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The Human Face of the Land: Why the past matters for India's environmental future*

Kathleen D. Morrison**

At this moment when we are aware that our climate is changing, and that humans have had a major role in effecting that change, we are perhaps more attuned than ever to the ways in which human and natural worlds are very closely connected, linked in many ways and at many levels. This interconnection is something that can be easy for those of us living in cities to forget; for urban dwellers 'weather' can be a nuisance but for farmers climate and its short-term manifestation, weather, can be a matter of life and death. But climate is only one way in which human and natural worlds are joined. At least as consequential (and not unrelated) are the slopes, soils, and hydrology, and the plants and animals that make up the geosphere and biosphere we inhabit. Vegetation assemblages may change only slowly and soils, streams, and slopes slower still, but historical analysis shows clearly that there have been quite significant changes in Indian landscapes, changes that are by no means all recent. Indeed, what we often think of as 'nature' is a complex historical product, one partially made by our ancestors; their actions, along with the actions of non-human agents, worked together to shape the world we live in today – vegetation, landforms, animals, and even climate.

For the last 10,000 years especially, the role of humans in making the Indian landscape has been quite significant[1]. Agriculture, to take one of the major drivers of landscape change, maintains vegetation

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complexes at specific, desired successional states which, although often mimicking 'natural' vegetation quite effectively, do lead to change. The anthropogenic movement of plants and animals around the world, too, has created conditions of possibility that make each moment in history in some way ecologically incommensurate with each other[2]. Contrary to established ideas of 'nature's' balance and stability, non-human actors can also create directed change. The ongoing existence of both extinction and evolution make this clear, but other agents such as disease may also lead to lasting transformations[3]. Human history and memory may or may not capture such change. As time passes, we tend to accept the world as it is, a phenomenon ecologists refer to as "shifting baseline syndrome"; an historical amnesia about past environments[4]. One aspect of that amnesia not often discussed in the literature, however, is the way in which humans come to write themselves out of their own histories. Over time, we come to think of things like forests, hills, and streams, as *natural*, even though they encode *human* history as well. Similarly, we often think of social arrangements and cultural forms as "traditional", without considering too closely their identity as historical forms[5].

Why might these entangled histories matter? In India today we face an agrarian crisis, an urban environmental crisis (relating to the increasingly problematic quality of our air and water), a climate crisis, and have many other concerns in which environmental issues figure prominently. While this is not the venue to consider any of these in detail, I would make the point that in every case *there are histories* that help us not only understand how things came to be as they are now but also, perhaps, what kinds of strategies have been successful in the past, and which have failed – and why. It is incumbent on those of us who study the past to look beyond our archives[6] now and then and think about how our histories might inform on the present, just as it is for activists and decision-makers grappling with contemporary issues to heed the lessons of the past, lessons never completely commensurate with today's world, never clear or complete, but nevertheless a critical source of information for us today.

In their 1995 book, *Ecology and Equity*, Gadgil and Guha take a serious look at some of the entangled social and environmental

challenges facing contemporary India[7]. As important as this book is for laying out the issues, in beginning with the false premise of a radical 'colonial ecological watershed', it eliminates any possibility of learning from the longer history of South Asia, a history with both success and failure, sustainable and disastrous environmental choices[8]. In the book's short introduction, we find an encapsulation of the argument made in the same authors' 1992 volume, *This Fissured Land*. Here they suggest that the single most important reason for contemporary environmental problems and inequities was the experience of British colonization and its associated institutions which had not only entailed environmental destruction in its own terms but also ensnared and transformed India's 'upper strata' into destructive environmental 'omnivores'. Of the precolonial past, there is no mention, an absence which implies (and is enforced by a vague appeal to tradition in the final chapter) a prior era of ecological harmony[9]. One can agree with much of their assessment of the present without, however, agreeing that colonialism constituted such a stark boundary between 'environmental eras'. As discussed below, people in the past – even the very distant past – sometimes had dramatic impacts on their environment. Conversely, they also sometimes devised and maintained productive and sustainable practices of production. This complex record resists simplistic periodization, with no moment of ecological 'innocence' to be corrupted by evil modernity. At the same time, this complexity gives us hope; hope that we can learn from the past and that, like those before us, temper our mistakes with better choices for the future.

