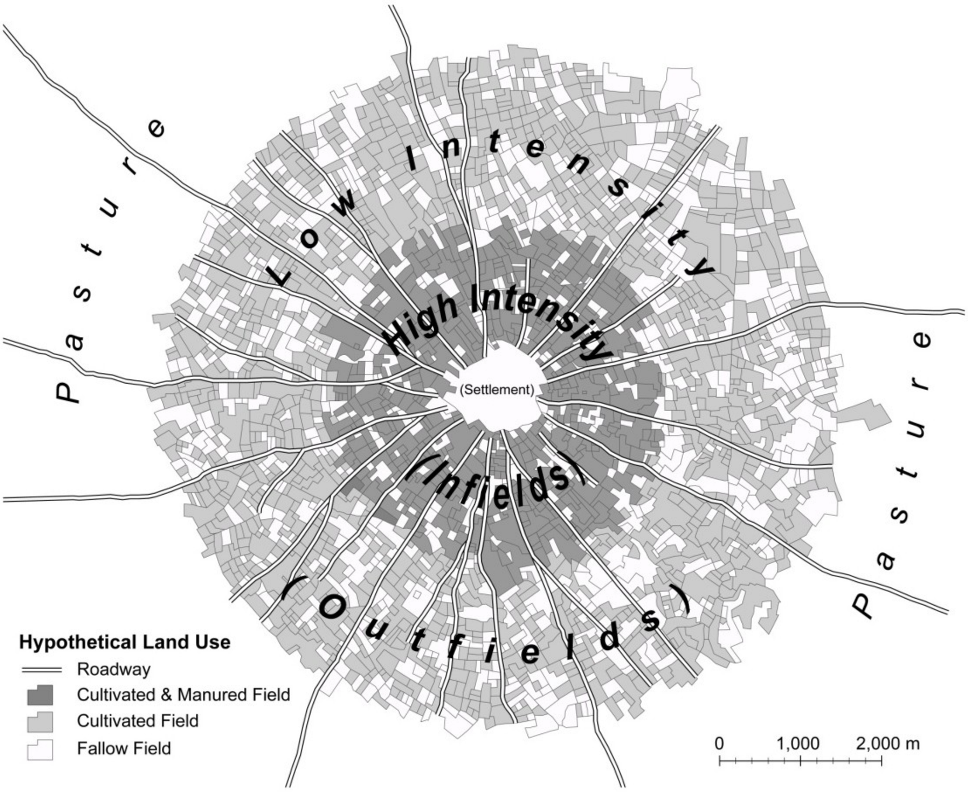

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Fig. 4.1 Fields and trackways around the village of Qara Qosh, northern Iraq (J.A.Ur).

From these traditional patterns of agricultural land use and landscape archaeological data, a static model of land use emerges (Fig. 4.1). Closest to the settlement, infields were intensively cultivated, including manuring and possibly reduced fallow intervals. Because of the intensity of land use, constraint of movement across these fields was high, and the tracks between fields became hollowed. Further from the settlement, outfields were less intensively cultivated, less frequently manured, and more likely to be maintained using a biennial fallowing regime. Constraint still forced traffic onto worn tracks, but at a lesser intensity due to the more frequent presence of fallowed fields. Beyond the outfields were areas of pasture, where the lack of fields meant no constraints on foot or animal traffic and therefore no formation of depressed track-ways. In some cases, depressed tracks did form when movement followed a straight line between settlements, but in most cases, tracks simply faded out in this zone.

One aspect of land use that appears not to have been significant in the EBA is irrigation. The deliberate redirection of watercourses for irrigation was not unknown in northern Mesopotamia. Canals are found in association with the Late Bronze Age-Iron Age city of Dur-Katlimmu on the Upper Khabur (Ergenzinger, Kühne & Kurschner 1988; Ergenzinger & Kühne 1991), and large-scale irrigation was implemented by Neo-Assyrian kings on the plains of northern Assyria (Bagg 2000; Ur 2005). More recently, sixteenth-century Ottoman tax records indicate substantial irrigation agriculture around Nisibin (Göyünç & Hütteroth 1997: 62-64, 113-115), the remains of which survive fossilized as field boundaries (Ur 2010: fig. 7.6). In the EBA, however, landscape evidence for irrigation canals in association with urban settlements is absent or ambiguous. It appears that EBA urbanism was sustainable solely through intensified dry farming techniques.

Clues to the sorts of crops and land cover surrounding EBA settlements can be derived from charred plant remains recovered from excavations. For most relevant sites, such studies have been published only preliminarily, if at all, but enough data does exist to reconstruct basic crop patterning (Charles & Bogaard 2001; Charles et al. 2010; Colledge 2003; Hald & Charles 2008; McCorriston & Weisberg 2002; McCorriston 1998;

Riehl 2010). The record suggests an emphasis on barley and wheat (and to a lesser extent on pulses and other crops), and is without unequivocal evidence for agricultural technologies other than dry farming (i.e., irrigation appears not to have been a significant land use technology). The paleobotanical record must be interpreted with caution, as the charred remains represent both human and animal food (Miller 1984; Charles & Bogaard 2001: 323-324). In the absence of any strong evidence for long-distance movement of bulk staples, however, excavated plant remains give a good idea of the sorts of crops grown on a site's immediate hinterland.

The final land use dataset is a limited corpus of cuneiform tablets found at Tell Beydar, ancient Nabada (Ismail et al. 1996; Milano et al. 2004; Widell 2004), discussed in more detail below.

The Reconstruction of Land Use in The North: A Case Study from Tell Beydar

The site of Tell Beydar provides an exceptionally rich case study for the reconstruction of past land use using multiple datasets. In the later third millennium BC, Beydar was the town of Nabada, a secondary town in the kingdom of Nagar (Tell Brak). At Beydar and in its hinterland, it is possible to bring together demographic evidence from intensive archaeological survey, off-site data from survey and remote sensing, and ancient cuneiform data pertaining to population and plow teams.

Archaeological evidence for ancient populations comes from two seasons of survey in the 12km radius (452km^2) around Beydar (Wilkinson 2000, 2002; Ur & Wilkinson 2008). The survey recovered 15 permanently occupied sites of the later third millennium BC. The total settled hectares were 62.1, of which 17.5ha were at Beydar itself. There is much debate regarding broadly applicable ratios of persons to settled hectares in the Bronze Age Near East (Postgate 1994). Nonetheless, earlier attempts to model the staple economies of third millennium urban systems suggests that they could have ranged between 100 and 200 persons per hectare; although the latter ratio could have been sustained in village settlements, such density would have unsustainable in urban places, and overall population density was more likely to have been closer to 100 persons per hectare (Wilkinson 1994).

The estimation of past cultivation in this manner reveals a landscape of largely self-sufficient agricultural towns and villages, even when one assumes a high population density (Fig. 4.2). At 100 persons per hectare, radial sustaining areas overlap only slightly, and generally not at all. If 200 persons per hectare is assumed, overlap increases, particularly between Beydar and its immediate satellites; however, even then these sustaining areas are largely separate. This simple method suggests that population was not so great that there was competition for arable land between these settlements. This picture is complicated slightly by the presence of an extensive area of thin soils atop a basalt plateau encompassing the southwestern quadrant of the Beydar survey area, known locally as al-Hemma or the Ardh al-Shaykh. This area would not have been as productive for cereal agriculture as the lower alluvial soils near the wadis. Beydar's sustaining areas overlap considerably with the basalt plateau, which suggests that its population-derived radial area under-represents the area of cultivation.

The survival of hollow way features presents a possible way to check these hypothetical radial sustaining areas (Fig. 4.3). The Beydar region has one of the densest and best preserved systems of later third millennium BC hollow ways in the Upper Khabur basin (Ur 2003, 2010). If one assumes that hollow ways fade out at the long-term average interface between cultivated fields and pasture beyond them (described above), it is possible to delineate the agricultural catchments of a number of sites from the TBS region based on empirical landscape data. In many cases it is possible to compare population-derived sustaining areas with hollow way-derived catchments (Ur & Wilkinson 2008: 312-314). In the case of villages and smaller towns, the hollow way catchments are consistently larger than would be expected; this can be interpreted as the production of surplus, possibly to support larger settlements such as Tell Beydar, with catchment areas that are smaller than expected and which therefore are possibly underproducing (see further below). The surplus produced at Beydar's smaller satellites would not only have covered Beydar's deficit: it could have sustained up to an estimated additional 10,939 persons (Ur & Wilkinson 2008: 313).[1]

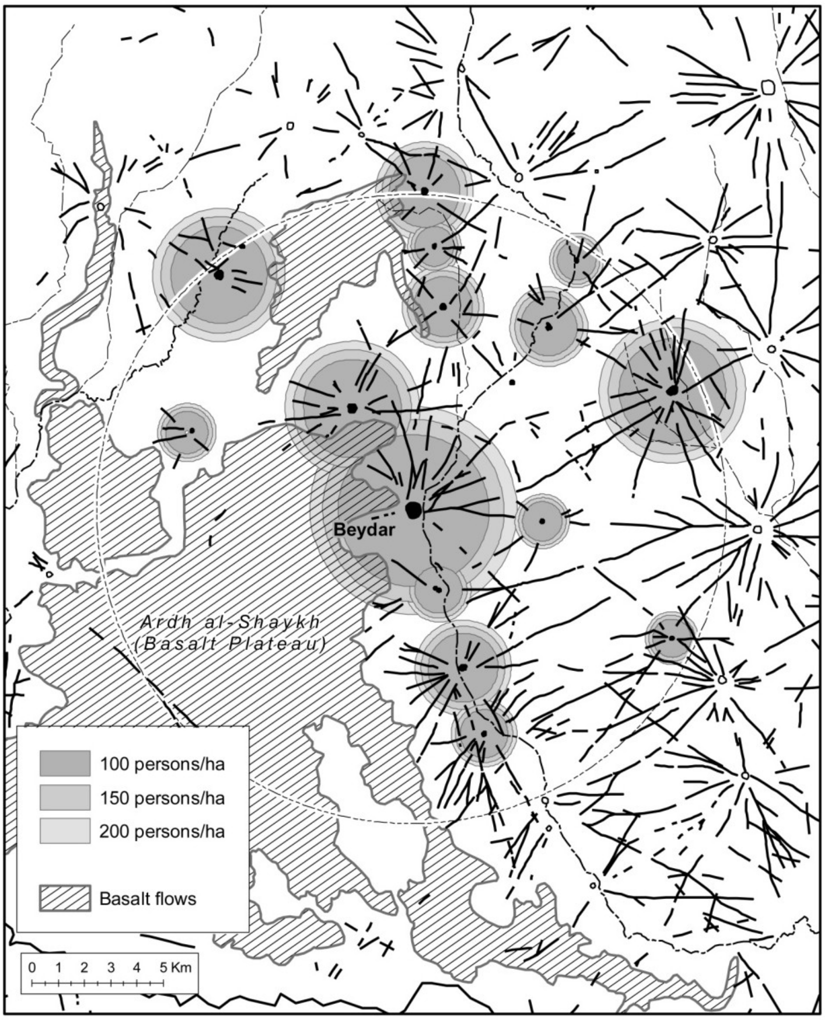

Fig. 4.2 Agricultural sustaining areas of sites in the area of Tell Beydar (J.A.Ur).

The third way that land use and the extent of cultivation can be estimated around different sites is by looking at the evidence for plow teams derived from cuneiform texts (Widell 2004; Pruβ & Sallaberger 2003/04: 303).

