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Tropical Development

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Abstract

For hundreds of years, the world's tropical regions have been poorer than the temperate zone countries. Does tropicality make the struggle for economic development harder? What do people caught up in the struggle do? The paper defines "tropicality" as uncertain and insufficient moisture supply, which, in the past, generated a variety of adaptive strategies such as migration and transhumance. In the twentieth century, however, the response pattern changed from adapting to moisture supply towards control of moisture supply. This process unleashed conflict and environmental stress in the vulnerable geography of the semi-arid tropics.

I. Tropical Development

It is well-known to development specialists that countries situated on or between the two tropics (23°27′ north and south latitudes) are poorer than the rest of the world. "In 1992," we read in an NBER blog, "GNP per capita in the tropical regions was 25 percent of that in the temperate zone" (Sachs 2001). Angus Maddison's data suggest that the inequality had been present in the early nineteenth century. In 1820, GDP per capita in major intertropical regions (South Asia, the Middle East, Sub-Saharan Africa, and Latin America excluding Argentina and Chile) was 30-32 percent of that in Europe and European settler regions.[1] Indeed, it was present, less starkly, from much before that. In 1600, the average income in Africa was 47 percent of that in Western Europe, and in India,

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[1] Maddison Project Database (2020).

60 percent of the latter.[2] In other words, the three great nineteenth-century forces economic historians sometimes cite to explain the origin of modern world inequality – industrialization, globalization, and European colonial rule – would not explain this inequality.

Here, the word "tropical" is a mixture of different ecological conditions, containing deserts, high mountains, drylands with seasonal rainfall, fertile deltas like Bengal, and very wet equatorial forests. However, this diversity does not make the inequality between tropical and temperate less compelling. No one has claimed that the diversity within the tropics was so great or changed in such a way as to make tropical underdevelopment an illusion. The inequality finding should apply to each one of these areas.[3] This paper is mainly about the semi-arid belts with significant human habitation covering the largest intertropical area.[4]

The inequality finding raises two questions for the historian. Does tropicality make the struggle to achieve economic growth more arduous than in temperate regions? And surely, people living in these lands did not suffer adverse conditions in silence. What did they do to change their condition?

Comparative economic history does not answer these questions presently. Most accounts of the origin of world inequality assume that Western Europe's rapid economic development since the nineteenth century is the real puzzle. These accounts hold one factor from a long menu responsible for Europe's emergence: institutions, market integration, trade cost, fossil fuel, enlightened economy,

[2] http://www.ggdc.net › horizontal-file_02-2010

[3] It is possible to suggest a deeper unity between the dry and wet areas in the intertropical region, their shared feature being geographically limited human control over moisture flow, of which floods and droughts were the symptoms. In turn, reclamation of land for productive use was relatively difficult compared with the temperate regions.

[4] Within that broad zone, the paper concentrates on three areas, countries in Sub-Saharan Africa with low average rainfall; South Asia, especially India and Pakistan; and the arid areas of Mozambique and Angola. The choice is driven by the availability of significant historical scholarship to draw on. One other region, north-eastern Brazil stretching over Ceará, Bahia, Pernambuco, Rio Grande do Norte and Paraiba provinces is also arid or semi-arid but appears less well-served by historical scholarship.

activist states, and political autonomy. They then ask why that factor was missing, weak, or worked differently in the tropics. It is equivalent to start from the other end, insist that tropical underdevelopment is the real puzzle, and the rise of Europe reflected the absence of a factor that made tropical development a struggle. Consider the following example. In the tropical regions, this paper will suggest, economic emergence and breaking the barrier of a traditional pattern of life depended on securing more water and distributing it more equally. That Britain was more affluent than, say, Mauritania in 1800 had likely owed to the former's higher agricultural productivity, which had partly owed to an average Briton having fourteen times more water than the Mauritanian. Britain's economic emergence is not so great a puzzle in this example. But if communities in Mauritania could change their conditions by securing water differently, that would surely be something to explain. Besides, most accounts of international economic inequality are too focused on the nineteenth century, whereas tropical underdevelopment had older roots. The post-1800 "great divergence" has little relation with the tropical-temperate inequality.

The broader argument is that the method of explaining economic emergence and its absence in every case of the world with a single variable is not a reliable one if world regions are incommensurate in their geographies. Because their initial conditions were different from those in Europe and North America, tropical economies could arrive at economic growth by solving different problems from those the Europeans and Americans needed to solve. The problem was ensuring reliable access to clean water and dealing with rainfall seasonality.

Although the main stem of economic history is not especially helpful, three subsidiary scholarships in the field engage with the concept of tropicality.

II. Three paradigms on tropicality

In 1970, the economist W. Arthur Lewis published an edited collection of essays called *Tropical Development* (Lewis, ed. 1970). Contributors to the book explored

an idea that Lewis had set out in a lecture the year before. The idea was that the nineteenth-century history of the tropical regions was indeed distinct, in that whereas "the engine of growth in the temperate world has been industrial production, the engine of growth in the tropical world until quite recently has been exports to the temperate world" (Johnson 1971: 132). Nearly all the chapters in the book attributed the export growth to the transport revolution, which reduced the cost of trading bulky agricultural goods. Some, however, also considered institutional and political shifts enabling or forcing market integration. A decade before, the economist Hla Myint had offered a variation of the same story in a series of papers, emphasizing the availability of surplus land in the tropics on the eve of the export boom. A synthesis of the historical interpretation appeared in the book form in 1965 (Myint 1965).

Against the main current of economic ideology then, Myint advocated openness rather than protectionism. Lewis and Myint were optimistic about trade. That optimism begged the question: if tropical export agriculture was almost as good a pathway to develop as industrialization, why did many tropical countries stay poor? Lewis' answer was inefficient agriculture, an idea that did not see much elaboration beyond a few suggestive remarks. Myint's historical analysis, too, did not go far in tackling the question, a result partly of the terse text of the book.

In comparative economic history, Lewis continues to be influential. Economic history writings continue to examine if Lewis' intuition was helpful or overstated the transformative potentials of tropical export growth.[5] However, for this paper, the trade-based concept of tropicality is not helpful. It is relevant for post-1880, whereas the tropical-temperate inequality has an older antecedent. Moreover, the definition of tropicality is not rooted in geography but is derived; tropical is what the western trajectory is not. And the account of inefficient agriculture is obsolete at worst and undeveloped at best.

[5] 'A tropical location did prove advantageous for .. the agricultural and forestry products which could be most easily produced in the tropics (such as palm oil, cocoa, rubber, citrus fruits and spices amongst many others) did not have temperate zone substitutes,' Havinden and Meredith (1996: 18). See also Williamson (2013) and Federico and Tena-Junguito (2017).