Hidden Histories and Multiple Archives

In this paper, I focus on one specific region, the semi-arid interior of northern Karnataka, and consider some ways in which humans have helped shape the face of the land. My research in this region is focused on archaeology, history, and paleoecology from around 5000 years ago, when agriculture was first established in the south, to the 19th century and the consolidation of colonial rule[10]. I have been especially concerned with the Tungabhadra basin, a broad area that includes the remains of the great Middle period city of Vijayanagara, popularly known as Hampi (circa C.E. 1300-1600). Although this huge city, built in a rather improbable location in the heart of a 'scarcity tract'

for agricultural production entailed large-scale, significant, and enduring landscape transformations, these changes took place in the context of landscapes already shaped by human action. In this work I have been specifically concerned not only with establishing the substantive contours of these changes, but also with investigating the ways in which both power and powerlessness came to be such forces in human life, and the ways in which these forces shaped (and were shaped by) South Asian landscapes. That is, I have tried to examine how *social worlds are literally inscribed upon the land, both making and being made by what we often think of as the 'natural world'*. These are long-term processes, still operative today. What this entanglement of 'natural' and 'cultural' processes points to is the need for integrated analyses of environmental problems and opportunities; no single discipline or constituency can encompass the challenges of a socio-natural world.

A great deal of Indian history – based on texts– either leaves out or makes invisible both the *powerless* (often, non literate people) *and the physical world*, especially in precolonial contexts. It is these "hidden transcripts" – the histories of the poor and of the natural world – that I've tried to make clearer in my own work[11]. This invisibility is more than an unfortunate by-product of history – it is an inaccurate picture of the forces that shaped past worlds and which, in some ways, continue to shape our world today. This matters, not just because the self-presentations of past writers give us an incomplete sense of the past, but also because our understandings of the past are often used to propose solutions to present-day problems.

How do we learn about these hidden histories, those of the powerless and of nature itself? Text-based histories, of necessity, highlight the literate and the powerful, though of course there are exceptions to this generalization. Fortunately, complementary evidence exists in the form of material records. This is the domain of archaeology and art history, of built environments, everything from impressive monuments to the subtle remains of short-term campsites or ancient paths. Material records also include biological and geological records; evidence for erosion and change in hydrology, records of past vegetation left by pollen grains, charred wood and seeds, and even

chemical and molecular-level analyses that can tell us, for example, if a crop was manured or irrigated. Of course, the material record is the *only* record we have for some periods of time and, even when we do have texts, it is often the only record we have that can tell us about the lives of marginalized groups of people and the physical landscapes they both created and confronted on a daily basis. Even for literate elites, however, many aspects of life must have seemed so ordinary and mundane that texts shed little light on daily practice; here, too, material records help us approach past experience, albeit through the lenses of our own time and often in temporally compressed ways.

Landscape Change on the Karnatak Plateau

In the semi-arid interior plateaus, rainfall and topography are among the most critical factors structuring local environments. Rainfall is influenced by the orographic effects of the Western Ghats, whose long rainshadow creates a distinctive dry zone with a west-to-east aridity gradient. Within the dry zone, precipitation is not only low and variable, but also highly seasonal, falling almost exclusively during the summer monsoon. The Bellary weather station is nearest to the region where my colleagues and I have worked most intensively (the *maidan* of the Bellary, Koppal, and Chitradurg Districts); here average annual rainfall hovers a bit below 50 cm. Like many semi-arid regions, rainfall has a high inter-annual variability, posing a challenge to rainfed farming. Over the course of the Holocene there have been periods of wetter and drier climate, but overall this region has always been dry, and sometimes very dry. As such, woody vegetation is classified as tropical dry thorn forest and thorn scrub though, as we have found, even the 'natural' vegetation has developed as an outcome of humanized histories.