In the years 1993 to 2002, 216 cuneiform tablets dating to around 2400 BC were excavated at Tell Beydar (see Ismail et al. 1996 & Milano et al. 2004). Almost all of the tablets concern various aspects of farming and grain management, labor or animal husbandry. One text (Ismail et al. 1996, no. 3) gives the number of plow animals used in Beydar as well as the number of animals allocated to six smaller settlements around the site (see Table 4.1).

[1] The above estimates assume biennial fallow.

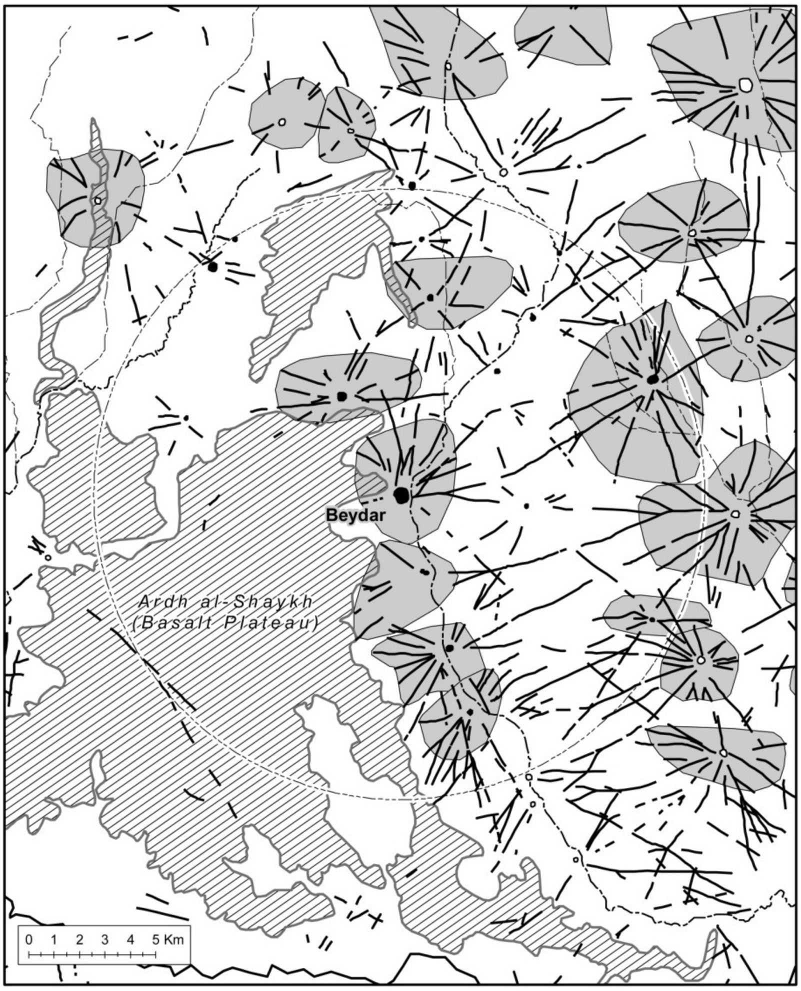

Fig. 4.3 Cultivated areas in the area of Tell Beydar inferred from hollow ways (J.A. Ur).

Table 4.1 Plow animals employed at Beydar and its satellites (adopted from Widell 2004: 720). For the reconstructions of the numbers in the text, see Widell 2004.

	Plowing Animal	
Settlement	Oxen	Asses
Tell Beydar	67–77	88
[Settlement ?]	4–7	16
Išgar	10	10
Sulum	10	0
(Settlement)	6–10	0
Akhudu	8	0
Tuamu	6	0

Ethnographic studies conducted in northern Syria have demonstrated that when oxen and donkeys are used for plowing they are primarily used in pairs. If we assume that this was the case in antiquity, text no. 3 (Ismail et al. 1996), shows that 33.5-38.5 teams of oxen and 44 teams of donkeys were used to till the fields directly attached to Beydar. The surrounding satellites would together have had 22-25.5 teams of oxen and 13 teams of donkeys. Observations from the northern parts of Jordan in the area around Irbid have provided data on the daily tillage capacity of plowing teams using the traditional symmetrical ard (Palmer 1998; Russell & Palmer 1993; see also Widell 2004: 721 n.23). Since the present environmental conditions of the area around Irbid are rather similar to those of the Upper Khabur, these data can be used to produce an approximate estimate of the daily tillage capacity of the Beydar teams. The data show that a team of oxen is able to till 0.3–0.4 hectares per day, while a team of donkeys manage 0.2–0.3 hectares per day.

Studies of modern planting seasons for barley cultivated under rain-fed conditions in the area (see Widell 2003: 721-722, with additional literature), taken together with ethnographic data on agricultural procedures under rain-fed conditions in northern Syria and Jordan from the last century (e.g. Sweet 1974; Palmer 1998; Palmer & Russell 1993; Russell 1988; Halstead 1995; Duwayari 1980 & 1985), allow us to roughly reconstruct the area these teams would be capable of cultivating in one year. While such calculations always will remain approximations, we may conclude that based on the availability of plow animals, the area of cultivated fields directly attached to Tell Beydar should be reconstructed to contain approximately 400-800 hectares, while the total tilled areas of the satellites around the site amounted to another 200-400 hectares. Together, these figures presumably constitute the total cultivated area required to feed the entire population of Tell Beydar. This land would feed roughly 1,200-2,400 people.[2] If resident at Tell Beydar, this would give a total population density for Tell Beydar's 17 hectares of occupation of 71–141 persons per hectare (see Widell 2004: 721-22, with additional references).

Assuming that the standard biennial fallow regime was used in the particular year of the third Beydar text, the total area of arable land would have to be twice as large as the plowed area. A certain amount of wasteland that was unsuitable or unavailable for cultivation and therefore not tilled at all also has to be added to the arable land. If we estimate that wasteland comprised 25% of the total agricultural area (see Widell 2004: 723), the cultivated fields, fallow and wasteland around Beydar (i.e., the same area as we assume was covered by the radial system of hollow ways around the site) would together amount to approximately 1100 to 2100 hectares.

The population-derived sustaining areas including fallow and waste – that assume a population density on Tell Beydar of 100 to 150 persons per hectare coincide rather well with the area estimates of cultivated land, fallow, and waste as derived from the cuneiform record of plow animals for Beydar and its surrounding settlements (Table 4.2). On the other hand, the sustaining area estimate that assumes a population density of 200 persons per hectare would have been too great for the quantity of plow animals. From the point of view of the textually based cross-check, a population density at Beydar of greater than 150 persons per hectare would not have been sustainable without the importation of agricultural products.

The lower part of the table shows the estimated agricultural limits of Tell Beydar alone derived from the hollow ways and from the plow teams. This convergence of the data on a common territorial limit of roughly 2-2.5km radius provides an extremely useful reconstruction of the agricultural landscape of Early Bronze Age settlements, and could represent the maximum distance the farmers were willing to walk in order to reach their fields (Chisholm 1962). This would mean that the cultivated areas around larger settlements (i.e. 10-plus hectares) were not simply determined by the sizes of these settlements, and therefore in all likelihood not by their direct consumption needs and/or labor and traction recourses. Instead, larger settlements would have had to routinely import grain from smaller sites to sustain their populations (Wilkinson 1994: 501-02); alternatively we would have to simply assume that the larger settlements had significantly lower population densities than the

[2] These calculations of people sustained by the cultivated fields of Tell Beydar and the surrounding satellites assume that one hectare of arable land (i.e., 0.5ha cultivated land and 0.5ha fallow land) is needed to support a single person for a year. More specifically, it is assumed that the average grain yield of one hectare of cultivation was 500kg, or 250kg per hectare of arable land subjected to biennial fallow, and that an average annual consumption of grain is 250kg per person.

smaller settlements, and that population numbers were driven by cultivated areas rather than settlement sizes. Settlements like Tell Beydar may not, therefore, have under-produced in relation to their populations, only in relation to their physical sizes. In reality, it is likely that there was a tension between the limit of the cultivated area set by a convenient walking distance to the fields and the 'push' that resulted from either the size of the population from the neighboring site, or from the demand required to sustain the main settlement (in this case Tell Beydar), a point that is returned to in Chapter 15.

In conclusion, it should be noted that the rather neat example above is based upon a number of assumptions which may or may not be correct. One strength of the approach of agent-based modeling is that it enables the researcher to vary the input parameters at will in order to see how the estimated plowing capacity and populations might vary.

Table 4.2: Comparison between estimates of cultivated areas using landscape data and the evidence from cuneiform tablets.

Beydar with Satellites		
	Area Required to Sustain the Estimated Site Population (100–150 persons/ha)	Area Estimated from All Plow Animals Administrated by Beydar
Total land allocated (demand?)	2,267–3,400 ha	1,683–3,132 ha
Beydar Only		
	Area Estimated from Hollow Way Catchment around Beydar	Area Estimated from Plow Animals Working Beydar Fields
Arable land around Beydar (supply?)	1,503 ha	1,131–2,097 ha

A Model Khabur Landscape

As a complement to the above, it is possible to suggest how the land around a late prehistoric or Bronze Age settlement may have been configured. Ottoman records and ethnographic analogies allow us to distill some essential features from traditional landscapes of the region which, in turn, make it possible to draw further inferences concerning the Bronze Age landscape of the rain-fed farming areas. However, as Halstead reminds us, 'Projecting traditional practice back into the past can be dangerous, but it can help us ask the right questions' (Halstead 1987).

As discussed in Chapter 5, the traditional Middle Eastern village was intimately linked to its surrounding fields. During the later phases of the Ottoman empire, the typical settlement in its semi-arid margins was a nucleated village around which extended the fields of the community. This makes a useful analogy with the Bronze Age tells of Upper Mesopotamia: not only do these sites, which form one of the most characteristic features of the Middle East landscape, appear to have been tightly clustered communities usually surrounded by defensive walls, the surrounding fields are also usually without evidence of Bronze Age occupation, except for the presence of a scatter of sherds as discussed above.

According to the official Ottoman registers (*defterlı*), a village consisted of 'a communal and territorial unit with fixed boundaries of arable land and pastures and total tax liability (*hasil*)' (Inalcık 1994: 173-74). The boundaries of the village lands were known to the inhabitants in relation to features of the landscape such as trees, conspicuous rocks and streams, and these limits were relayed to the Ottoman authorities by local trustworthy individuals via kadis (Islamic judges). The Ottoman village, like the Greek and Roman town, was expected to be self-sufficient under normal circumstances (Inalcık 1994: 176).

It is by no means as straightforward to establish equivalent data sources for the ancient Near East. Despite the considerable number of cuneiform texts recovered from sites in the rain-fed zone, it is difficult to derive much direct evidence for the detailed practices of Bronze Age agriculture. Cuneiform texts from northern Syria sometimes refer to the ownership of agricultural land or the layout of field plots (Zaccagnini 1979; Liverani 1992; Mori 2004), but they do not discuss methods of working the land and distributing its products (Magness-Gardiner 1994: 43), nor the methods of land distribution within the community. Most texts relate to the state and temple sectors of the urban centres of power, rather than to the rural communities that were the most common element of Mesopotamian society (Adams 1982: 11; Diakonoff 1975: 131). This problem also extends to land tenure, and Postgate has reminded us that:

> '…clearly most existing entitlement to land would be unwritten, though fixed by custom, and the need for documentary proof probably crept in with the gradual encroachment of urban landlords.' (Postgate 1982: 311-12)

Nevertheless, at Alalakh and Ebla cuneiform texts refer to villages that were transferred between rulers, together with their population, their surrounding lands and the revenues derived from them (Schloen 2001: 306-307; Zaccagnini 1989; Magness-Gardiner 1994: 40; Wiseman 1953: 47-48). This reinforces the notion that the village and its surrounding lands formed a single unit, which under normal circumstances remained together, were indivisible, and could not be parcelled up into individual units and sold off privately.