The second set of writings to foreground tropicality are the attempts by Karl Marx, Karl Wittfogel, and Fernand Braudel to write a history of the world. Taken together, they insist, rightly, that in the world's arid lands, water control was a crucial matter. Such control, these works suggest, involved *large* projects, *state* projects, *command* over labour, and, therefore, *despotic* states. "The administrative officialdom [in China, Egypt and India formed a] mighty hydraulic bureaucracy," wrote Wittfogel (1957: 8). Similarly, for Braudel, wet (irrigated) rice cultivation "implies a stable society, state authority, and constant large-scale works."[6] As these societies saw a political system develop that concentrated power at the top, the concept of private property and the capitalistic impulse remained repressed. European intrusion, by implication, introduced these concepts in Asia and Africa.

The central purpose of these books is to explain how power works to set world regions apart, not to explain economic change nor show how geography matters to the process. The geographical notion is, by and large, crude. Wittfogel, for example, rarely mentions the word monsoon, thus missing a crucial fact about tropical dry zones, that these are uninhabitable lands without seasonal rainfall. These works overlook the numerous small works from borewells in Africa to step-wells of India maintained by landlords, chiefs, and communities. Indeed, the history of these lands does not tell us that water control in the past ordinarily involved mainly large or state projects. Furthermore, large-scale works were often maintained by communities or local powers, which points to a theoretical flaw in the argument. The agency of local authority suggests *shared* sovereignty rather than despotism. Finally, the states' command over labour can be overstated. Evidence from India suggests that in a tropical monsoon society with high seasonality, many types of service, from soldiery to construction, on which the states depended worked only for a part of the year. Soldiers were peasants for the rest of the year.

[6] Cited by Moore (2003: 442). See also Stargardt (2018).

The third literature that engages with tropicality is famine history. The benchmark contribution here is a 1981 book by Amartya Sen, which suggests that droughts are more frequent in specific geographies, and droughts can cause famines (Sen 1981). The proposition for which the book became famous is that droughts, while a sufficient cause, are not necessary for famines to occur. Legal access to available food can also cause famines. The book used three illustrations for the argument, of which famines in late-twentieth-century Ethiopia and the Sahel showed the direct causal link between drought and famine better. In contrast, the Bengal famine of 1943 established the proposition that droughts are not necessary for famines. Sen's reading of the evidence others later challenged.

Droughts are indeed crucial for the paper because they need to enter any definition of tropicality. But then, trying to understand droughts through the lens of famines is misleading and distracts from a sound conception of tropicality. Droughts are moisture stress, and famines are shortages of food. The two things are different. Famine deaths were less than half a percent of the more than two billion people droughts affected in the twentieth century.

The thread running through this survey is that economic history displays a weak conception of the geography of tropical arid lands. This drawback needs attention.

III. What is tropicality?

The average summer temperature in the intertropical region far exceeds that of the temperate zones. Except for the mountains, that condition applies for the winters of the northern and the southern hemispheres as well. Excessive heat implies that the evapotranspiration rate is considerably higher in the tropics.[7]

[7] There is a discussion on this issue in Bloom, Sachs, Collier and Udry (1998). There have been other, mostly amateurish, and ahistorical, attempts at defining tropicality and linking it to comparative development. For a survey of the first generation works in development, see Karmack (1976). These studies notwithstanding, the statement that "economic writing on

Surface water bodies evaporate much faster in the tropics than in temperate lands. In India, 50 percent of the annual inflow of moisture via seasonal rains disappears into the atmosphere; in Egypt, nearly 100 percent does; in England, the rate is about 30 percent. The seasonal variation in water flow in rainfed rivers shows the actions of heat. Before the dams (Kainji, Jebba, Shiroro Gorge) came up, the Niger north of its confluence with Benue had a ratio of summer to spring flow of 7 to 1; the Benue at Makurdi town in east-central Nigeria had a September-March ratio of 50:1 (Wagland 1969). Before the late-twentieth-century dams appeared in the Deccan plateau of India, the mighty Godavari would have a million cubic feet of water flow per second on an especially wet October day near its confluence. In contrast, the river's upper reaches reduced to "a series of shallow pools" in April or May (Bombay 1903: 8).

Because evaporation is so high, most of the tropics would be a desert, but for the intertropical convergence zone (ITCZ), the area where the trade winds of both hemispheres converge, causing rainfall. The ITCZ is a low-pressure and high rainfall belt that shifts northward or southward with the thermal equator and at variable speed over land and sea. Air over land warms faster than the sea in summer. As low pressure develops over land, moist ocean air rushes in, causing widespread rainfall. These rainfall episodes are highly seasonal, concentrated in a few months, sometimes a few weeks, of the year, and are often called together monsoons. Monsoons, however, differ significantly in strength and predictability.

A third feature of tropicality is the savanna. Over an enormous tract in the intertropical zone, the heat-rain balance is enough to create seasonal grasslands. These grasslands sustain pastoralism, typically migratory herds of cattle for an extended part of the year before high summer sets in. But even in the wettest seasons, these lands cannot sustain agriculture. In Sub-Saharan Africa and South Asia, 50 percent of the land is under tropical savanna.

development has paid little or no attention to any possible influence of climate" seems broadly valid now as it was in 1976 (Ibid., 4).

In the remaining 50 percent, moisture inflow compensates heat enough to create conditions for agriculture. The compensatory mechanism operates in broadly two ways. In India, of the total annual moisture inflow of about 4000 cubic kilometres, 100 percent comes from seasonal rains.[8] In the inland Niger delta, of the total yearly moisture inflow of 40 cubic kilometres, 13 percent comes from rains, 87 percent comes from flooding of the larger rivers that receive rains near their sources (Ibrahim et al 2017). Much of the Niger river plains is semi-arid. But in the inland delta in Mali, a land of lakes formed of annual flooding of the river, which sustained cultivation and fishing over thousands of square miles. In both South Asia and the Sahel, evaporation and seepage losses are big. It is 50 percent of India's inflow (as mentioned) and 43 percent in the inland Niger delta.

A fifth feature of tropicality follows from this point. It is seasonality. Seasonality combines the high evaporation throughout the year and the bell-shaped annual rainfall pattern in the tropical zone (Figure 1). By contrast, most temperate zone places have more even rainfall patterns through the months. In parts of monsoon Asia, such as Japan, rainfall has a bell shape, but the bell looks like a longer and flatter hill than a sharp spike as in South Asia. Japan is also a temperate zone region by the benchmark of aridity or evaporation loss. In other words, not all monsoon areas are alike, and the tropical monsoon is a distinct package formed of alternating periods of moisture flow and moisture stress, or in other words, alternating risk of flood and drought.

