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# The rivers of civilization

Mark G. Macklin [a, b, *], John Lewin [a]

[a] Centre for Catchment and Coastal Research and the River Basin Dynamics and Hydrology Research Group, Department of Geography and Earth Sciences, Aberystwyth University, Ceredigion, SY23 3DB, UK
[b] Institute Agriculture and Environment, College of Sciences, Massey University, Private Bag 11 222, Palmerston North 4442, New Zealand

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ABSTRACT

The hydromorphic regimes that underpinned Old World river-based civilizations are reviewed in light of recent research. Notable Holocene climatic changes varied from region to region, whilst the dynamics of floodplain environments were equally diverse, with river channel changes significantly affecting human settlement. There were longer-term trends in Holocene hydroclimate and multi-centennial length 'flood-rich' and 'flood-poor' episodes. These impacted on five identified flooding and settlement scenarios: (i) alluvial fans and aprons; (ii) laterally mobile rivers; (iii) rivers with well-developed levees and flood basins; (iv) river systems characterised by avulsions and floodouts; and (v) large river-fed wetlands. This gave a range of changes that were either more or less regular or *incremental* from year-to-year (and thus potentially manageable) or *catastrophic*. The latter might be sudden during a flood event or a few seasons (*acute*), or over longer periods extending over many decades or even centuries (*chronic*). The geomorphic and environmental impacts of these events on riparian societies were very often irreversible. Contrasts are made between allogenic and autogenic mechanism for imposing environmental stress on riverine communities and a distinction is made between channel avulsion and contraction responses. Floods, droughts and river channel changes can precondition as well as trigger environmental crises and societal collapse. The Nile system currently offers the best set of independently dated Holocene fluvial and archaeological records, and the contrasted effects of changing hydromorphological regimes on flood-water farming are examined. The persistence of civilizations depended essentially on the societies that maintained them, but they were also understandably resilient in some environments (Pharaonic Egypt in the Egyptian Nile), appear to have had more limited windows of opportunity in others (the Kerma Kingdom in the Nubian Nile), or required settlement mobility or exceptional engineering response (Huang He, Mesopotamia) to accommodate problems such as river avulsion, desiccation or local salinization.



## 1. Introduction

The first Old World civilizations, along the Huang He, Indus, Nile, Tigris and Euphrates rivers were almost entirely on alluvium. They were 'hydraulic' (cf. Wittfogel, 1957) or 'potamic' in the sense that they were in relatively dry environments and farming depended on natural inundation or controlled irrigation from river water. This most commonly involved floodwaters from 'exotic' rivers passing into semi-arid or arid environments; discharges were strongly seasonal, and in most cases derived from headwater precipitation regimes often very different to their receiving floodplains. Floods also brought nutrient-rich sediments. This provided the potential for a prosperous agriculture and for organised societies to develop urban cultures in which deified rulers, writing, and artistic creativity flourished. At the same time, these early civilizations were vulnerable to both political and environmental stresses, and there has been much debate as to which factors were most significant in contributing to periods of decline and collapse (McAnany and Yoffee, 2010; Butzer, 2012). From the environmental point of view, causes of settlement abandonment are believed to have included prolonged drought (e.g. the Indus; Giosan et al., 2012), channel network contraction and retraction through abrupt reductions in river flow (e.g. Nile in Nubia; Macklin et al., 2013b) destructive floods associated with short-term climate change (e.g. Huang He; Kidder et al., 2012), and long-term soil

* Corresponding author. Centre for Catchment and Coastal Research and the River Basin Dynamics and Hydrology Research Group, Department of Geography and Earth Sciences, Aberystwyth University, Ceredigion, SY23 3DB, UK.
*E-mail address:* mvm@aber.ac.uk (M.G. Macklin).

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deterioration through salinization (e.g. Euphrates; Jacobsen and Adams, 1958). Flood regimes were essential to all Old World river civilizations but floods needed to be neither too large, nor too small or infrequent.

This paper considers the variability of river regimes: climate, hydrology and geomorphology driven, and collectively termed 'hydromorphic regimes'. These varied both spatially and temporally, and they underpinned the major hydraulic civilizations of the Old World. This is not at all to claim that environmental character and variability were necessarily of overriding importance, nor to minimize social and political factors for the development or the demise of ancient civilizations. Instead we explore with greater focus the opportunities and stresses which living in particular river environment posed. These were not uniform either in space or time, and we believe it important to provide evaluations of the diverse and dynamic qualities of these environments that are, as far as possible, independent of the evidence of human occupation. Were there characteristics of some alluvial settings which made them especially attractive or, ultimately, hazardous? If there were cultural crises, did they coincide with dated flood or drought episodes? Did civilizations or cities decline when particular river channels can be shown to have shifted course or dried up? Such changes need to be independently verified and precisely dated rather than hypothesised on the basis of settlement abandonment, and they need to be understood in the properly combined context of regional and local palaeohydrology, as well as river channel and floodplain dynamics.