A major problem in trying to recreate a model Bronze Age community comes from not knowing whether the land was private or held according to some form of communal land holding systems similar to, for example, the manorial systems of medieval Europe. A number of Near Eastern archaeologists and ancient historians have referred back, somewhat vaguely, to a phase of rural settlement in which early village communities were organized along communal lines. These range from Lamberg-Karlovsky's estimate (1999: 179-80) that this was during the ceramic Neolithic to Fales' (1984: 8) argument that such a communal phase of village land holding continued until the last two centuries of the Neo-Assyrian empire.[3]

An analogy for such communal practice can be found in the musha'a system of the Levant in which individual parcels of land are rotated regularly, with the result that no one individual or household 'owns' the land and therefore cannot settle on it. Although a compelling case can be made for translating the Ottoman practice of musha'a back into the Bronze Age or earlier, some scholars harbor significant doubts about extrapolating such a landholding system into the distant past. For example, Inalcık (1994: 164) does not accept that such a system can be applied to land ownership in Byzantium. However, the musha'a system does provide a relatively straightforward process of land redistribution that avoids the ever-finer systems of field sub-division that result under systems of private land-holding and partible inheritance. Moreover, such systems of communal land holding can be readily modeled and the results compared with systems of private land holding.

Whatever system of land-holding was practiced in the Bronze Age, however, it can be argued that transhumance and bare fallowing are integrally bound up with the nucleated nature of human settlement in the recent past (Halstead 1986: 64). Plow teams are thought to have been a fundamental part of such systems of agriculture, but were expensive to maintain because of their high fodder requirements; in fact the feeding costs of such work animals has been described as prodigious.[4]

[3] The question of land holdings and labor is considered by Schloen (2001: 230-231).
[4] A point confirmed by R. Adams, pers. comm. 18th Feb. 2010.

Plow Teams, Village Herds and their Role in The Landscape

Texts from southern Mesopotamia lend support to the above-mentioned fodder requirements of draft animals. A group of approximately 100 tablets from Ur III Umma can be used as an example (e.g. MVN 21 253, BIN 40, SA 147), as they record the daily barley and bran fodder expenditures to smaller groups of cattle for shorter periods of time. The daily fodder amounts in these texts display a relatively wide range of variation, but typically an ox would be hand-fed some 20 liters of bran (duh) every day (approximately 5-6kg), and often this intake would be complemented by an additional 4-6 liters of barley (≈ 2.5-3.7kg).[5] In fact many Roman colonial land allotments may have been too small to maintain such work animals: for example, two hectares worked by hand could feed a family, whereas some five hectares would be required if work animals were kept. According to Delille (see Halstead 1986: footnote 48), maximum cultivable areas of 3.5ha and 10ha respectively can be estimated for small holdings without and with a pair of oxen, and Halstead even suggests that grazing of 10-12ha was required to provide for a single ox (Halstead 1986: 64).

According to the cuneiform records from southern Mesopotamia in the late third millennium, fodder for plow animals was typically calculated by the administrators as half of the field's seeding rate (Powell 1984; Civil 1994: 82). For example, in a Girsu field with 10 furrows/ninda (i.e. the furrows were 60cm apart), one bur$_3$ of land (about 6.48ha) would cost 450 sila$_3$ of grain (about 450l) to cultivate (not including human labor costs); 300 sila$_3$ would be seed, and 150 sila$_3$ would be fodder for the oxen pulling the seeder plow. In other words, for every hectare tilled/planted, the team of oxen would consume roughly 23l of grain (about 14kg).

According to Hruška (1994: 10-12), who studied the administration of draught animals in the Old Sumerian administrative texts from Girsu, most equids used for plowing (and other agricultural tasks) received daily rations of 3 sila$_3$ barley (≈ 1.9kg), although the largest male animals received as much as 4.5 sila$_3$ per day (≈ 2.8kg). In these Old Sumerian fodder texts, all draught animals are counted in 'teams' (EREN$_2$) consisting of four animals, although Hruška assumes that the plow was drawn by two animals, accompanied by reserve animals receiving 3 sila$_3$/day (Hruška 1994: 8 n. 6).

Obviously, such figures derived from cuneiform texts from the south are not necessarily applicable to the north, where the soils often (but obviously not consistently; see Chapter 2) can be lighter than on the alluvial plain, which would result in less demanding plowing, and where the (broadcast) seeding rates in general were much higher than in the south where the seeder plow was employed. Nevertheless they demonstrate the significant feeding costs of the Mesopotamian plow teams. Some data from third millennium cuneiform texts from the north are also available. For example, the Tell Beydar texts inform us that donkeys (or possibly donkey-onager hybrids; see Widell 2004: 728, n. 63) used to pull chariots were counted in 'teams' (see below) and typically hand-fed 10 sila$_3$ grain per day during the lord's visits to city (Sallaberger 1996a: 103-106). This would roughly correspond to a daily intake of 6.2kg barley or 7.7kg wheat, which certainly must be considered excessive. In fact, if kept up for a longer period of time, daily rations of this size, which would represent more than 2-3 times the daily amounts received by Hruška's equids in Old Sumerian Girsu, would be very harmful to larger equids (see Widell 2004: 729-730). Not surprisingly, the monthly rations for plowing donkeys in Tell Beydar were significantly less generous, and amounted to only 37.5 sila$_3$/month (≈ 23 kg barley or 29 kg wheat), although the 'donkey of the pen' is recorded to have received as much as 90 sila$_3$/month (≈ 56/69kg barley/wheat), which would represent an adequate monthly intake of grain for a 250kg donkey if the grain was supplemented by an additional 80-100kg straw (Widell 2004: 727-728). Based on this, it is reasonable to assume that all donkeys not referred to as being kept 'in the pen' were supplementing their grain rations with some amount of grazing.

The high costs of maintaining donkeys and, in particular, oxen would be further exacerbated if the plow teams were larger than two animals, as might be inferred from the Tell Beydar texts in which the plow animals were counted in "teams" (EREN$_2$) consisting of four animals (Sallaberger 1996b: 82). However, it is necessary here

[5] For a useful volume-to-weight conversion table of agricultural products, see United States Department of Agriculture 2000: v-vii.

to remember that while all draught animals in Tell Beydar (not just plow animals) may have been counted in such teams by the administrators of the city, this in itself does not constitute conclusive evidence that a typical plow in Tell Beydar was drawn by four animals. As mentioned above, the Sumerian term $EREN_2$ was also used for teams of four draught animals in southern Mesopotamia, and the administrative use of $EREN_2$ for groups of four draught animals in Tell Beydar may simply be a reflection of southern plowing and traction practices, where the ideal plow team consisted of four oxen (see Renger 1990a: 275).[6] However, as mentioned above, the soil on the southern plain is generally finer and heavier than in the rain-fed agricultural zone (although it should be noted that soil conditions are regional, and that there are many exceptions to this north vs. south generalization), and would therefore in most cases require stronger plow teams than in the rain-fed north. It is also well known that the more demanding seeder plow was used in the south from at least the middle of the third millennium. Plow teams consisting of four oxen are extremely cumbersome to maneuver and turn around, and are ideally used on very large (and elongated) fields, while dual traction is more economic and meaningful on smaller fields with lighter soil. It should furthermore be noted that the tractive force and general effectiveness of the individual plow animal decreases by a factor of 7-10% for each additional working animal added to the team (see Renger 1990a: 274-275), and the most economic plow teams will therefore always consist of as few animals as the soil and general plowing conditions in a particular area permit. As mentioned above, ethnographic studies and observations of traditional agriculture practiced in the rain-fed agricultural zone in the last century suggest that two animals drawing the plow should be regarded as the norm in upper Mesopotamia (see further Widell 2004: 719).

Given the high cost of the maintenance of draft animals, it is likely that these would not only have been prized by their communities, but also that it may have been necessary to share them between several households. Because of this intrinsic importance of draft animals to the local economy, Ottoman records frequently state the number of plow animals, and the number of plow teams were indicative of the strength of farming communities in the Levant. Thus the faddan, namely the amount of land that can be plowed by a pair of oxen in one day:

> '…was therefore not ….a standard indication of surface area; it was rather a social unit of measurement testifying to the productive strength or wealth of village or individual.'
> (Schaebler 2000: 258)

The scattered nature of many traditional farm plots made it difficult for households to graze their small herds of livestock on their own agricultural land. Moreover, fields under cereals and in fallow, tended to be grouped into large blocks to facilitate herding, and such large herds facilitated transhumance. Consequently, livestock were often consolidated into large flocks or herds, organized either communally or under the oversight of specialist pastoralists (Halstead 1986: 64). That similar practices were adopted in ancient Upper Mesopotamia are suggested by Middle Assyrian texts (ca. the thirteenth century BC) from Tell Bir Ali in northern Iraq, which document the existence of flock masters (nāqidu) who controlled flocks for government officials and the local palace in the town of Atmannu (probably present-day Tell Bir Ali; see Ismail & Postgate 2008: 149 and 153). Such flocks, which consisted of between 250 and 800 animals, would have placed a significant stress on the vegetation as well as more generally on the landscape, and probably contributed significantly to the erosion of the broad hollow ways described above.

Reconstruction of Land Use Patterns around a Tell Community

Although field patterns dating back to the fifth millennium BC have been recorded in southeastern Iran (Prickett 1986), unfortunately none are known from northern Iraq or Syria. Consequently, for many of the MASS simulations, cultivation units were reconstructed as a series of block-like fields as illustrated in Chapters 10 and 11. An alternative field pattern can be generated based on the logic of accessing fields via the hollow ways etched into the Bronze Age landscape described above, supported by the pattern of fields evident in Ottoman-period villages such as Bar Elias in Lebanon or Qara Qosh in Iraq (Figs. 4.4 and 4.1). At Bar Elias, embedded

[6] Similar to how e.g. the fuel economy of a car in the UK is measured in MPGs (miles per gallon), despite the fact that petrol is measured and purchased in liters in the country.

within the dense mass of finely sub-divided field strips and now infilled by them, are broad radial features reminiscent of drove ways or hollow ways (compare Figs. 4.4 and 4.5). The fields (albeit now highly fragmented) can be seen to have been set nearly at right angles to the tracks. Although in the limited cultivated area of Bar Elias only three tracks are evident, in the Khabur basin representative examples of radial hollow way routes average six hollow ways for a minor settlement and in excess of 12 for the larger tells (Ur 2010; Smith 2008). In the case of Bar Elias, a further set of subsidiary routes appears to have led to the further outlying block-like fields following the boundaries between the fields laid out from the broader drove ways (Fig. 4.5). This suggests that at Bar Elias the broad tracks granted access to the older fields nearest the settlement, whereas the narrower secondary tracks led to the more recent distant fields.