A typical year in a tropical monsoon land contains an extended period of acute moisture stress. During a long stretch of the year, agriculture is not possible, and as consumption levels reduce, nor are there many prospects for non-agricultural work. Because of evaporation losses, this season is also exposed to the risk of water shortage for drinking or agriculture. Human settlement gravitated towards rivers throughout the premodern world. In the tropics, the rivers ran dry in summer. In turn, seasonal migration, transhumance, and circulation of

[8] "India's Water," https://economictimes.indiatimes.com/news/politics-and-nation/the-precarious-situation-of-indias-water-problem/articleshow/57965416.cms?from=mdrInland

people and livestock either in search of moisture or of work were intrinsic features of tropical economic life from a long time ago. Pastures appeared in contiguous areas at different times of the year, depending on rainfall, floods, and retained surface water. Stock-keepers typically accessed the wet-season pasture in arid regions. At the same time, in the wet areas, seasonal crops grew. Herders returned to the dry-season field in the wet areas – hence transhumance.

Drought is the sixth and final feature of tropicality relevant for the paper. Droughts or exceptional aridity occur when trade winds weaken. The exact causes of the phenomenon are not known, except for one factor, variation in the eastern Pacific Ocean temperature. And therefore, droughts are not perfectly predictable. Droughts, of course, can happen in any geography, tropical or temperate. The point that needs stressing is that a severe drought is more likely in the tropics for the same percentage shortfall in the rain because of high surface water loss.

When thinking about disasters, economists often think of insurance. If droughts can be insured against, at least one distinction between the tropical and the temperate should disappear, we may think. But droughts cannot be insured against. Droughts are not discrete events that either happen or do not happen. They are an annual event somewhere in the tropics. On average, two severe droughts should occur every year. In the twentieth century, droughts seriously affected nearly two billion people in Asia, Africa, and the Middle East. The corresponding number in Europe, the Americas, and Oceania was five percent of that figure, even though the rainfall shortage were quite similar between these two regions (Below, Grover-Kopec and Dilley 2007).

There is no single quantitative definition of a drought. One widely used measure since the 1990s is the standardized precipitation index, where monthly precipitation is normalized using a probability distribution function (Mishra and Singh 2010). The precipitation probability data are used for prediction of severity of a natural disaster, for example, more than two standard deviation numbers

would presage a severe disaster. Other measures are based on shifts in isohyet, the length of the crop growing season, and percentage shortfall in annual moisture inflow (about 15-30 percent would qualify as drought). Droughts are hard to predict and respond to because it is difficult to identify when a subnormal dryness begins and when it ends. "Establishing a strict temporal definition of the hazard is .. problematic" (Below, Grover-Kopec and Dilley 2007). In short, aridity is a range, and so is drought. The same environmental event can cause variable stress if we shift the isohyet slightly. At low isohyets, a mild drought can have a more powerful impact than at higher isohyets.

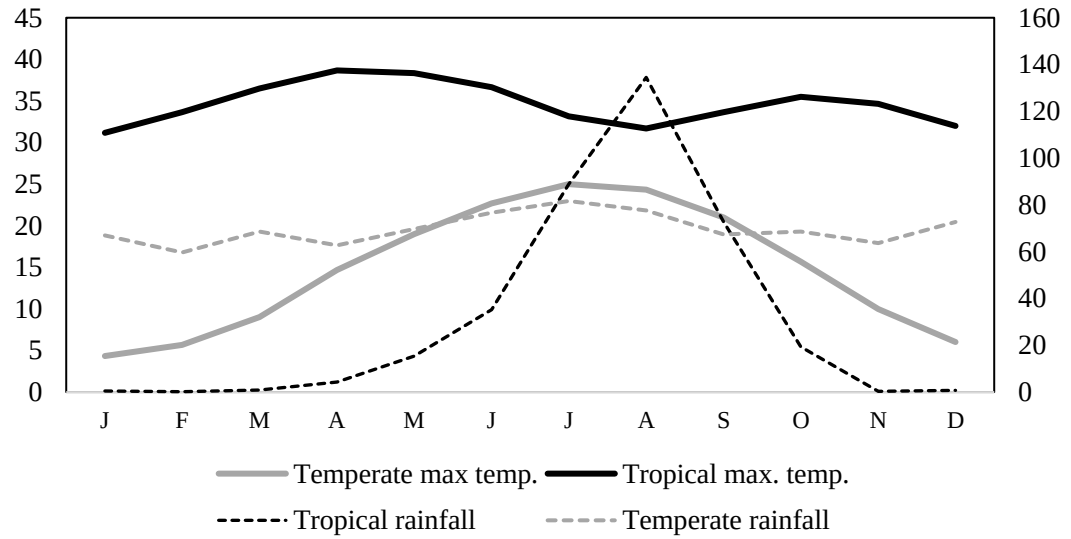
Droughts are not food shortages or famine but a more complex condition with various outcomes. The first-order effects may include reduced planting, livestock losses, drinking water shortages, and outbreaks of waterborne diseases as the quality of surface water falls. Most droughts are mild, local, and end this way. One Africanist historian called these the "ubiquitous lesser drought" (Miller 1982: 32). When the rain failure is large, or affects larger areas, a series of second-order effects follow – famine, migration, loss of assets, and consumption.

Occasionally there are mega episodes. Both African and Asian history registers seven-year and ten-year droughts. One of these the fourteenth-century Maghribi traveller in India, Ibn Battuta, described in graphic detail. Such events led to political disorder, institutional change, and cultural remaking. In Battuta's Delhi, an unhinged king ordered the citizens to march to a new capital, a march that killed thousands of people from hunger, thirst, and disease. Episodes of severe and lasting drought weakened polities by reducing taxes and making it likely that the mercenary soldiers would switch sides depending on who could assure food or wages better.[9] In recent history, a series of violent civil wars in Chad, Mali, Ivory Coast, and Darfur in Sudan testifies to the disruptive legacies of the 1970s and 1980s droughts.

[9] For a nineteenth century example of this dynamics from southwest Africa, Miller (1982).

The rest of the paper uses this six-dimensional concept of tropicality to re-read the economic history of the tropical drylands. The purpose is to understand why sustainable economic growth is difficult to attain and what individuals and states do to improve living standards. Why is sustainable economic growth difficult to attain?

Figure 1. Maximum temperature (c, left axis) and rainfall (mm) by month



Notes: The samples consist of the capitals of six countries in Sahel-Sudan (tropical), and New York, London, and Berlin (temperate). In each case, the figures are the average maximum monthly temperatures and the average monthly rainfall.
Source: https://en.climate-data.org/

IV. Why tropicality predicts poverty

Tropicality predicts poverty in several ways. First, extreme seasonality implies under-employment for an extended part of the year. Second, it means rain-dependence rather than irrigation-dependence; that is, a single plot of land can be used only once in the year for cultivation. Third, droughts create a preference for precautionary savings or make people lose hold of their savings too frequently, resulting in underinvestment. Thanks to food aid and emergency relief, outright starvation and loss of life due to hunger during famines have almost disappeared over the last century, except in war zones where relief supplies cannot enter quickly. But famine causes distress in other ways. "For

Africans," writes a study of recent famines in the Sahel, "the essence of famine is .. widespread asset liquidation and destitution" (Grolle 2015: 183).