What has been confirmed in recent years, both from much improved records of Holocene climate variability (Mayewski et al., 2004; Wanner et al., 2011), and from directly studying the alluvial sedimentary record (Macklin et al., 2012b), is that the Holocene was characterised by significant changes in river discharge regime. In a growing number of environments, episodes of higher and lower flood frequencies and magnitudes have been demonstrated (Ely et al., 1993; Knox, 1993; Macklin et al., 2002, 2005, 2006, 2010, 2012a; Macklin and Lewin, 2003, 2008; Thorndycraft and Benito, 2006; Zielhofer and Faust, 2008; Sinha and Sarka, 2009). This is of special significance for presently semi-arid and arid environments (Waters, 2000; Huckleberry and Duff, 2008; Harden et al., 2010; Macklin et al., 2013b) where quite small differences in annual flood level or runs of drier years are likely to have had a considerable impact on community prosperity and on the durability of physical structures and the organisation of water distribution. Awareness of such sensitivities in past times is tangentially confirmed, for example, by the efforts made to gauge flood levels in Egyptian 'nilometers' and the use of such information to set levels of taxation (Bell, 1970; Butzer, 1976). Crop yields, and therefore equitable tax demands, could be related to floodwater levels.

A further important consideration is that large rivers and their floodplains – such as the Huang He, Indus, Nile, Tigris and Euphrates – are, like large rivers in general, highly varied both in dynamics and form (Lewin and Ashworth, 2014a, 2014b). In some, river channels are relatively stable for centuries; they may aggrade their beds and bank zones, and then avulse to a new location (Huang He, lower Euphrates) – but only rarely. Where rivers flow through broad basins, such avulsions can shift channels in single events for tens to hundreds of kilometres. Channel contraction and wholesale abandonment of once multiple channels took place along the Nubian Nile (Woodward et al., 2001; Macklin et al., 2013b) and retraction in former tributaries of the Indus (Giosan et al., 2012). In other situations channels have shifted short distances but frequently, with annually evolving bank erosion and meander loops (upper Tigris), or the formation of islands which over decades to centuries have become attached to floodplains (the Nile in Upper Egypt). In yet others, highly unstable braided systems occupy a broad zone of ephemeral channels and temporary gravel or sand bars (middle Indus). Changes here may sweep across entire floodplains or alter the local topography in a matter of one or two seasons. Finally, river incision, largely resulting from a changed balance between sediment supply and runoff, may considerably affect groundwater levels and floodplain agriculture as channels become entrenched. However, on the large rivers here being considered, channel entrenchment has not played a major role in settlement development as it did for example in the American Southwest (e.g. Hack, 1942; Waters and Field, 1986) and mountain piedmont settlements along the Pamir and Tien Shan mountains, Central Asia (Lewis, 1966; Macklin et al., in review).

Despite individual exceptional studies (e.g. Hack, 1942; Adams and Nissen, 1972; Butzer, 1976; Waters and Field, 1986; Wilkinson, 2003; Morozova, 2005; Arnaud-Fassetta et al., 2010; Giosan et al., 2012; Macklin et al., 2013b), there has been limited overall appreciation of the global complexities of floodplain hydromorphologies that formed the environmental contexts for early riverine agriculturalists. Considering these issues only for broad geographical areas, or from the viewpoint of cultures and governance alone, does not provide an adequate framework for understanding the site opportunities and hazards that these populations faced when their life ways depended entirely on local river dynamics and flooding regime. Large rivers such as the Egyptian and Nubian Nile, the Tigris, the Euphrates, the Indus and the Hwang He, both at present and during the periods that these first Old World civilizations flourished, were dissimilar from each other, and they also displayed considerable variability from reach-to-reach. Hydroclimatic fluctuations, or major floods and droughts, which might have been catastrophic in one situation, could be survived in another – because of differences in natural river channel dynamics, floodplain morphologies and floodwater distribution systems. It is also likely that some changes that were ruinous from a settlement point of view, such as channel shifts and avulsions, were triggered by relatively minor events within the normal spectrum of local hydrological regimes and not necessarily related to external climatic signals. For human exploitation given the technologies available, *local* site opportunities were of particular importance. These may have been almost incidental to the main activities of rivers, as in the provision of ponded 'reservoirs' of annually replenished water in cutoff palaeochannels or in geomorphologically moribund river branches that still carried flow, at least seasonally. The ways floodwaters spread, could be 'stored' on floodplains, or could be re-directed must also have been crucial. In the context of prehistoric and early historical irrigation-based agriculturists, it is necessary to consider what may now seem to be quite minor features of alluvial landscapes as these often had a major controlling impact on the routing of floods and of water storage.

There have been considerable advances in river system and environmental change research in the last several decades that have particular relevance to the study of riverine civilizations. These have involved: a greater understanding of alluvial sedimentology (Miall, 1996; Brown, 1997; Marriott and Alexander, 1999; Bridge, 2003); an appreciation of the global variety to floodplain character and evolution (Nanson and Croke, 1992; Schumm and Winkley, 1994; Tooth, 2000, 2013; Latrubesse et al., 2005; Gupta, 2007; Tooth and McCarthy, 2007; Latrubesse, 2008; Weissman et al., 2010; Ashworth and Lewin, 2012; Lewin and Ashworth, 2014a, 2014b); the availability of high-resolution maps of floodplains and channel ways generated by LiDAR (Lane, 2006; Jones et al., 2007; Wheaton et al., 2010) and other remote sensing imagery (Syvitski et al., 2012); the sequencing of floodwater inundation and transmission (Anderson et al., 1996; Mertes, 1997; Schumann et al., 2009; Trigg et al., 2012); and the numerical