This paper presents a whirlwind tour through time in one region in northern Karnataka, with three stopping places along the way. Beginning with the Late Neolithic and subsequent Iron Age (Table 1), we take a brief look at the Early Historic and Early Middle periods before moving on finally to the Late Middle period, on the verge of the Early Modern. Note that all of this account takes place prior to British colonization and its attendant shift towards 'modernity'. Far

from the stereotypic notion of ecological romanticism, which suggests that there was once a golden age when humans lived in harmony with the natural environment, we see instead a variable record of both environmental damage and improvement[12]. In the first period examined, human land use caused massive erosion but also created new rich soils for later farmers. The extension of irrigation transformed regional hydrology and soils, but also created new bird habitats and isolated the rocky granitic hills in ways that may have enhanced their biodiversity. With Medieval urbanism came large-scale environmental damage, including deforestation and erosion. But deurbanization was associated with forest resurgence and post-urban landscapes include both highly successful forms of farming as well as others abandoned for very good reason (Figure 1)[13]. Across this very long history we find no pristine harmony with nature – instead, the past was messy, political, and sometimes unfair. Human transformation of environments did not start with colonialism, with capitalism, or with the 20th century. On the contrary, this is a very long record, but also one that is a hopeful record, with both success and failure. The world we have to work with now is the product or outcome of these experiences, as indeed are we.

Table 1:

Late Middle Period	1300-1600
Early Middle Period	1000-1300
Later Early Historic	500-1000
Early Historic Period	300 B.C.E.-C.E. 500
Iron Age	1200-300 B.C.E.
Later Iron Age	500-300
Middle Iron Age	800-500
Early Iron Age	1200-800
Southern Neolithic	3000-1200 B.C.E.
III	1800-1200
II	2300-1800
I	3000-2300

Table 1. Precolonial South Indian chronology from the beginnings of agriculture.

Figure 1. Landscape history inscribed: fields in this colluvial valley north of the Tungabhadra River are watered by a 16th century canal. The canal made a 15th century runoff-fed reservoir redundant; the dam of the reservoir is visible in the middle of the rice fields. Both older and more recent granite quarrying are visible on the inselberg in the background; in the foreground a modern cart track runs along piles of boulders formed from Middle period structures and from field clearing. The hills in the background have evidence for Iron Age occupation.

I: The Southern Neolithic and South Indian Iron Age: Domestication, Extirpation, Erosion, and New Possibilities

Although fully modern humans have been living in what is now India for more than 72,000 years and likely had some impact on vegetation even then, what we know about South Asian environments really starts only in the Holocene. The early Holocene was, as noted, marked by the development of domestication, with the use of newly-modified plants and animals – cultigens and domesticates – being added to existing practices of wild plant collecting and hunting. In what is now northern India and Pakistan, agriculture was adopted very early, around 9,000 years ago, but in the South, farming started only around 5,000 years ago, or about 3000 B.C.E. Here, in what is usually called the Southern Neolithic, groups of farmers grew dry-farmed millets,

some locally domesticated as well as some species from Africa, alongside a range of pulses[14]. Southern Neolithic people also made extensive use of herded animals, including sheep and goat, but most especially cattle. Interest and investment in cattle is attested not just by evidence for significant herds but also by abundant rock art depictions and by ashmounds.

Our study region is part of the distribution of ashmounds, the most well-known feature of the Southern Neolithic[15]. Ashmounds are large hills made by accumulations of fired and vitrified cattle dung. Yet another link to cattle, these rock-hard mounds have been suggested to be related to some kind of ritual and community use, clearly associated with aggregations of large numbers of cattle. Not always associated with settlements, ashmounds are also found in strategic locations such as hill passes, where in some instances the fragrant smoke, and perhaps flames, would have been intervisible from ashmound to ashmound[16]. Whatever role these fascinating features played in Neolithic life, they do suggest that dung was not, for the most part, being used to manure fields. We have no evidence for the use of formal irrigation but Neolithic farmers almost certainly engaged in some form of water harvesting to support the small-scale gardening of 'boutique' crops such as wheat, barley, and perhaps rice[17]. Although much of the Southern Neolithic period was actually more arid than today, farmers successfully grew and, one might say, also invented a range of crops, linking more permanent villages with many other smaller sites that attest to a high degree of regional mobility