Fourth, reliance on seasonal monsoon can reduce agricultural productivity by causing floods or high evaporation. World's water databases register estimates of freshwater withdrawal and freshwater sources but do not adjust the freshwater source statistics by the variable costs of accessing different types of sources. This makes a straight comparison of water security between countries, and in turn, correlating these with GDP or land yield, quite difficult. A straightforward cross-country correlation between either heat or water and income is unlikely to yield any sensible result. Still, a few conclusions on moisture data and economic conditions seem robust enough. The Sahel-Sudan region of the tropics (Chad, Mali, Niger, Burkina Faso, Mauritania, and Sudan) has a low land yield, low GDP per head, and low per capita renewable water. As a proportion of the world average, the index ranges from 5 percent in Sudan and Mauritania to 30 in Mali.[10] South Asia falls in between with 20 percent. On the other end of the water curve, the USA, Canada, and Scandinavia are water-rich, income-rich, and have high land yields. So do Japan, and Europe, though within Europe, there is considerable variation on all three indices (Figure 2).

Like Europe, there is a wide dispersion among middle-income countries. The data of the tropical drylands does not tell us that the hotter a country is, the poorer it must be, but that an arid country must search for strategies to overcome aridity. The Sahel has few options in that search. But India, China, or Egypt do have options. In all cases, river morphology creates the options. China and India are relatively water-poor and yet relatively high-yield regions. One answer to the puzzle is the presence of Himalayan rivers, a water source that is more reliable than rainfed ones thanks to snowmelt. This factor sets Asia apart from Africa. Egypt and Sudan are both arid and dependent on the Blue Nile for cultivation. However, the inundation of the Nile and silt deposits over centuries

[10] This is a flow, based on seasonal rainfall, cross-border flows including floodwater, and drawals from upper aquifers.

make Egyptian soil much more fertile than in Sudan. The low-income middle east and north African countries have relatively high land yield because of the benign climate in a narrow strip of land near the Mediterranean.

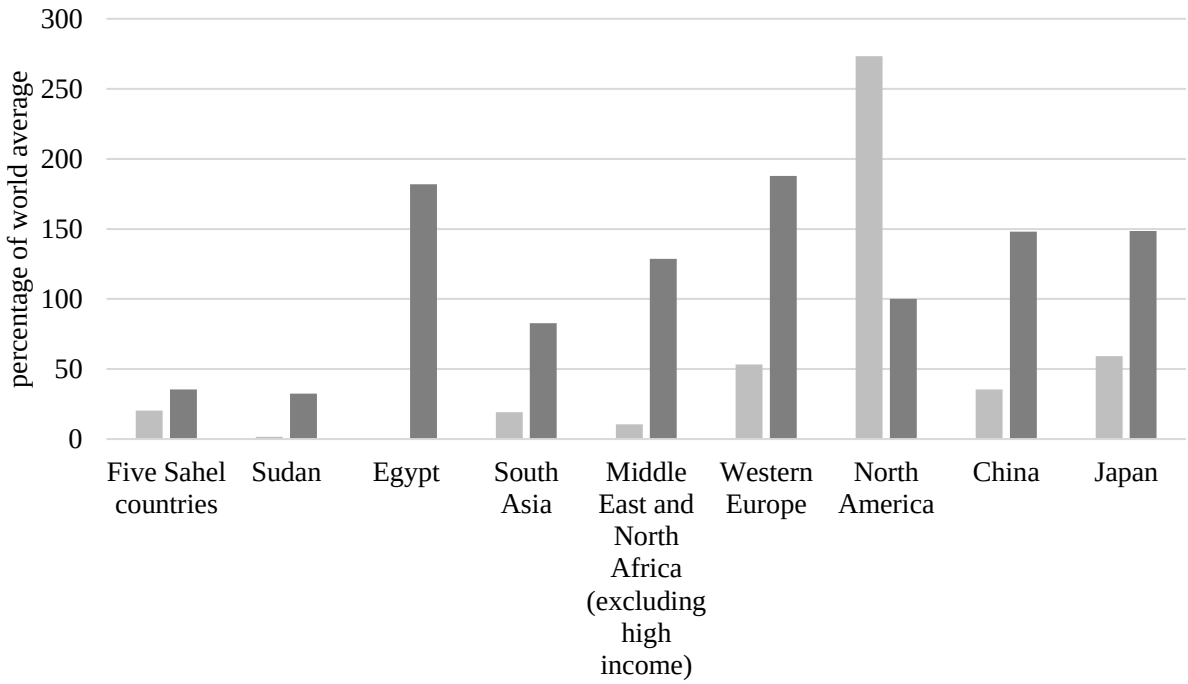
Fifth, evaporation loss can limit urbanization rates too. Around 1950, the average water consumption in India's cities was about 20 gallons per day or 100 litres. Large metropolises like Bombay, Calcutta, Madras, and Pune had daily water use of around 50 gallons per head (Gadgil 1952: 235). Smaller towns had much less water than that, and the countryside had possibly 80-90 litres, including water for the fields. In the 1970s, the daily per capita water consumption in Sudanese towns was about 100 litres. A study suggests that only when the average exceeded that figure, the chance of industrial and business growth improved (El-Bushra and El Sammani 1977). In 1950, an average American consumed 145 gallons per day (MacKichan 1951), and an average Briton consumed a slightly smaller quantity. These differences stemmed mainly from how easy or inexpensive it was to recycle surface water for consumption.

Finally, as Parthasarathi (2011: 172-5) suggests in a discussion on premodern China, it is plausible that the natural priorities of premodern states in the tropical regions were to avoid famines rather than generate economic growth. How well they did this job is another matter. There is now a considerable scholarship showing that the premodern and colonial states in Asia and Africa earned too little money per head to sustain a significant public goods drive. Limited capacity derived from the poverty of the livelihoods that were taxed (Karaman and Pamuk 2010).

The second question about human response occupies the rest of the paper. The paper reads a cluster of works in history, development, and historical geography that pay significant attention to droughts, famines, seasonality, and water to build this narrative. The intention is to discover themes that cross region-bound studies. One such theme is that the expansion of European colonial rule over Asia and Africa made a difference in how geography shaped states' will and

capacity to intervene in the economic sphere. Before coming to that point, it will be helpful to consider tropical development before colonial rule began. The material reveals a range of adaptive responses.

Figure 2. Water resources and land yield (darker shade)



Source: World Bank, World Development Indicators (https://databank.worldbank.org/source/world-development-indicators)
Note: Western Europe stands for European Union countries.