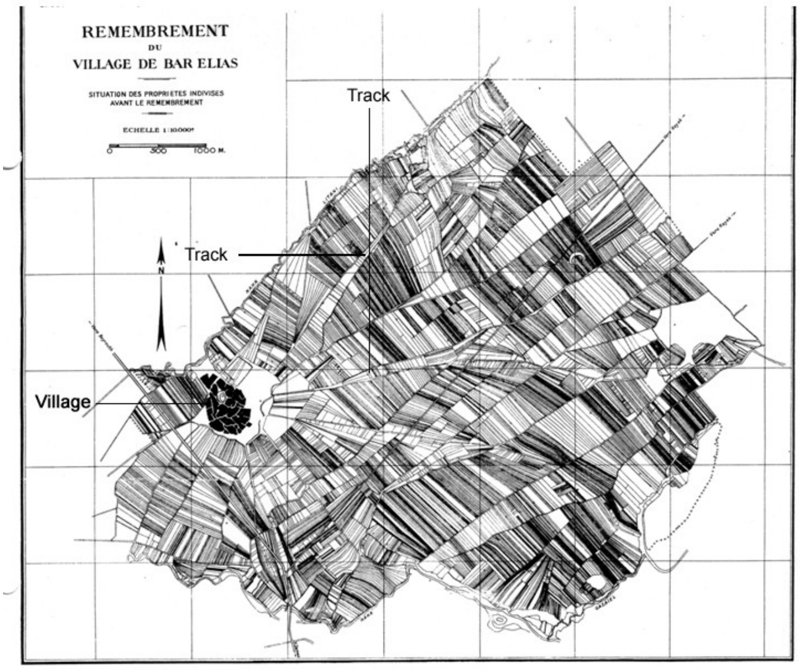

Fig. 4.4 Bar Elias (Lebanon): strip fields remaining from the Ottoman period (after Weulersse 1946: fig. 37).

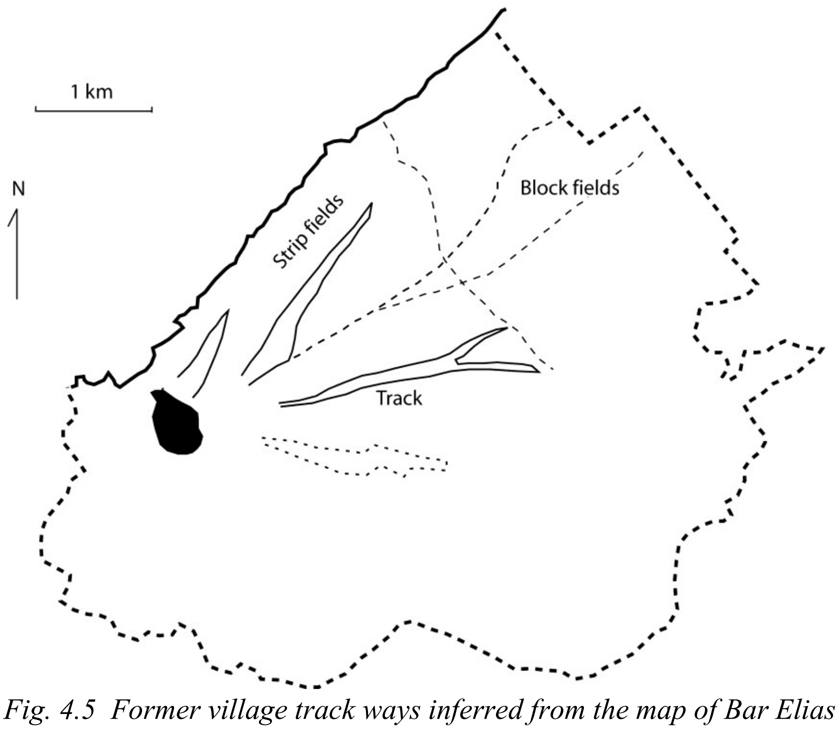

Fig. 4.5 Former village track ways inferred from the map of Bar Elias (Fig. 4.4).

Applying this principle of secondary tracks to a hypothetical field layout developed over three broad phases (Fig. 4.6), one can reconstruct the tracks of the third phase to follow the boundaries of the primary fields close to the site, and therefore to lead to the fields that developed in the outlying zones as the agricultural area expanded. This development of additional tracks or hollow ways, which is proportional to the growth of the central settlement (Fig. 4.6), is apparently in harmony with both the pattern of hollow ways evident in the Khabur basin of Syria and the tendency (weak, but evident) for larger sites to be associated with an increased number of hollow ways. The resultant radial landscape provides a marked contrast to those of southern Mesopotamia discussed below.

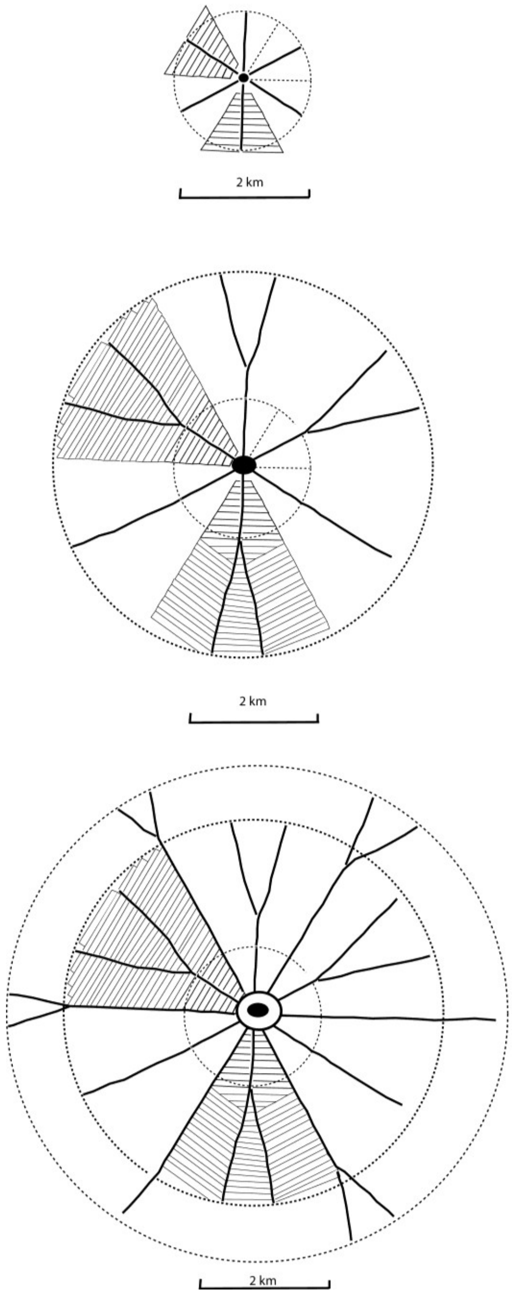

Fig. 4.6 Reconstruction of the development of radial track ways around a Bronze Age centre, based upon data from hollow ways and Fig. 4.5. The top figure shows an early stage of growth, the center where the limit is just beyond the track bifurcations and the lowest where the maximum limit is achieved by pushing beyond the conventional 'fade out' zone (center).

THE AGRICULTURAL LANDSCAPE OF SOUTHERN MESOPOTAMIA

The rural landscape, comprising the physical arrangement of irrigation channels and cultivated fields, has been rather neglected in many studies concerned with the administration and economy of ancient Mesopotamia (although see Richardson 2007). This neglect is not entirely surprising: first of all, the focus of many studies in the past, both by archaeologists and epigraphers – especially if we go far back in time – has been on ancient cities rather than on the countryside. This is not only because cities, temples and palaces have been considered more interesting than furrows and drainage channels, but also because useful data on the layout of the agricultural landscape have not always been readily available. Of course, epigraphers have had a number of field plans and cadastral texts at their disposal. However, many of these so-called 'field plans' represent theoretical or mathematical problems rather than the outlines of actual fields, and the cadastral texts have always been limited to a few areas and periods (see e.g. Liverani 1996, 1997; Seth 2008), and do often not offer all the details necessary for comprehensive reconstructions of the rural landscape. Nevertheless, although many field plans are thought to represent school texts as used for an exercise, we assume that they represent an underlying reality and constitute useful evidence on the organization of ancient field systems.

Archaeologists have also been faced with some difficulties. The ancient landscapes themselves have been destroyed by natural erosion and sedimentation, alluviation and diversions of rivers and canals, as well as modern interventions of humans, leaving only a palimpsest of features visible. The situation has improved in recent years, with detailed survey data becoming available for several larger areas of southern Mesopotamia (see Ur 2012: 136-137). However, many surveys offer only a low-resolution perspective on relatively large areas, and are therefore less applicable for reconstructions of individual fields and the physical arrangement of cultivated plots along the levee systems.

In order to reconstruct the agricultural landscape of the alluvial plain, we have to look at traditional epigraphic sources in combination with existing survey data, as well as new data made available through remote sensing techniques. The epigraphic material offers some very detailed information crucial to our reconstruction of rural space in southern Mesopotamia. The remote sensing data, on the other hand, provide an overall and more comprehensive picture that complements the detailed epigraphic material. By combining these two sources, we can reconstruct the physical and administrative arrangement of the rural units and irrigation systems along the levee systems of southern Mesopotamia.

Environment and Irrigation in Southern Mesopotamia

Agriculture is not possible in the semi-arid desert environment of southern Mesopotamia without irrigation, which takes place in the context of an interlinked network of water supply, transport and settlement. The presence and dominance of the Tigris and Euphrates rivers have contributed to a landscape that consists of a multitude of environmental and topographic zones (see Chapter 2). Within the plain, such zones include areas of dunes, marshes and tracts of land with agricultural potential. Many of the soils of the alluvium have lowered agricultural potential due to high levels of salt. When viewed as a whole, these features of the alluvial plain indicate that in order to model land use patterns and settlement in southern Mesopotamia, a different emphasis and structure than that used in the rain-fed north is required.

Today the once thriving agricultural landscape of southern Mesopotamia is a combination or irrigated farmland interspersed with 'windows' of semi-arid desert, characterized by the presence of scrub vegetation, active and abandoned agricultural fields and channels, archaeological sites (tells or ihsan), traces of relict channels, migrating barchan dunes and marshes.

The channels of the Euphrates and Tigris rivers form a branching system in which ever-smaller channels branch off the larger channels. Whereas some of these branching channels ultimately find their way into the topographic depressions of flood basins, others led back into the main river channel (see Chapter 2).

Due to the low gradient of the plain and the need to distribute water as widely as possible, the branching network of channels and canals have a very low gradient. From the main river channels, a network of smaller waterways make their way towards agricultural fields and settlements. These smaller channels represent the primary loci for settlement in the alluvium. As ground survey has documented (Adams 1981), most urban sites would have been located on these branches, but at a convenient distance from the main channels in order to maintain access to them. These main branches would have acted as a gateway for transportation along the channels throughout the entire alluvium. The smaller branches also act as a conduit to cultivated fields. From these branches the dendritic pattern of yet smaller channels led to agricultural fields and small farmstead settlements.

Elements of the Irrigated Landscape of Southern Mesopotamia

From the scant archaeological and textual evidence, it seems that early agriculturalists took advantage of the network of anastomosing branches of the Euphrates River, using simple techniques such as canal levee breaks, which functioned as informal sluices to control the flow of the water to fields or settlements. A gradual shift from a reliance upon natural anastomosing branches to increasingly artificially created and manipulated channels appears to have become fully developed by the late third or second millennium BC (Adams 1981). This shift from the natural branches, which constrained settlement and agriculture in narrow bands of cultivation along the main branch, to subsidiary channels farther away from the main branch, meant that settlement could then eventually extend along the newly created channels.