Our work on the imprint of Neolithic people on regional landscapes has only just begun, but we can already see from the published literature that like early agricultural worlds everywhere, plant and animal bodies were increasingly being shaped by humans, who were also introducing new plants and animals imported from elsewhere[18]. Genetic studies have shown that zebu cattle themselves were domesticated in South Asia, probably in the Indus Valley area, from which they spread to the Gangetic plain (and on to Southeast and East Asia) and also south to the peninsula[19]. Wild cattle (*Bos primigenius namadicus,* wild aurochs) contributed to the gene pool of domestic cattle (*Bos indicus*) for a

time, especially in the Gangetic region and the south, but this wild species which once ranged all across Eurasia was extirpated in South Asia during the early Holocene. Interestingly, southern India itself has the latest finding of wild auroch bones in South Asia, dating to ca. 2,200 B.C.E. from Banahalli[20], suggesting that here, at least, there was a little more room for this once-abundant grazer. There is, however, no getting around the temporal coincidence between the appearance and expansion of domestic cattle and the disappearance of wild cattle. Here we might see both continuity and rupture. On the one hand, the localized extinction (species extinction took until the 17th century C.E.) of an entire species; on the other, a pattern of continuity in the presence of large-body-sized grazers in South Indian landscapes. Cattle, then, which are often viewed by ecologists entirely in terms of environmental disruption – as entirely cultural rather than natural components of a landscape – occupy a role once held by wild aurochs. As such, we might consider rethinking cattle as only *potentially* but not necessarily problematic for local environments.

Following the Neolithic, the subsequent Iron Age saw some significant changes in how people engaged with the land. Most well-known for its monuments, (a range of) megalithic features and structures, Iron Age southern India contained more and larger settlements than preceding periods, with some habitations that might legitimately be called towns[21]. In our region, most of these towns are perched atop high, rocky granitic hills. Although Iron Age agriculture has only been well-studied in a few locations, it seems that early Iron Age farming generally resembled that of the late Neolithic. As before, wild animals and plants such as *Ziziphus* (*ber*) and yams continued to be important. The primary form of farming was summer cropping of millets and pulses alongside very small-scale boutique production of water-loving (and in some cases, winter-growing) crops such as bananas, rice, wheat, and barley[22]. The latter was supported by a new form of technology, the reservoir. Iron Age reservoirs often occur in large megalithic complexes, suggesting a critical ritual role, but they are also found in and near settlements and, in the form of rock pools and small ponds, atop the high outcrops where people grazed their livestock, gathered fuel and other products, and also made their homes[23].

We suspect, but can not yet confirm, that Iron Age farmers used manure, no longer incorporated into ashmounds, as a field amendment, enriching soils that supported more intensive forms of agriculture.

Finally, we see in the Iron Age emergent forms of social differentiation and ranking, with differences in wealth developing. From this point onward (and perhaps before this, too, in ways we do not yet understand), power relations, especially as manifest in forms of consumption, increasingly made a difference in how people engage the earth. Just as today, choices about what to eat, what to wear, and how to live had implications for both social and natural worlds. While we cannot, as yet, pinpoint the transition, it was perhaps in the Late Iron Age or subsequent Early Historic period that the basic rupture between patterns of food consumption within South Indian society first emerged; that fundamental distinction between irrigated rice-based cuisines and dry-farmed millet-based diets. This development, as we shall see, led to measurable environmental effects.

It is not, however, necessary to look ahead to see landscape anthropogenesis. We can ask, first, what the impact of Iron Age land use itself on local environments was. One way we have studied this, besides using evidence from ancient plant remains, is by using remote sensing and geoarchaeology[24]. In non-technical terms, as one walks across the many hills of the study region, it is clear that some show significantly more signs of soil stripping than others. These hills are granitic inselbergs – 'island mountains' – dramatic isolated hills that march in diagonal lines across the plain. Archaeologically, we know from our survey work that different hills have different occupational histories, with some showing evidence for use during the Iron Age or even earlier, and some not. We can ask, then, did this land use have a lasting geomorphological impact?

In order to evaluate the distribution of exposed rock and soil stripping in the study region, we produced a land surface classification based on a principal components analysis of ASTER remote sensing data[25]. We then analyzed this land classification in combination with a digital elevation model of the region to quantify the degree of exposure

of residual rocks and the extent of soil cover remaining on the inselbergs and residual hills, a measure of erosion and landform transformation. We then checked our remote sensing-based categories with on-the-ground observations and were pleased to see that almost 86% of ground truth collected points were classed correctly, suggesting the classification is relatively accurate.