V. Tropicality before colonialism

Movement is a constant theme in the economic history of tropical Asia and Africa before colonialism. "Half of India's population" in the eighteenth century, speculates the historian David Ludden, was mobile, and many were seasonal migrants (cited by Kerr 2006: 89). Similarly, in Africa, vast stretches of less stressed and more water-secure lands could be found next to the drought-hit ones. The seaboard, deltas, riparian floodplains, lacustrine highlands like the Great Rift Valley provided insurance, sometimes opportunities for resettlement and farmland development. Tree rings, the Nile water level estimates, and oral traditions enable recreating a long history of drought-generated migration (Webster 1980).

Large movements occurred not only in response to short-term crises but also in response to climate change – like shifts in the isohyet and along with it the start of disease-prone zones – in turn enabling military conquests that would have been impossible before. Shifts in desert edge and the uprooting of people in the seventeenth-century savanna zone in Sub-Saharan Africa "had harsh consequences for many [as] ecological change .. expanded zones of conflict and the loss of human freedom" (McCann 1999: 269; also Webb 1995).

Transhumance, or seasonal movements of animals and people tending them, were moisture-seeking movements. In the savanna lands, pastures appear in contiguous areas at different times of the year, depending on the amount of rainfall, floods, and retained surface water. Stock-keepers must chase moisture. Like stock keepers, whole agricultural systems would display considerable mobility, again chasing moisture.[11]

A second theme that often shows up in accounts of movements is unfreedom. The short-term nature of the effect is open to different interpretations depending on the evidence. "[F]amine," writes a study of early-nineteenth-century droughts in Mozambique, was "[a] major factor in filling the slave baracoons." "[T]he Atlantic slave trade," wrote Joseph C. Miller, "flowed in part from the tides of drought and disease" in that the "historic peaks in exports" (from Angola) came when the most lasting and severe droughts were running their course. The link suggests that the slave trade was "in some ways less a cause of depopulation than a consequence of it when viewed in terms of droughts and demographic changes in West-Central Africa" (Miller 1982). However, another study suggests that the relationship between famine and slave trade was mediated by the cost of conducting raids, which was high during droughts (Fenske and Kala 2015). The general point that people with insufficient means to cope with shortages became dependent upon strangers during crises may still hold.

[11] Iliffe (2007) describes examples of this.

There is also a long-term dimension to this link between subsistence crises and unfreedom: persistent risk seemingly led to the consolidation of hierarchy. "Periodic waves of refugees from the surrounding dry land," wrote Miller on premodern Angolan droughts, "fled into these areas when the rain failed. There the refugees often accepted subordinate civil status as 'guests' or 'slaves,' a price for asylum on the land of local communities of landowners. Many of these newcomers ended up later at the courts and markets of slave-selling kings and merchants" (Miller 1982). An analytical narrative of Indian economic history in the *longue durée* contends, similarly, that frequent famines in the ancient past drove "aboriginals [to contract] away their freedom for bare but regular subsistence" (Kosambi 1965: 88). A broad claim like this one is almost impossible to verify with evidence. But in fact, there is an indirect confirmation of the link. With a significant rise in food production and water distribution in the Indian countryside from around 1900, many long-term and caste-based attached labour contracts crumbled away quickly (Roy 2022).

Unfreedom also had an association with a shortage of water and with seasonality. An argument known as the land-abundance view of precolonial Africa suggests that an abundance of low-quality land and labour scarcity encouraged labour coercion (Austin 2013; Fenske 2013). Rainfed or recession agriculture imposed long idleness upon the workers and acute labour shortages during the few days or weeks when moisture supply was just right for sowing. Coercive arrangements helped employers solve shortages on those days.

In a tropical monsoon climate with high evaporation, storage of excess inflow in sufficient quantity to withstand evaporation can significantly enhance the quality of life – none understood that better than the people who lived in these regions. India offers plentiful examples of "[a] rich historical tradition of local water harvesting .. from the *ahar-pyne* system in Bihar, the *tankas* of Rajasthan,

the Himalayan *dharas*, the *talabs* in Bundelkhand to the *eries* of Tamil Nadu".[12] So does tropical Africa. Besides reservoirs, there were various systems in the arid areas to retain soil moisture: from terraces to slow runoffs along slopes, to the choice of water-saving crops and plants (millets, sorghum, citrus trees), planting grass, mulching, and dew harvesting. Environmental experts have studied many of these ancient constructions and techniques. These studies tell us that most such storages were of a scale small enough to provide slightly greater security than relying on insecure surface water. Many dried up or became contaminated during years of exceptional dryness, and almost none of these systems could sustain intensive or year-round cultivation. Geodetic satellite data show for the recent times that the humanmade lakes or "tanks" in southern India would shrink so much during exceptionally dry times as to be unusable for human or livestock use (Roy 2022).

A final lesson from these accounts is that, in the average years, people exposed to high risk of droughts chose to save in assets that gave them little long-term return but were often valuable as food or for quick liquidity. It is a truism that animals are a better investment than the poor-quality land in the savanna. Economic historians have long wondered why rural Indians chose to save their windfall profits in the form of silver jewellery. Episodes of mass liquidation of these assets during acute economic stress showed why. Two such episodes occurred in the 1820s and the 1930s, though neither of these followed a drought event.

It is now well-known that European rule in Asia or Africa did not set off a series of top-down interventions and revolutionary changes. Colonial states did not share a single plan, origin, and ideology, and while militarily a success, they had too little tax revenues to do anything other than defend themselves. If one overarching feature defined a colonial economic system, it was the desperate and

[12] Shah (2013: 44). A*har-pyne*: network of channels and retention ponds; *Tanka*: Rainwater-harvesting tank; *Dhara* harvests natural spring water; *Talabs* human-made ponds; *Eri* another name for the tanks

ever-present drive to raise more taxes and make the administration self-sufficient. That dive did create a significant legacy.

VI. The colonial transition

Where they could, these states consolidated private property in farming or plantations and encouraged trade, hoping to collect more money either from assets or from the businesses sustained by using these assets. Although land tenure was neither uniform nor legally perfect, the peasant-planter property was legally more robust than the right to the commons. The two drives – encourage settled farming and encourage trade – converged in those areas where forests could be cleared, or pastures resettled to create commodity-exporting farms. These farming clusters exported rubber, wheat, rice, tea, cocoa, coffee, palm oil, groundnut, and sisal. With small success as an African export, cotton was a semi-arid crop (though irrigation helped), and gum arabic came from the arid commons. Otherwise, the twin bias favoured the water-rich deltas, basins, river valleys, and newly cleared forests.[13]

The twin bias left far-reaching legacies. Regional inequality was one of these. Where a country contained different geographies, the wet zones commercialized, and the dry zones fell behind or gave up labour. As we have seen, economic life in the tropics was crucially dependent on the commons, whether impermanent bodies created by rain, or floodwater, or pasture. None of these assets was sufficiently or at all legislated. Therefore, the subsequent regional inequality between the watered zones of export agriculture and the semi-arid pastures and areas still dependent on rainfed and recession agriculture was reinforced by an institutional divergence, laying the basis for future farmer-herder conflicts. Precolonial arid-area livelihoods, like the trans-Saharan trade and transhumance, reduced in extent. These livelihoods had earlier sustained a form

[13] Davis (2016) suggests that the colonial bias for farms stood on a profound misreading of aridity. European colonists few among whom had direct experience of aridity read it as a product of human action and thought it could be reversed or mitigated by scientific practices.

of interdependence between the desert zones and the savanna and acted as a protective buffer against droughts (Baier 1976).