Agricultural Cells

Following the conventional terminology used in most studies on Mesopotamian field systems (see e.g. Widell 2013), we will here refer to the larger tracts of cultivated land as 'fields' (a-ša$_3$), and the smaller family-sized fields as 'plots', typically measuring one eše$_3$ each (approximately 2.16ha). Remote sensing techniques were used to identify ancient levees, settlements and fields over a wide area of southern Mesopotamia (Chapters 2 and 3). Among these, a field system situated in the northeastern part of the alluvium plain between Babylon and Seleucia appears to have drawn its water from a large channel of the Euphrates. There are few dated archaeological sites associated with this levee because it is located largely outside the boundaries of archaeological surveys. However, in his Akkad survey (in Gibson 1972), Robert Adams located two Sasanian to Islamic period sites in the area where the levee turns south near Baghdad, as well as two second millennium BC sites that seem to be located along the northern part of the levee. He dated the levee to the Sasanian period, that is, from the early third century AD to the middle of the seventh century AD.

On the CORONA satellite images, taken in 1968, long and narrow off-take canals run from the crest of the primary channel down the back-slope of the levee on both its northern and southern sides (Fig. 4.7). By following the gradient of the levee, water in these secondary channels is distributed by gravity flow. The secondary canals delineate long, narrow fields that create a 'herringbone' pattern on both sides of the main channel. These canals can be traced until they terminate in the basin areas off the levee gradient. Any excess water will have run into drainage canals or ultimately into marshes or rivers downstream. The secondary channels average 1.3-2km in length from levee crest to basin and are located approximately 150-300m apart (Fig. 4.8). In other words, each long field contains roughly 35-39ha of agricultural land.

The long narrow fields thus delineated are further subdivided by canals that cut across from secondary branch to secondary branch. These tertiary cross canals, located at intervals of 60-100m, are in part accentuated on the satellite image by pale-hued deposits of sand or silt, to form plots of roughly 2-3ha in area (Fig. 4.9).

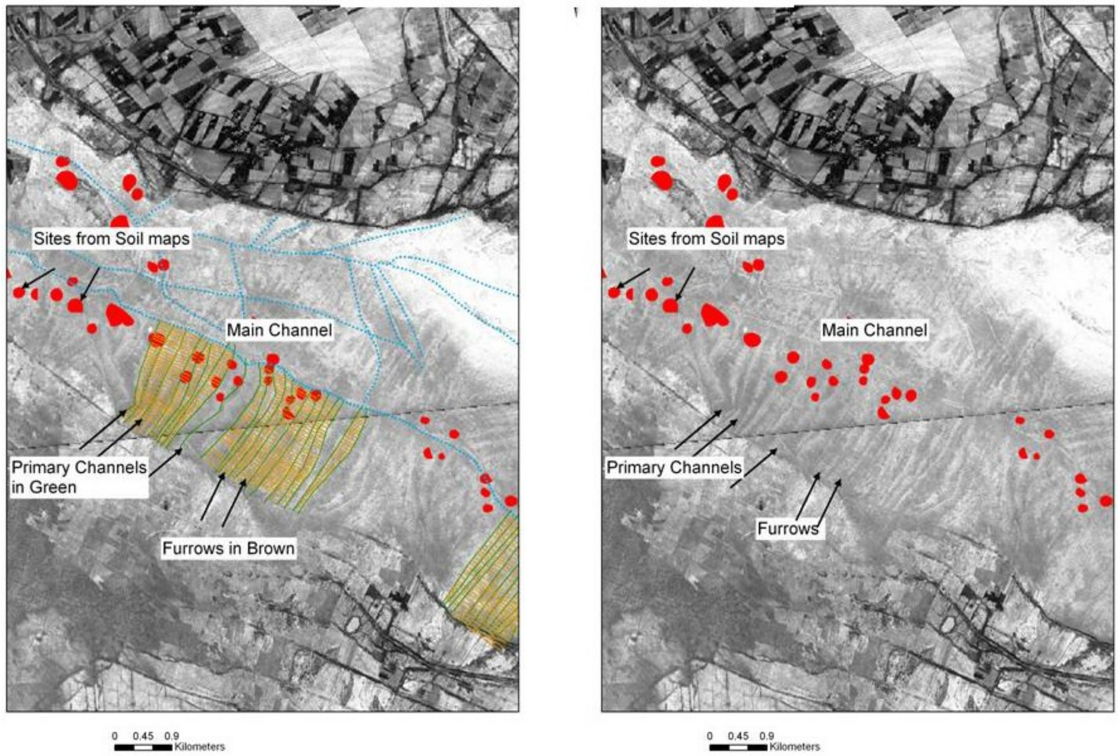

Fig. 4.7 Corona image of pattern of 'herringbone' fields to the west of the Tigris, a) (to left) with field patterns superimposed, b) with fields only (C. Hritz; Image courtesy of US Geological Survey).

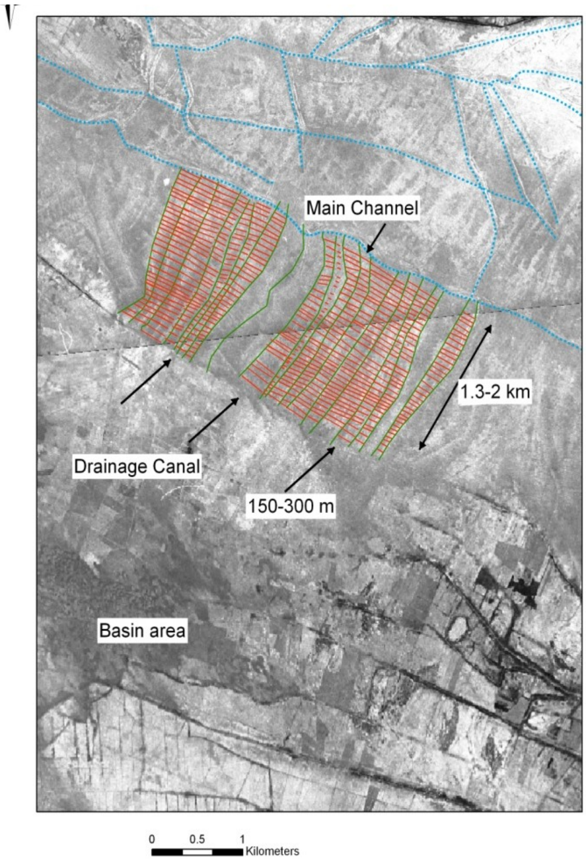

Fig. 4.8. Long channels (1.3-2km) creating strips of land in a 'herringbone' pattern (C. Hritz; Image courtesy of US Geological Survey).

The satellite mapping demonstrates the existence of two basic agricultural subdivisions which can then be compared with the textual evidence.

- Long narrow fields measuring between 1.3 and 2km in length, 150-300m in width and covering an area of 35-39ha.
- Thirty-one smaller plots of roughly 2-3ha each within the above-mentioned long fields. There can be little doubt that these smaller plots represented the actual family-sized fields cultivated in antiquity.

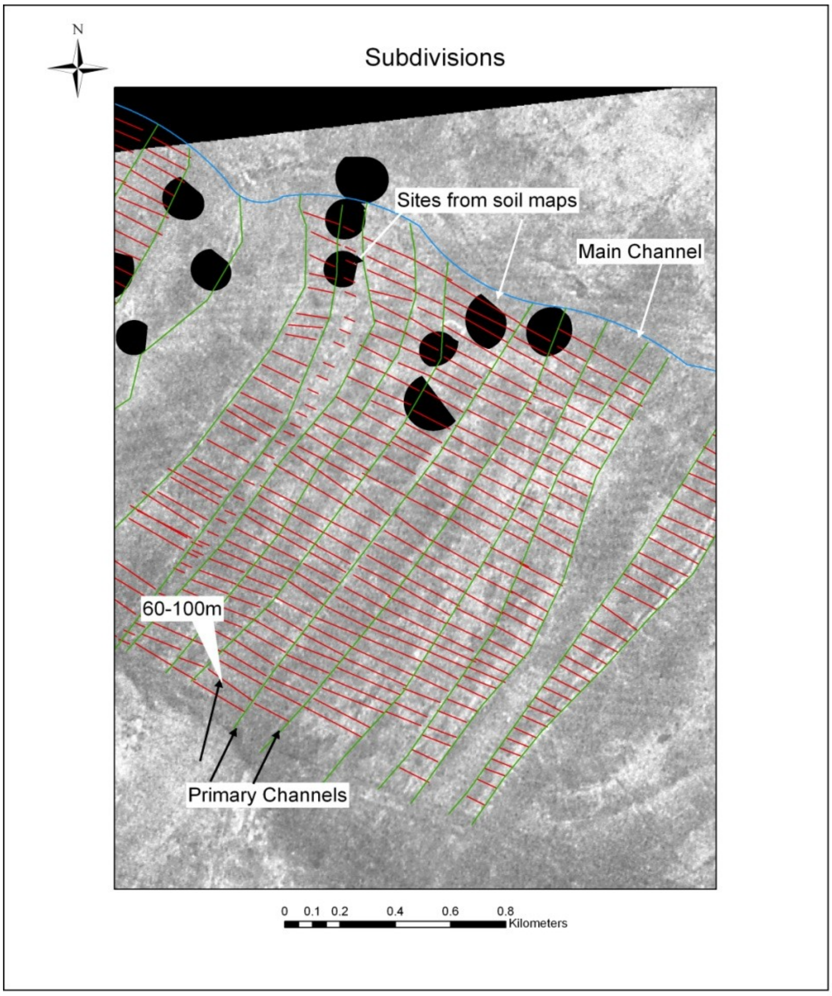

Fig. 4.9 Detail of Fig. 4.8 showing the subdivision of the long, narrow strips into smaller plots measuring 60-100m x 150-300m (i.e. 1-3 ha) (C. Hritz; Image courtesy of US Geological Survey).

Land Use in the South: Evidence from Cuneiform Texts

The Mesopotamian economy was largely based on agriculture, and textual evidence provides detailed information on practically every aspect of agricultural production, including the crucial canal network and its maintenance. The canal network was used for both long- and short-distance transportation of goods, and for the all-important irrigation of the agricultural fields. Terms for canals of all sizes are well attested, in both Sumerian and Akkadian, and virtually all of them have analogs in southern Iraq today (Steinkeller 1988, citing Fernea 1970: 122). Also attested in the cuneiform texts are detailed descriptions of the building and digging of canals, repairing and maintaining them, and of the devices used to control water flow from the river to the field (Kang 1973: 429-438).

Of particular importance for our understanding of hydraulic cultivation are those data bearing on the associated labor. Standard excavation rates in Ur III times were $3m^3$, $2.25m^3$, and $1.6m^3$ per day, the first being the most common for full-grown men (Waetzoldt 1990). Additional evidence is also found in an Old Babylonian mathematical text, which gives rates of $6m^3$ per day to a depth of 0.5m, $3m^3$ to a depth between 0.5m and 1.5m, and $2.55m^3$ to a depth of 1.5m. Less is known about the decision-making processes involved with irrigation, and water management varied with social, economic, and political conditions. A Sargonic text probably originating from ancient Umma (IM 5592/6, published in Steinkeller 1988) may indicate that the water level at an assigned time was one criterion that could be used for water allocation, although the precise Sitz im Leben of this unique text remains uncertain (see Steinkeller 1988: 83-87). On a more organizational level, both the palace and the local populations bore responsibility for irrigation maintenance; Old Babylonian texts, as well as administrative documents from the preceding Ur III period, show that holders of crown land were assigned corvée-duty in order to work on the canals and irrigation systems. One Old Babylonian letter (AbB 2 70) indicates that the labor ratio of the canal maintenance was split 5:1 between the palace and the farmers of crown land (see Renger 1990b: 39). Moreover, the Code of Hammurabi suggests that individual farmers were responsible for maintenance of canals around their fields, and there is one Old Babylonian letter (AbB 8 133) showing two families irrigating their fields on successive days, as is the case in some villages in modern Iraq.