Archaeological survey (from Andrew Bauer's thesis project, so this analysis was done on a sample of the total area surveyed) has shown that 19 hills in the study region contain prehistoric archaeological sites, most from the Iron Age, though some also show evidence for Neolithic and/or Early Historic use. Other hills were without ancient settlements. We then explored the statistical relationships between archaeological site distributions and landform transformation, as well as some other measures likes slope and elevation. What we found was that archaeological site densities represent the *best single explanatory variable* for the proportion of remaining soil cover on the sampled hills. Site estimates per hill are inversely related to the proportion of remaining soil cover on a hill, and positively related to the proportion of exposed rock. So people's activities during the Iron Age seem to be the primary reason for large-scale erosion off these granitic hills.

The correlation between human activity and erosion is not, of course, definitive. Correlation need not imply causation, but we can also look at the sediments more directly and these tend to support the evidence from remote sensing. A deep exposure at the base of an ephemeral drainage channel near the site of Kadebakele, for example, revealed that nearly three meters of sediment accumulated at the base of the outcrop in a brief 300 year period between 350 B.C.E. and 50 C.E., at the end of the Iron Age and beginning of the Early Historic period. This is a dramatic accumulation of sediment at the base of the hill, commensurate with our documentation of newly-exposed rock on the hill above. Furthermore, prehistoric inhabitants were busy building erosion control walls during the Iron Age, suggesting they, too, might have recognized soil stripping of the hills as a problem to be managed.

It is clear, then that the new large Iron Age settlements such as Kadebakele, where we are conducting research, created new forms of environmental degradation not evident for earlier periods. Hilltop Iron Age settlements left measurable impacts on regional vegetation and soils, with centuries of grazing, fuel collection, burning, and other activities leading to large-scale erosion of these granitic inselbergs. It is worth noting that at least some of this erosion was tempered by human *accumulation* of sediments on the level terraces of these hills; these accumulations are the very archaeological deposits we excavate and study. Terrace build-up, alongside erosion of the steeper rocky slopes, helped change the shape of these inselbergs, creating a more diverse topography. As hilltops were abandoned, the reservoirs, rock pools, terrace walls, eroded boulders, and melted remains of buildings and courtyards played host to a range of plant and animal taxa[26].

One lesson of this brief tour through prehistory is that we need to recognize humans as both biological and even geological agents. Beyond this, it is also clear that time and history conspire to entangle what we might be tempted to classify into a binary division of 'natural' and 'cultural'. The domestication of zebu cattle may have led to the extirpation of the wild auroch, but cattle also apparently moved into the role vacated. As hybrid socio-natural creatures, domesticated cattle continued to operate within ecological as well as social contexts; changes in either would have had consequences for both humans and the environment. When cattle were massed around ashmounds (it is unlikely dung was transported long distances), they must have overgrazed local pastures, though this may have had little lasting impact. More obvious are the effects of Iron Age settlement and land use atop granitic outcrops. While erosion is not usually seen as positive, large-scale soil movement created new rich colluvial soils downslope, colluvium that still supports limited areas of very rich agriculture (Figure 2). Amid a dry and challenging landscape, the verdant colluvial valleys of the Tungabhadra corridor are still arresting today; rich, green fields providing a stark contrast to the grays and browns that surround them. Upslope, too, previously-settled outcrops present new opportunities; small level terraces with deep soils; declivities where water pools seasonally, and an enhanced separation from the valleys below.

Figure 2. Part of the hill containing the site of Kadebakele, Koppal District, occupied from the Neolithic through the Late Middle period. The 15th century fort walls atop the hill enclose an area that was occupied during the Early Historic period and used for megalith construction somewhat earlier. Colluvial sediments from the outcrop now support irrigated rice fields at the foot of the slope.