Lewis was aware of the regional dimension of tropical development but did not give it much importance. Unnoticed by most reviewers of *Tropical Development*, Lewis had added a twist to his West-centric history. "The richness or poverty of a tropical agriculture," he said, "depends *more than anything else* on water" (Lewis, ed. 1970: 17, emphasis added). Indeed, as export agriculture grew, the axis of capitalist development shifted from drier areas to wetter areas and from the interior subtropics to the seaboard, deltas, forest edges, and estuaries where conditions permitted meeting the water challenge more readily. As the process unfolded, the axis of capitalism also shifted from overland and caravan trades to maritime trade and from indigenous businesses to expatriate ones. Along with these movements, there was migration. "Population started moving from the drier to the wetter areas, and this movement still continues today" (Ibid. 18).

Corresponding to the colonial obsession with land right, oversight of the rights over water and pasture was profound. This oversight carried over into the historiography of economic change in the long run. "Whole volumes of African history spanning a thousand years have been written without even passing mention of rainfall," writes Webster (1980). M.D.D. Newitt says that it took the horrors of the 1970s and 1980s famines in Africa to "[heighten] the general western awareness of the importance of drought and famine as a factor in African history" (Newitt 1988).

If water right received little attention, rivers were another matter. All states, colonial or indigenous, understood the economic importance of perennial rivers in the tropical landscape. But the colonial ones went much further than the indigenous states on transboundary fluvial treaties. From the treaty of Vienna in 1815, the principle was established. Following the start of "formal imperialism" after the 1885 Berlin conference, there was a systematic effort to develop such principles in tropical Africa. To begin with, this was a commercially motivated

action. The treaties allowed for a navigational rather than productive use of rivers. Still, the treaties and limited usage of laws like an easement, public trust, and eminent domain established some rules to share common property resources. A field of action was defined that had implications for the distribution of water (Lautze and Giordano 2005). Most of these laws were responses to specific situations. The absence of any radical shift in perspective was evident in the almost total neglect of a vital commons, groundwater. "No substantive colonial water treaty mentions ground water" (Ibid.).

While fluvial treaties advanced in Africa, the productive use of rivers expanded in South Asia. The large volumes of water that passed through the South Indian deltas and Himalayan rivers enabled the building of canals and reservoirs on a large scale. These gravity projects recycled water from a secure source to water-scarce areas using the slope of the land. New ideas, including silt control and basin management, allowed projects to be built on a much larger scale than the past Indian regimes did in hydraulics (Gilmartin 1994). In the interwar years, the notion that river water was an input for economic development spread in Africa, as abortive Nile project plans and treaties would suggest.[14]

Late in the interwar period, a new model of river project began to be popular, involving controlling the flow of water by damming rivers as they descended from the mountains to the plains. Such projects would generate water for the dry months as well as electric power. A dam, in this way, would serve the wet and the dry areas, the countryside and the cities, agricultural intensification, and industrialization. The enthusiasm for the multipurpose river valley projects, thus, signified the arrival of a new model of world development, one that civil engineers would script to a large extent.

The Mettur dam on the Kaveri was possibly the largest in the world when finished around 1935. The dam involved "mobilization of engineering expertise

[14] For example, the Nile Waters Agreement 1929, Century Storage Scheme, after 1952, suggesting an 'unmistakable shift' in the assessment of rivers, Maluwa (1988).

from across the world .. the changing political scenario in British India and .. local water politics" (Ramesh 2019). The dam sustained intensive cultivation in one of the drier regions of south India. The electric power generated in the dam and the thermal plant near it supplied energy to a cluster of engineering and textile towns in northern Tamil Nadu. The almost contemporary Markala dam in Mali, meant to encourage cotton cultivation in the north-eastern part of the inland Niger delta, did end up helping rice cultivation. With such impressive beginnings as these, after colonial rule ended, politicians, engineers, and aid agencies zeroed in on this model of river use as the answer to underdevelopment.

With somewhat more dramatic results, a third field of colonial-era intervention was what Abdel Omran had called the "receding pandemics" phase of an epidemiologic transition (Omran 1971). Diseases like cholera and schistosomiasis had a direct association with the quality of water, which was ordinarily poor in the arid lands, and became worse during droughts. Public health and medicine to tackle just a few waterborne diseases could substantially bring down deaths from droughts. It appears that in both South Asia and Africa, the initial effect of colonialism – focused on market integration and commercialization – was a rise in epidemic incidence, especially cholera, malaria, trypanosomiasis, and rinderpest. Around 1900, cholera, smallpox, plague, and malaria accounted for 24 of 40 deaths per 1000 people in South Asia. By 1940, however, deaths from the four diseases fell below 14 per 1000.

The turning point came in 1920. "Populations [in Africa]," writes Manning (2014), "rose at a very modest rate from 1890, then accelerated from 1920 to 1950." Manning's figures stand revised, but the revision does not change the inflection point (Frankema and Jerven 2014). In both regions, a part of the actions that led to the epidemiologic transition involved water purification and a centralized supply of filtered water, which significantly reduced cholera deaths and deaths during droughts. Where did these actions come from? The recent history of water quality in India suggests that it owed rather little to a top-down statist desire to improve colonial welfare. Instead, it built bottom-up from many

local and initially disjointed efforts: the municipal water supply schemes funded by merchants, easements law, movements for equality, press campaigns, and legislative autonomy (Roy 2022). African demographic history conforms to that pattern to some extent. Life expectancy increased significantly (with inequalities persisting) in 1900-1950 in Cape Colony, partly owing to smallpox control and water control (Simkins and van Heyningen 1989).

General interpretations of the impact of colonial rule on economic development remain sharply divided. The Marxists, Immanuel Wallerstein, Eric Wolf, Walter Rodney, Samir Amin, and A.K. Bagchi, stand on one side. They believe that colonies as a whole lost from colonialism because of surplus extraction and transfer. Market-optimists like W. Arthur Lewis, Hla Myint, Celso Furtado, and D.K. Fieldhouse stand on the other side. They believe that the colonies made significant gains from colonial trade and do not emphasize surplus transfers.