Of particular importance for the control of irrigation water was the canal regulator (kab_2-kud), which was found at canal-canal, canal-field, canal-orchard, and canal-garden junctions. As with other parts of the network, maintenance of kab_2-kuds was done just before the flood season. This involved draining the regulator, removing earth and silt, cleaning, deepening, and reinforcing it, along with the banks of canals, with reed mats and bundles. In the Ur III period, the canal regulator may have been under the control of a specific official; a reconstruction of the device and its place in the irrigation network was offered by Kang (1973: 440; Fig. 4.10).

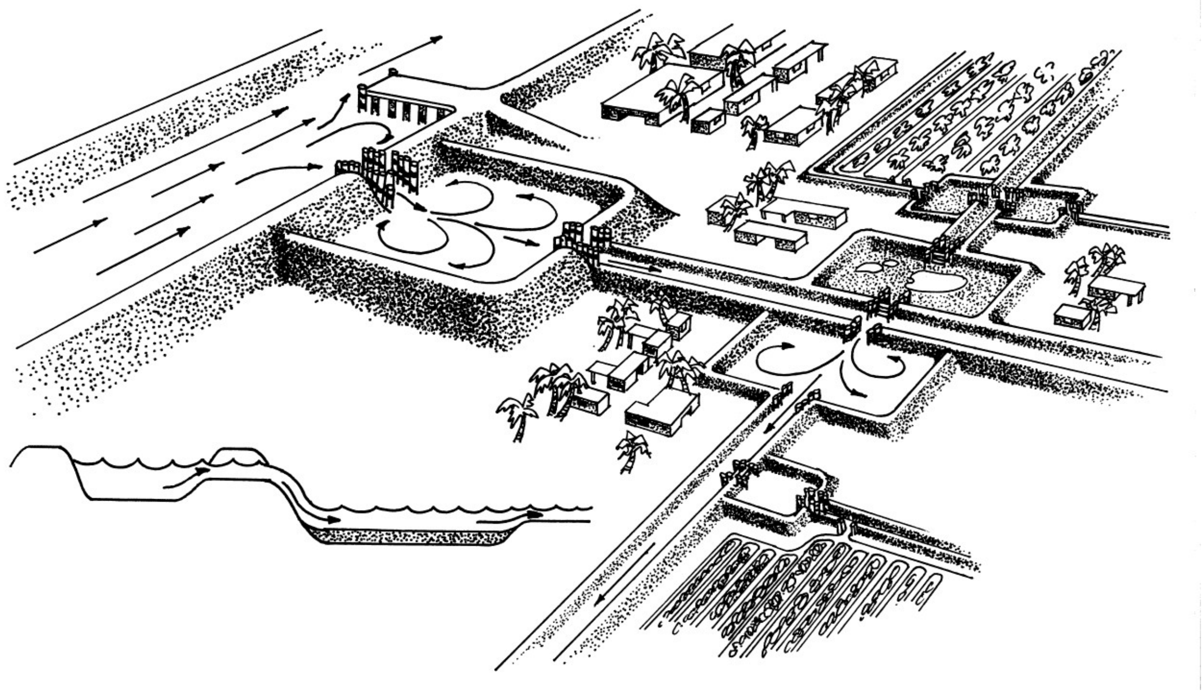

Fig. 4.10 Reconstruction of field irrigation in southern Mesopotamia (re-drawn from Kang 1973: 440, by M. Widell).

For the reconstruction of the physical layout of the ancient field systems in southern Mesopotamia and the sizes and shapes of the agricultural fields and plots, we rely primarily on the tens of thousands of published administrative and economic texts from the Ur III period dating to the final century of the third millennium (see Widell 2013: 55-56). One series of economic documents from this period, which has been studied intensively in order to reconstruct ancient field systems, is a group of approximately 70 cadastral texts from the province of Lagash in southern Mesopotamia, first collected and more systematically studied by Anton Deimel in the beginning of the last century (1909a, 1909b; see also Pettinato 1969; Maekawa 1982). More recent studies of this important group of texts include Liverani (1990, 1996), Maekawa (1992) and, most recently, Widell (2013). The texts were drawn up by the Ur III administration to calculate the barley yields of different fields, and can be used to describe the agricultural landscape of the alluvial plain. As demonstrated by Mario Liverani, these so-called 'round tablets', of which the majority can be dated to the seventh and eighth years of king Amar-Suen's (2046–2038 BC[7]), provide the orientation, size and shape of the individual fields cultivated in the province.

As becomes clear from Figures 4.11 and 4.12, the majority of the fields in these texts (which of course were drawn up within the administrative realm of the Ur III state's interests in the province of Lagash) were very large, with the most frequent sizes in the range of 105-115 iku, which would equal approximately 38-41ha. Approximately 55% of the fields were in the range of 100-125 iku (≈ 36-45ha) while roughly 70% were in the range of 90-135 iku (≈ 32-49ha).

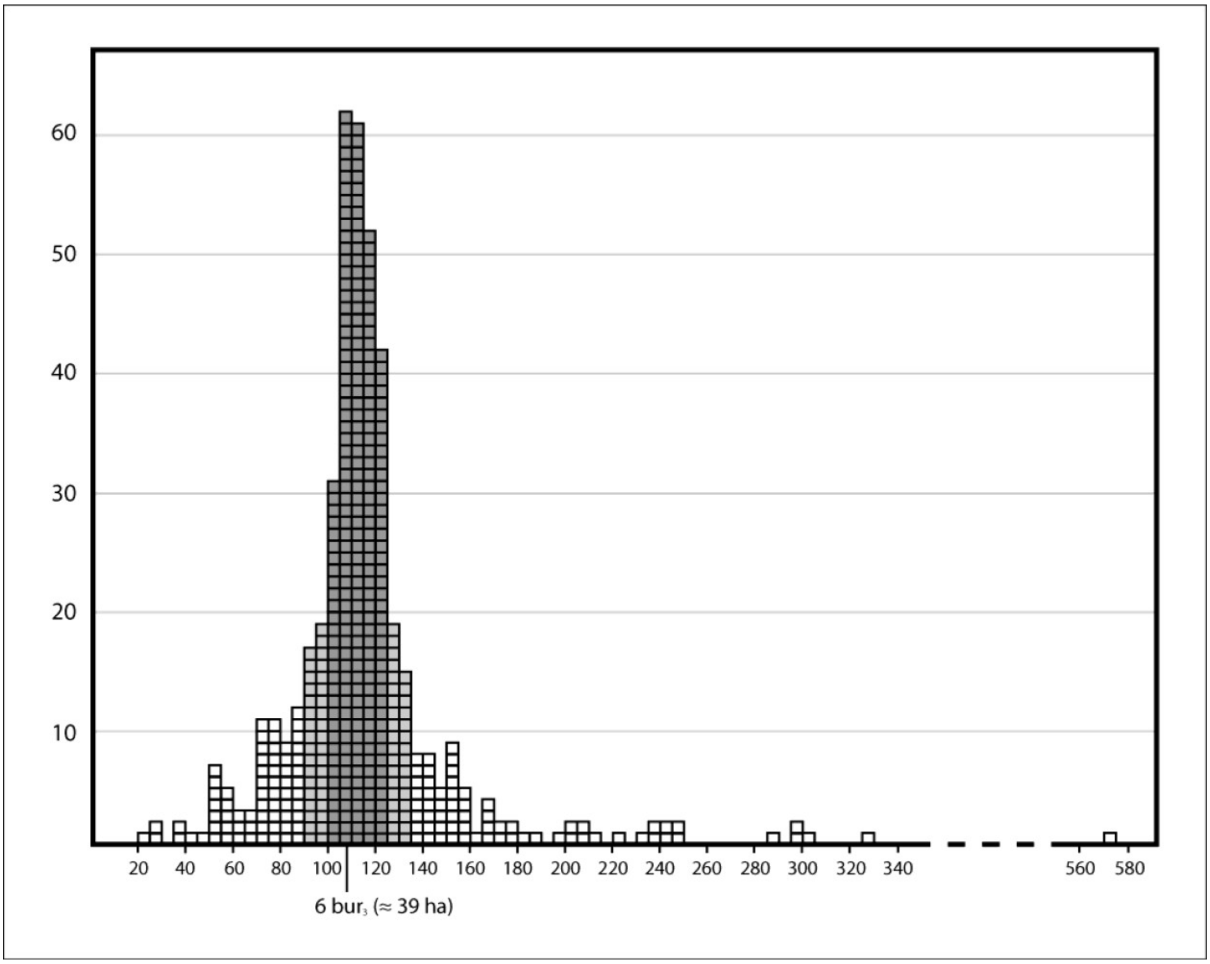

Fig. 4.11 Sizes of Ur III Fields (a-ša$_3$) from Lagaš measured in iku (adapted from Liverani 1996: 156, by M.Widell).

Based on the rather obvious congruity in sizes of the fields, Liverani originally assumed that the standard Ur III field measured 100 iku (i.e. 100 × 100 ninda). This was later challenged by Kazuya Maekawa (1992: 408), who also studied the round tablets as well as other relevant Ur III texts, and who successfully argued that the sizes of these trapezoidal fields were not originally measured in iku (GAN$_2$) but in the bur$_3$ (≈ 6.48ha). According to Maekawa, the standardized (or ideal) field in the Ur III period measured 6 bur$_3$ (= 108 iku), which would equal

[7] The absolute chronology of the earliest Mesopotamian history is debated. If we use the 'Middle Chronology' (which most people use simply out of convention) the Ur III period falls between 2112 and 2004 BC, and the reign of Amar-Suen between 2046 and 2038 BC.

roughly 39ha. The 6 bur_6 field would also be based on the ninda, since it would be composed of three units measuring one square UŠ each, which would equal 60 × 60 ninda (see below).

While it is clear that the surface measurement of the majority of the fields remains relatively consistent at the size of approximately 6 bur_3, the fields display a significant variation in their length-width ratios. While practically all the fields can be described as elongated rectangles or strips of land, some fields were only two or three times longer than they were wide, while other fields had lengths that exceeded their widths by a factor of ten or more.