II: The Early Historic and Early Middle Periods: Irrigation, Isolation, Diversification

Although rice has been present in South Asia since the third millennium B.C.E., a more important consideration than its initial appearance is when, how, and why rice came to be grown on a large scale across many parts of the subcontinent. India's 'rice bowls' need not have developed at all, but the fact that they did grew out of a long history of decision-making and value-creating on the part of prehistoric peoples. In the south, the record of rice expansion is rather different in different regions. In more well-watered and favorable regions such as the deltas of the Kaveri and Krishna-Godavari, the transition from millets to rice was probably earlier. The semi-arid interior, however, poses significant challenges to rice farming and here, as elsewhere, dry-farming of millets continued to be important even as tremendous

effort was expended to facilitate rice cultivation. In our study area, the new colluvial soils formed by hilltop erosion became a key agricultural resource after the Iron Age, in the subsequent Early Historic and Early Middle periods. This was time when the contours of what we think of as 'South India' became more or less recognizable – a landscape that included the spread of temple-based sectarian religions, urbanization, literary traditions, and differentiated economies with irrigated rice, fruits and vegetables for the well-off and dry-farmed millets and pulses for the less affluent. These were highly diverse economic landscapes as well, with pastoralists, hunter-gatherers, and great many other kinds of specialists both living and visiting the region.

The expansion of irrigation and of paddy created new environmental opportunities, including perhaps an increased range for water birds, as ecologist Gopi Sundar shows to be the case for the Gangetic plain[27]. The increasingly isolated granitic hills – now more than ever 'islands' surrounded by newly-created moist ecosystems consisting of paddy fields, canals, and ponds – took the role of refugia. Recall that the shape of some of these hills had been partly made through human action, including erosion, more deeply sedimented terraces, and reservoirs and modified rock pools. While fragmentation is seen a negative in most ecological thinking, this fragmentation, ironically, appears to have created new micro-environments, places now supporting a diversity of insects, gastropods, turtles and lizards. More charismatic fauna include sloth bears, some now protected within reserves.

Worldwide, inselbergs such as the South African kopje (but not yet the South Indian Hampi-Daroji Hills), are increasingly being recognized as "biodiversity hotspots" and are the often the focus of conservation efforts[28]. Here it is important to recognize the complexity of the challenge of conservation. There is no doubt whatsoever that inselbergs can be irreparably damaged by humans. Such damage is taking place at an alarming rate in Karnataka and Andra Pradesh. Granite quarrying, in particular, is non-renewable, utterly destroying the hills along with their biodiversity, cultural and archaeological heritage, and scenic beauty. The consequences of large-scale quarrying cannot be repaired; much contemporary quarrying activity is illegal, employing

local workers in extremely unsafe conditions, and leaving wrecked landscapes that can no longer support vegetation, even the thorny shrubs eaten by goats, nor can they serve as watersheds for the recharge of run-off fed reservoirs used by small farmers.

On the other hand, it is important to recognize granitic inselbergs, like other South Asian landscapes, as socio-natural places, as in part *made by* humans and (to a still unknown extent), *maintained by* human action such small-scale grazing and fuel collection. Conservation efforts in other countries focus on things like preventing the expansion of woody vegetation which can reduce lizard habitat as well as that of plants adapted to hot and dry conditions. Obviously, one can obtain this same effect by livestock grazing, lopping bushes for goats, and setting small fires to clear thorny shrubs for fuel and enhance grazing. All of these "traditional" land uses are currently at work. Unlike large-scale quarrying for national and international markets, small-scale grazing and fuel collecting for subsistence need to be reimagined not as destructive, but actually as constructive of inselberg biodiversity.

III: The Late Medieval: Urbanization, Agrarian Expansion, Reservoir Siltation, Forest Loss and Regeneration

While earlier land use strategies led to significant but localized changes in the landscapes of north interior Karnataka, the establishment of major urban centers would later prove to be even more transformative. The first of these was the "city of victory", Vijayanagara, a small pilgrimage center that very quickly grew into a vast megalopolis[29]. Vijayanagara had, by the middle of the 13th century, become the capital city of an expansive empire which would eventually lay claim to a good part of southern India. Now known by name of the small village and original sacred river-crossing[30], Hampi, that would become the core of this large city, the capital was located near the northern edge of the empire, far from the richer deltaic regions to the south and east and within what was called by colonial writers the "scarcity tract".