The account presented in this paper is a little different from both. The Lewis pathway of agricultural intensification and trade was strong where water was secure, accompanied by business growth in port cities. There was more disruption in seasonal livelihoods in the savanna and drier lands, sometimes de-urbanization where railways and ports took away trade and people. At best, nothing much changed except population growth rates. The colonial legacy cannot be reduced to net growth or net decline. The legacy was the generation of inequality within colonies, often a systematic inequality between dryland agriculture and the service economy in partnership with commercial agriculture.

Indian national income data helps us quantify the inequality effect. India's port cities were a part of the Indian Ocean trade from a long time before British colonization. The emergence of an empire consolidated their position as business cities, founded on different trades and supported by an extensive railway network. There were areas of dynamism in the countryside, where irrigation water became available, but by and large, the rural economy was dominated by stagnant arid lands. Between 1900 and 1945, real income in industry and

services increased by 133 percent, and real income in agriculture by 26 percent. In the same period, income per worker in manufacturing and services increased by 180 percent, and income per worker in agriculture increased by six percent (Roy 2020). The mainstay of business growth was long-distance commodity trade. Cargo carried by the railways and the ports increased from five to 140 million tons between 1871 and 1939. Finance and banking expanded to support the growth. Merchants and trading firms invested trading profits in cotton and jute textile factories. There was economic growth, but a regionally unequal one.

Sometime in the late nineteenth century, the idea emerged that development was a pure public good and not an externality generated by free trade or colonial capitalism. Droughts and famines acted as a catalyst behind the emergence of that idea. Colonial governments were answerable to their parliaments. There was a realization that "[w]ater scarcity, internal conflicts linked to water usage, floods or epidemics are factors that could undermine the power and legitimacy of states" (Padt and Sanchez 2013). The growth of the press stimulated public discourse. Famines energized nationalist movements as powerfully as the desire for self-government: ".. the effective politicization of hunger by Irish and Indian nationalists, .. contributed to the late nineteenth-century shift in British understandings of famine" (Edgerton-Tarpley 2013).

VII. Tropicality in the era of development

When tropical countries became free from colonial rule between 1947 and 1965, development was firmly on the agenda. Traditional livelihoods depended on seasonal rains and floods. Land productivity was low, and most farmers were poor. Still, agriculture was environmentally sustainable because it adapted to moisture flow rather than controlling it. From the 1920s, however, it was not economically unsustainable anymore because of population growth and the drive to catch up with the western world.

The colonial obsession with land rights carried over into postcolonial economic thought to shape an obsession among economists, policymakers, and Marxist ideologues with institutional reforms, land reform, and land rights.[15] In many countries, land retitling programmes were undertaken, and in most, it had an unhappy history. Land reform programmes in country after country drowned under the absurdity of redistributing poor quality land among poor peasants.

Water was another matter. Politicians in the newly independent world understood by development two things, industrialization and intensive agriculture. The vast river valley projects killed three birds with one stone, promising cheap electricity, irrigation, and flood control. Further, dams displaced people settled in the areas where a reservoir hundreds of square miles in extent would appear. Many displaced people were resettled as peasants in the savanna lands in the Niger river basin dams in Nigeria, Ghana, and Senegal. That move helped diffuse political tension while contributing to agricultural improvement. Directly or indirectly, development, dam-building, and a pro-peasant bias in policy reinforced each other.

The scale of dam building around the tropical world between 1965 and 1990 was nothing short of staggering. The golden age of dam building began when Western European governments and the World Bank offered cheap loans to finance the projects. The governments wanted to create work for large engineering and consultancy firms looking to go global after the postwar reconstruction boom began to flag. Gigantic projects were designed on the Nile, Niger, Volta, Senegal, Zambezi, Jordan, Euphrates, and Indus Basins. By 1990, there were over 2000 dams across Indian rivers. Most of these had appeared in the Deccan region, where there was less water overall, yet the topography permitted storage more easily than in the flat Indo-Gangetic Basin. China pursued dam building on an

[15] For two examples of land fixation, 'Ownership of land determines.. the range of choices .. open to different members of agrarian societies [in India],' Raj (1975: 7); and '[t]o own the land is the highest mark of esteem [in India],' Myrdal (1968: 1057). Raj and Myrdal, the latter a Nobel laureate, were influential thinkers of their times.

ever-larger scale. One grand strategy would supply water and power to agriculture, industry, and the cities.

That these expectations were partly fulfilled, no one can doubt. As mentioned before, the world's water dataset is patchy and often difficult to read. Still, what there is, would suggest that in the late-twentieth century, even the driest countries like those in the Sahel increased their annual freshwater withdrawal levels, both total and per head. The India data is richer and suggests that the trajectory had begun from around 1880 and accelerated in the twentieth century. The impressive record of the green revolution worldwide, massive expansion of multiple-cropped irrigated agriculture in Asia and partly Africa, service sector development in India, or industrialization in China prove that the promise was fulfilled to some extent. If the solution was so obvious and pursued with so much energy, why isn't the whole world developed? Why do the tropics remain relatively poor? The answer is that the pathway of recycling and controlling the natural inflow of moisture generated costs. There are two types of cost.

"The utilization of water, more than any other resource has experienced tremendous conflicts," writes the geographer Josephine Msangi (1987: 63). Controlled water harvesting on a large scale unleashed three types of conflict. First, there is a potential conflict between two principles in transboundary river-sharing. One of these asserts sovereign territorial rights over resources (the Harmon doctrine of 1896), and the other seeks to maintain the unity of the source. Countries situated in different places in a river basin can choose the principle that best suits their interest.

Second, the accent on intensive agriculture worsened farmer-herder conflicts in Sahel and Sudan. The conflict came under the spotlight when mentions were made of it in the wake of the 2007 Nobel Peace Prize awarded for awareness about climate change (Benjaminsen and Ba 2009). Climate change, however, did not create it, and how climate might complicate it depends on how we read the history of the conflict.

Farmer-herder conflict in central Africa has been in the making for nearly half a century and is well-researched. Much of that research accepts the premise that it stems from a contest over land and rejects the belief that the competition reflects an imbalance between population and land, though population growth undoubtedly complicates it. Herding is a season-bound activity. It needs access to pastures that are viable in different seasons. If one of these tracts starts growing crops year-round, herding is at risk. Already under pressure from the accent on intensive agriculture, herding faced a crisis when the 1970s droughts reduced pastures.

One of the most violent countries of the late-twentieth century, Sudan, is a telling example of how politics joined with vulnerable geography to fuel such conflicts. The concentration of business and intensive agriculture in the riverine areas and the main urban-industrial centre Khartoum was aided, if not created, by the British colonial accent on commercialization. The "alliance of riverine, northern Arab elites" sustained an ethnic-religious nationalism formed in reaction to British rule (Straus 2015). Colonialism, however, ruled with a light touch here, which left a legacy in weak land titles. Successive failure in land titling initiatives left landed property vulnerable to capture.