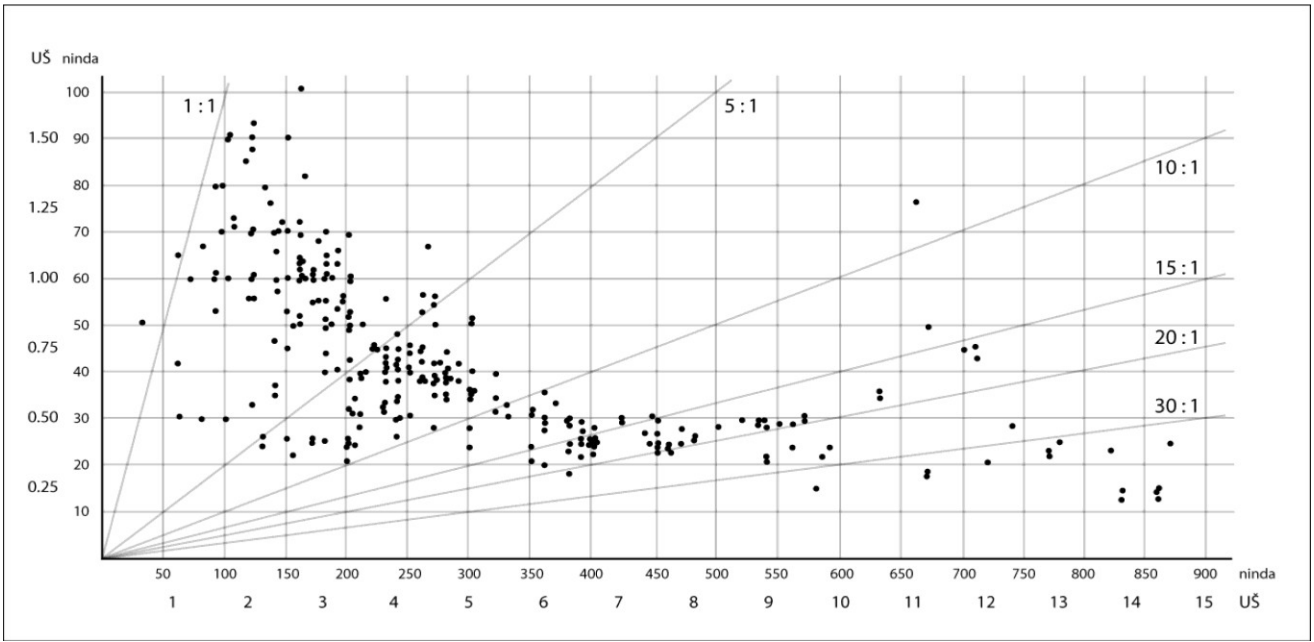

Fig. 4.12 Shapes of the 269 fields (a-ša$_3$) measured in the Lagash cadastral texts. Measurements provided both in ninda (6m) and UŠ (360m). A 6 bur$_3$ field would equal 3 UŠ^2 (adapted from Liverani 1990: 168).

According to Liverani (1996: 21), the average Ur III field had a length that exceeded its width by a factor of ten, and modern studies of ancient field systems in southern Mesopotamia have typically involved the reconstruction of extremely narrow and elongated strips of land (see e.g. Liverani 1997). However, as Figure 4.12 and Table 4.3 demonstrate, the majority of the fields in the cadastral texts can more accurately be described as a highly heterogeneous set of more or less narrow rectangles of cultivated land. Exceptionally elongated strips of land with lengths exceeding their widths by a factor of ten or more certainly existed, but they by no means dominated the agricultural landscape. Fields with a length:width ratio within the modest range 1:1-5:1 were 4-5 times more common than fields in the range 10:1-15:1, and fields within the 1:1-10:1 range were almost 3 times more common in the agricultural landscape than fields ranging from 10:1 to 20:1.

Despite the significant variation in the available data, it is possible to offer a tentative reconstruction of a typical (or ideal) field in Ur III Lagash, as a rectangular area being approximately 30 to 60 ninda wide (about 180m to 360m) and between 180 and 360 ninda long (about 1080m to 2160m). The field would cover a surface area of approximately 35-44ha, and the length:width ratio would be somewhere within the range of 3:1 to 12:1.

Table 4.3. More than one-third of the fields (approximately 38%) were less than five times their width, while more than two-thirds (roughly 68%) were between 1:1 and 10:1 in their length:width proportions (from Widell 2013: Table 3.1)

Length : Width	***Fields***	***Percent***
< 1 : 1	2	1%
1 : 1-5 : 1	100	37%
5 : 1-10 : 1	80	30%
10 : 1-15 : 1	23	9%
15 : 1-20 : 1	41	15%
20 : 1-30 : 1	9	3%
> 30 : 1	14	5%
Total	**269**	**100%**

As already observed by Liverani (1996: 10), fields in the range of 35-44ha would be roughly ten times larger than the family plots of land usually encountered in Mesopotamia. The huge fields of the round tablets have been accepted as a natural feature of the well-known institutionalized agricultural production of the Ur III period referred to in the texts. The elongated shape of the fields adds further support to this theory. As mentioned in the discussion above, longer and narrower fields are more suitable for plowing with teams consisting of two or more oxen and the heavy seeder plow characteristic of the large agricultural societies of southern Mesopotamia, since elongated fields would minimize the number of turns required of the plow teams.

Armed with an approximate idea of the size and shape of fields in the Ur III period, scholars have tentatively been able to reconstruct larger irrigation systems. It is generally accepted that southern Mesopotamia relied on 'furrow irrigation', which usually led to the development of 'herringbone landscapes'. The principle of the system is simple. It was relatively easy for ancient farmers to introduce water from the main waterways onto the fields by making an opening in the levee or canal bank. Gravity would do the rest (Chapter 2). The water flow into secondary channels would have been strictly regulated to save water and to avoid flooding. According to the traditional reconstruction of the agricultural landscape, the water would have been introduced from the secondary channel onto the fields using the natural gradient of the land. This would have been done via the furrows that had been plowed along the elongated fields. In his article on Mesopotamian fields, Liverani writes (1997: 219):

> 'The slight sloping of the field from upper to lower front is necessary in order to irrigate the entire strip (whose length can reach hundreds of meters and even a few kilometers) by gravity flow alone.'

It is generally assumed that the water from the rivers was diverted onto the units of land by means of 'furrow irrigation', and that the furrows must have followed the natural gradient of the land. Surplus water would have been drained by means of a dedicated channel at the end of the system. However, irrigation water did not necessarily flow via single furrows extending all the way from the secondary channel to the final drainage channel. According to Itzhak Arnon (1972: 219), who studied crop production in dry environments, the ideal length of the furrows in furrow irrigation regimes varies from 50m to 300m. Because the natural gradient of the land in southern Mesopotamia is extremely low (Widell 2013: 58), it therefore seems unlikely that irrigation furrows were designed to be much more than one hundred meters long.

If more water than necessary was introduced to a field, the surplus water would flow into a drainage channel, either to low lying areas and marshes or, if possible, back into the main channel further down the system. Water also had to be drained from the fields or it would seep into the soil and raise the salts to the surface, which would lead to soil salinization.

A pictographic representation of the furrow irrigation system with the main channel, the secondary channels and the drainage channel, can be seen in the archaic cuneiform sign *GAN*$_2$, which, synonymously with *a-ša*$_3$, was used to denote a field in ancient Sumer (Fig. 4.13; Nissen, Damerow & Englund 1993: 55).

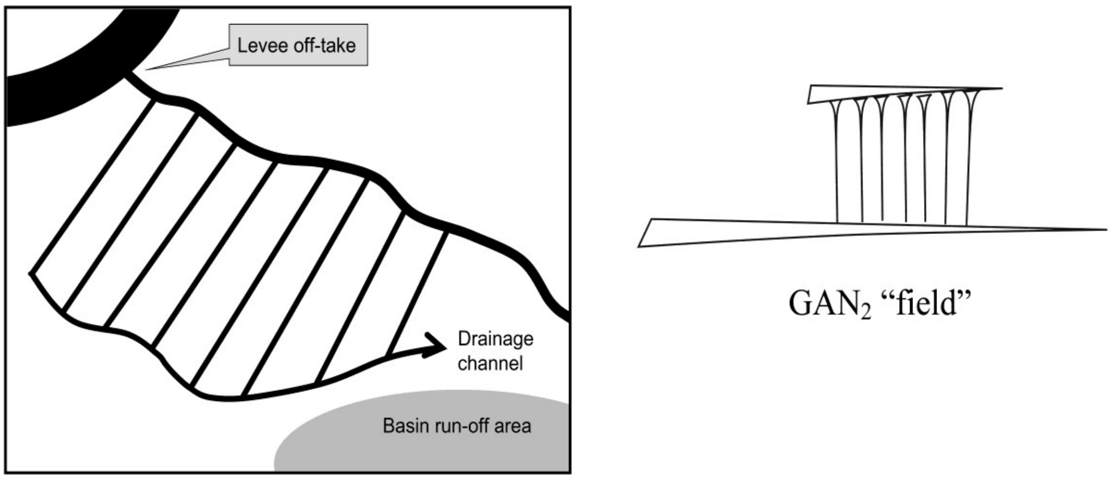

Fig. 4.13 Schematic irrigation system in southern Mesopotamia compared to the archaic sign GAN$_2$ *'field' as it was written around 3000 BC (the sign is copied from the Uruk tablet A.2515 kept in the Oriental Institute of the University of Chicago, which was drawn up to calculate the amount of grain needed to plant a field area).*

Until now, our reconstruction has been largely based on information derived from cuneiform texts. In order to model such a system it is necessary to ask how this system worked and what it looked like. The texts have given us a reasonable, albeit somewhat theoretical, picture of third millennium irrigation systems; it is now possible to use the methods of remote sensing and satellite imagery to cross-check and improve the text-based reconstruction of the physical layout of the cultivated fields.

Combining Texts and Satellite Images

As discussed above, the CORONA satellite image indicates the trace of a primary channel, as well as secondary channels, which provide the outlines of the strips of land referred to as a-ša$_3$ in the Ur III textual evidence. The secondary channels average 1.3-2km in length when measured from the main channel to the long drainage channel that runs southwest of the levee. This allows us to calculate an area for the elongated strips of land: roughly 35-39ha, each being located at intervals of 150-300m apart. The long, narrow fields delineated by the secondary channels on the CORONA images are therefore very similar in appearance to those described by the Ur III cuneiform texts (Fig. 4.4). It is possible that the striking similarity between the preserved irrigation system on the satellite imagery and our reconstruction of the agricultural landscape around Lagash based on the cuneiform texts is a result of the fact that the topography and the gradient of the land in the two areas are very similar.

The satellite imagery also indicates that smaller tertiary canals further subdivide these long fields. These cross field tertiary channels are located at intervals of 60-100m, creating smaller rectangular plots measuring one to three hectares.

Table 4.4: Comparison of major land holdings ("fields") according to images and texts.

Satellite imagery:	**Textual data:**
150-300m wide	180-360m wide
1,300-2,000m long (35-39ha)	1,080-2,160m long (35-44ha)

It is perhaps worthy to note that these reconstructed field lengths of 1,300-2,000m and 1,080-2,160m (respectively) appear to have been roughly half the widths of a levee (i.e. 2-5km: Chapter 2; Wilkinson 2013: 43). It seems plausible that these long and narrow fields constituted the building blocks of the so-called 'herringbone landscapes' mentioned above that characterized the countryside in southern Mesopotamia (Fig. 4.14).