The paradox of Sudan was that it was too weak and impoverished a state to impose a strong form of federalism. In Darfur, the elites could provide only logistical and moral support in a battle fundamentally about land and water. That battle turned fierce in the wake of the devastating droughts as pastures reduced and herders threatened to encroach on farmers' lands. Ethnicity was one dimension of the battle that made the conflict brutal for the non-combatants, but competition for natural resources rather than ethnic sentiments was the driver. "[E]nvironmental stress on a vulnerable landscape .. forced some to defend their land and others to migrate or find new land" (Ibid.).

Third, water inequality is not necessarily an interpersonal inequality. It is also inequality between regions. Where regions entail different cultures, water

conflicts can merge into and feed inter-ethnic wars. “Coping with drought, shift between agriculture and pastoralism,” writes an analyst of the Darfur conflict, “have been not only adaptive processes, but have also been characterised by shifts in identities” (Manger no date). Examples of contests over resources to spill over into ethnic bloodshed abound in the Sahel-Sudan.

A second answer to the question – why isn’t the whole world developed? – is that tropical projects carry a high environmental cost. With few exceptions, big dams built on rain-fed rivers were a high-maintenance, inequality-creating, and environmentally damaging pathway. In a water-scarce economy, cheap or free water leads to wasteful use of the resource. The shift to paddy in the arid areas is a good example of the syndrome. Arid-land crops like sorghum and millets require moist soil when the plants are young but can then withstand dryness. Therefore, they are better suited to arid monsoon conditions than rice varieties that require moisture throughout their life cycle. But rice is traded over wider areas and promise more profits. There is now considerable literature on these effects. Since the 1990s, the dam drive started to recede. Dams are being built on a much smaller scale than before, and multilateral funding for such projects has greatly reduced.

A further area of concern, especially for Sub-Saharan Africa, is desertification. The human agency behind desertification supposedly owes to overgrazing. The control of disease contributed to a sharp rise in livestock (in East Africa), and in turn, to overgrazing and declining quality of pastures (Heady 1965). Overgrazing can impact the climate.[16] Over almost a century, in the inland Niger delta, there was a gradual shift away from pastoralism towards agropastoralism, a regime where farmers kept herds and herders farmed. The 1970s drought hit the region hard and left a variety of legacies. The droughts and the Niger dam projects permanently shrunk the active delta in some accounts. At the same time, the droughts encouraged agropastoralism as strategies to diversify risk. The reliance

[16] In the Otterman cycle, overgrazing leads to a rise in surface albedo (a measure of diffuse reflection in total solar radiation) and reduced convection.

upon artificial irrigation systems increased. The pressure on year-round fields still available increased.

These examples of the degradation of resources do not cause as much alarm as they might because the technology to mine water from deep aquifers is being used far more extensively in the last thirty years in both Asia and Africa. Indeed, groundwater extraction is now the mainstay for India's irrigation and urban water supply. Since India's economic miracle began about thirty years ago, borewells and urbanization became interdependent. Eighty percent of urban and industrial water now comes from wells. The ratio is not good for groundwater management in tropical monsoon land.

Groundwater resources are technically plentiful – more for Africa than for Asia – but groundwater mining is expensive and triggers a legal problem the colonial regimes avoided dealing with. The tap or well above ground is legally protected private property, but the water below is a common property of too unknown features for regulation to work efficiently. The resolution of this problem requires laws to incorporate the public trust principle, and countries have moved at different speeds in doing that. Besides, entire nations and large regions have little underground water in the first place. Many aquifers in desperately water-scarce Pakistan are saline (Sindh) or overused (Baluchistan). Outside the Nile Corridor, which has most towns and industries in Sudan, geological conditions (the hard rock formations of the Basement Complex where little underground water can be found) make sinking wells an unprofitable enterprise in that country.

Economists, activists, and scientists offer other solutions to scarcity. Water markets are one potential solution, but pricing water from the commons is complicated and does not necessarily help conservation. Conservation technologies like drips and sprinklers, *diguettes* (mounds built to reduce runoff), and watershed management, do work. Some work only on a small scale, and others like overground drips work better in a few commercial plants and rarely

in the main food grains. Many non-governmental organizations inspired by the tragedy of the commons discourse advocate cooperation, which again works only on a small scale and breaks down in a large region with a diverse population.

Despite these difficulties, the dams, urban projects, and laws did deliver a manifold increase in average entitlement to water in the tropical world.[17] But the same movement also generated environmental stress. Water stress measures the withdrawal of freshwater as a percentage of renewable sources. The dataset is noisy because it does not factor in the costs of accessing different sources, thus delivering low stress for some of the driest countries. For what it is worth, in 2016, stress levels ranged from 42 percent in India to 105 percent in Pakistan and parts of Sub-Saharan Africa. The levels were considerably lower in the UK (10), USA (22), Japan (28), and China (30) (World Resources Institute 2021). A close across-country correlation between average temperature and stress suggests a geographically located stress pattern.

VIII. Conclusion

This paper began with two questions. Does tropicality make the struggle for economic development harder? The answer is that it does because there is no cheap, reliable, and peaceful response to moisture stress and because economically successful responses have adverse environmental effects. What do people caught up in the struggle do? In an earlier era, moisture stress episodes induced migration and the prevalence of livelihoods that chased moisture. Since the late-nineteenth century, as colonialism integrated Europe with Asia and Africa more firmly, responses took new forms, including medical intervention, gravity projects, river-sharing, and legislating property rights. These interventions delivered some positive results (mortality decline, green revolution) and some adverse ones (regional inequality, ethnic conflict, environmental stress).

[17] The India data is explored in Roy (2022).

Overall, the tropical societies did much better at reducing mortality than raising productivity, and trying to do the latter risked conflict or environmental stress. The joint outcome was a sharp rise in population growth, limited income gains, and relatively low average income growth. We see these societies as a failure if we assess performance by observing per capita income trends as economists do. Instead, they did solve one immediate problem stemming from tropicality, shorter lives, quite successfully.

This paper has contemporary relevance. The unhappy history of multilateral negotiations on climate change tells us that the poorer countries (most are tropical) do not seem to share the same passion about climate change as politicians and activists in the western world do. A cynical explanation for this is that they want money. A deeper reason is that the perception of why the environment matters differs between the two worlds. In the more affluent world, a radical narrative drives environmental activism, one that says that overconsumption and the pursuit of profit led the world into a mess, and the solution is to consume less. That message fails to inspire in the tropics where consumption levels even of essential goods like water are abysmal, yet attempts to overcome the barrier led to environmental stress. Asking people suffering from a trade-off to go in one direction is futile.

In recent years, western media has tried to bridge this gap between temperate and tropical regions by suggesting that climate change affects the poorer world more by causing droughts and floods. Whatever the scientific basis for the assertion, the campaign must fail again. The discovery that the tropics suffer droughts is redeeming for the western media but not news in the tropics where these events have been occurring every year for several thousand years of the late Holocene.

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