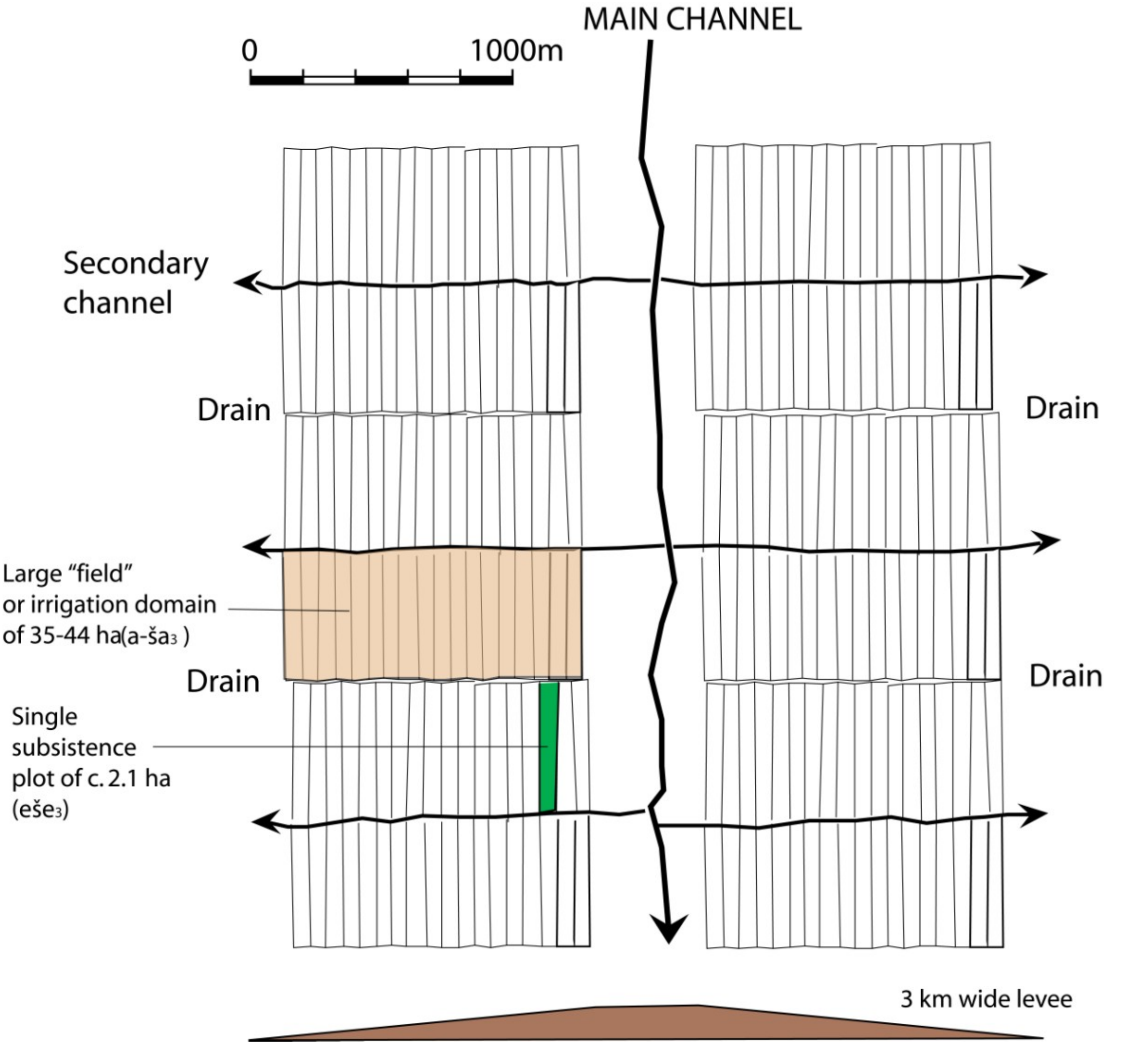

Fig. 4.14 Reconstruction of a 'herringbone' irrigation system based upon the width of a typical levee and the length of branch canals as recorded in cuneiform texts. Note that the presence of drains is speculative (T.J. Wilkinson).

Based on the remote sensing data, which reveals long narrow fields that are divided vertically into subdivisions that result in field plots ranging from one to three hectares, we may conclude that the Sumerian a-ša$_3$ in the Ur III cadastral texts from southern Mesopotamia should be understood as rectangular units of cultivation, which in turn were composed of many individual plots of land. Canals breaking through the a-ša$_3$ units divided the plots, and the water was diverted onto the plots of land through irrigation furrows from these channels.

As demonstrated elsewhere (e.g. Maekawa 1987; Widell 2013), each a-ša$_3$ field was the responsibility of the 'Cultivator' (engar), who directly supervised three 'ox drivers' (ša$_3$-gu$_4$). Since 6 bur$_3$ – the ideal field size in southern Mesopotamia – can conveniently be divided into three equal units measuring one square UŠ each (60 × 60 ninda), we may with some confidence conclude that the each ox driver was (under ideal circumstances) responsible for the cultivation and maintenance of a square UŠ. Each square UŠ would be further subdivided into 6 separate plots measuring 1 eše$_3$ each (= 6 iku), which would be roughly equal to 2.16ha. Plots measuring one eše$_3$ represented the standard sustenance land allocations (GAN$_2$ gu$_4$) in southern Mesopotamia, and it seems highly likely that these eše$_3$ plots represented the smallest units of cultivation measuring one to three hectares observed in the satellite imagery discussed above (Fig. 4.15).

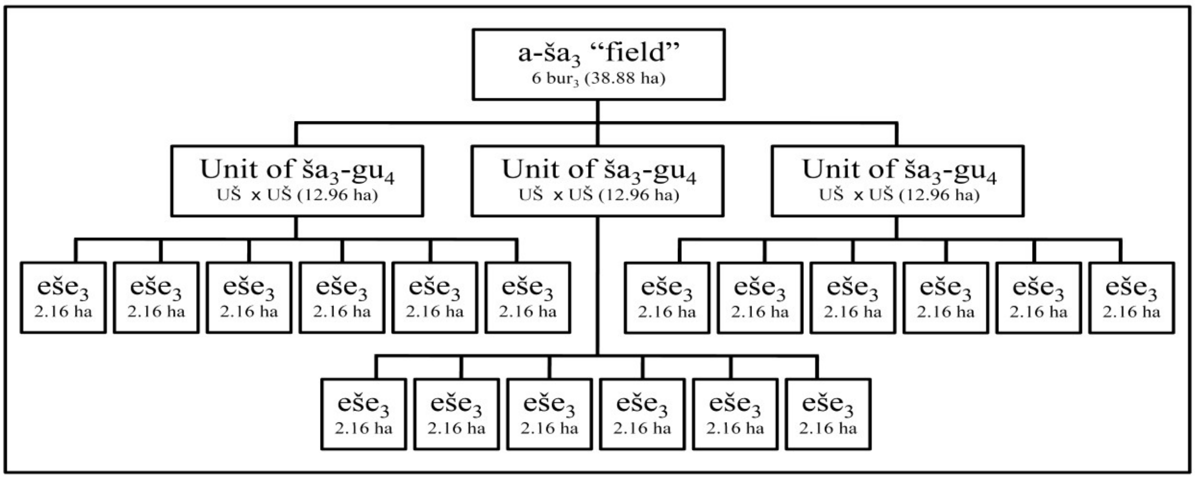

Fig. 4.15 The administrative composition of a 'field' in southern Mesopotamia (from Widell 2013: 61).

Building a Southern Model

Although southern Mesopotamia has provided us with a wide range of information on the rural landscape, our data come from widely separated areas. Unfortunately, we were unable to find on satellite imagery a distinct field system, as is described above, in the vicinity of the area where the texts were obtained (in the area of al-Hiba in the south). We therefore took Partho-Sasanian field layouts and superimposed them on a representative and well-documented landscape of the third millennium BC, which can be found roughly halfway between the area of field evidence and where the texts were found. This landscape was found to the south of Nippur, where a combination of high-quality SRTM imagery and survey data have revealed a pattern of third millennium settlement along a well-developed levee (Adams 1981: figs 30 and 31; Chapter 13). The third millennium BC sites are spaced at intervals of 2-4km along the levee system to provide a basic template for the southern model (Fig. 4.16). This figure illustrates the new configuration, with a similar herringbone field layout and associated third millennium sites.

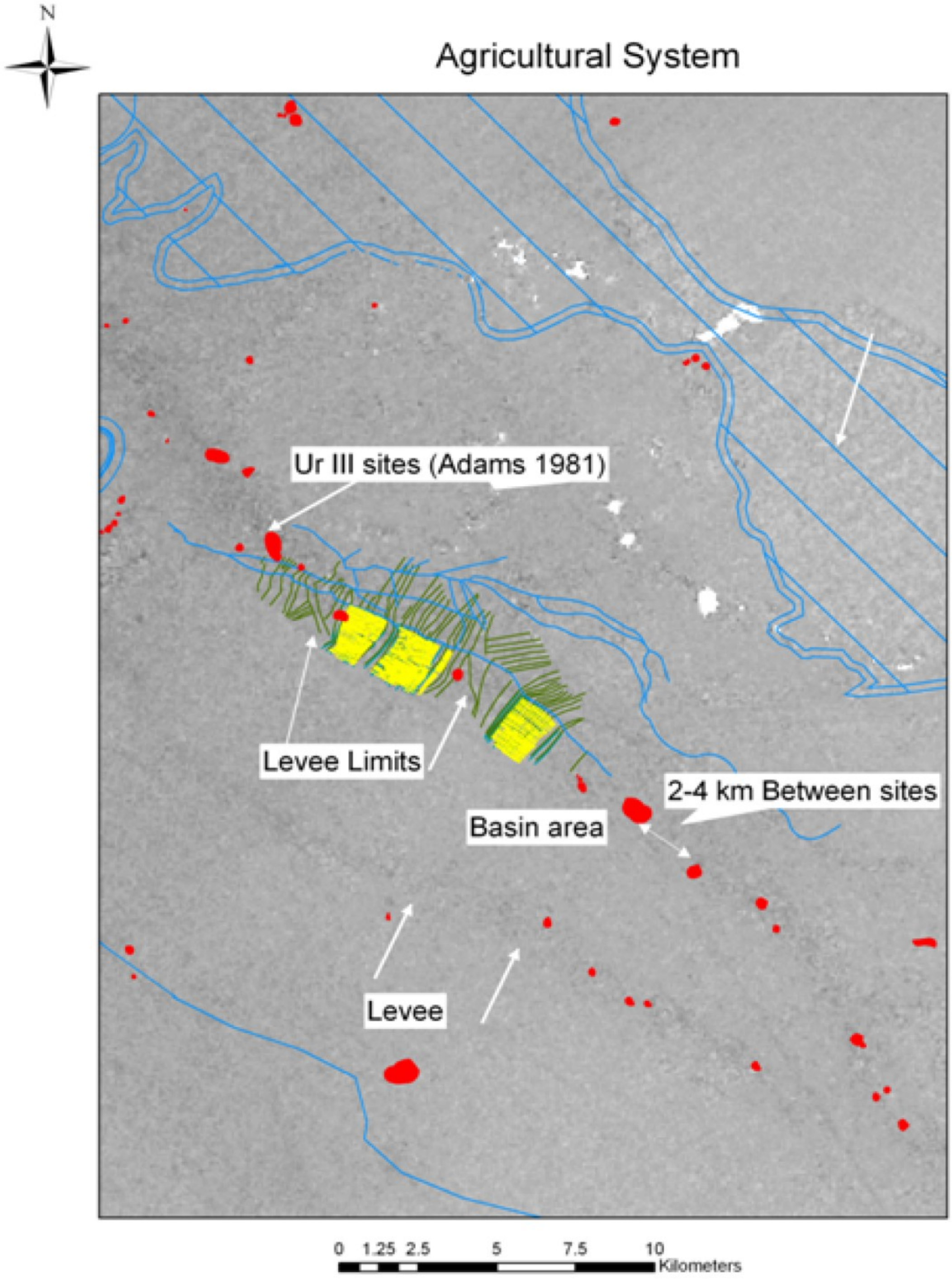

Fig. 4.16 Herringbone irrigation and field system superimposed on a levee in the region of Nippur (C. Hritz).

Overall, this chapter has demonstrated that ancient landscapes inferred from field surveys and geoarchaeology align remarkably well with those registered in cuneiform texts. However, what we lack is the human element in the landscape and knowledge of how people actually used this landscape to provide for their everyday needs. Moreover, we need to know how the households coped with crises of food supply, as well as external factors such as meeting the additional demands from taxation and corvée labor. These topics will be elaborated in Chapters 13, 14 and 15.

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