In an effort to understand the provisioning of this large city and its long-term impact on regional environments, my colleagues and I

completed a decade of systematic regional survey, excavation, and paleoenvironmental analysis in and around the city[31]. The results of this work have been published in detail elsewhere, but we were able to document the impressive extent to which slopes, soils, hydrology and vegetation were reworked to serve the needs of urban residents. In this region of low and variable monsoon rainfall, the braided, perennial Tungabhadra River was an essential resource, feeding a network of irrigation canals criss-crossing the narrow alluvial strip and the colluvial valleys near the river and supporting a small but highly intensive zone of agriculture focused on the production of rice. Further away from the city (and in unirrigable pockets closer to it), large numbers of people's lives centered around vast tracts of grazing, gathering, and dry farming of millets and pulses mostly invisible in the historical record.

By this time, we know that there was already a sharp differentiation in consumption practices, differences to some extent still evident today. By the first millennium C.E. in South India, there was a codification of several elite cuisines based on irrigated produce, especially rice[32]. Except in very well-watered areas, virtually all of the critical components of this cuisine require artificial irrigation, making the raw ingredients of elite meals extremely capital and labor intensive; costly, set-apart foodstuffs nevertheless essential for making proper 'meals.' For many, perhaps even most of the population, such meals were not an option.

Rice-based meals also played a role in expanded temple-based rituals in the later Middle periods. Temple feasts and meals, as well as rituals, further required varied spices and aromatics, many of which derive from the more humid upland Ghat forests. In addition to plant foods, dairy products were critical elements of the elite meal, products derived from grazing animals, especially cattle (cows and buffalo).

Foods of the poor, conversely, were very dry, an adjective that can also describe cropping regimes. While some fields would have been aided by runoff-fed reservoirs (Figure 3) and many by smaller-scale features such as low terraces, gravel mulching, or check-dams, millets, pulses, and oilseeds did not, in general, enjoy the benefits of perennial irrigation. Non-elite consumption was built around a variety

Figure 3. Sixteenth century Timmalapura reservoir with its massive double sluice. Unlike reservoirs to the south and east of the city of Vijayanagara, this reservoir southwest of the city has only had minor silt deposition and is still in use. Photo taken in January.

of hardy millets and legumes. Oils, too, were much more commonly derived from oilseeds such as sesame and castor rather than coconut or animal-based products. Even modes of cooking seem to have been different, with dry, millet-based *roti* contrasting with the moister boiled forms of rice-based dishes[33].

Like elite humans, gods too enjoyed labour-and water-intensive rice-based cuisines and large temple complexes — often reckoned as cities in their own right — both produced and consumed prodigious quantities**.** Not only did large temple complexes employ a diversified staff, they were also associated with feasts, some quite large. The elite meal is metonymically connected to the plate or *thali* on which it is served, classically a banana leaf. Bananas, like almost all the other parts of the meal, are also products of 'wet' agriculture and as such, the elite meal is surprisingly coherent as a semiotic as well as material and social product.

While this is a highly condensed account, we can see that for at least a thousand years, irrigated or wet rice has been important economically, socially, and ritually across much of southern India, even as other food grains and foodstuffs constituted the diet of the majority, at least in the dry zones. These diverse consumption practices were reflected in a mosaic of forms of production, from rainfed farming, to grazing, to intensive irrigated agriculture and gardens laboriously watered from wells. Different forms of production had varied long-term environmental effects. Permanently irrigated fields were associated with the development of paddy soils, the extension of disease vectors such as mosquitoes, and transformed flora and fauna – possibly including expanded water bird habitat but also with the fragmentation of grasslands for the grazing animals so important in diets of earlier people[34].

What was the impact of Vijayanagara urbanization and the land use changes it engendered? The enduring legacy of Middle period canals is starkly obvious, the striking contrast formed by lush green fields surrounding high, rocky hills forming a substantial part of the attraction of this region for tourists and visitors. Dry farming and grazing, too, made their marks on the landscape, an impact in some ways more difficult to see, but not less significant. Although this impact was multi-faceted, I illustrate it here with the example of runoff-fed reservoirs (tanks, in South Asian usage). Just as in the Iron Age, in this later period, too, we can clearly see humans as biological agents, transforming regional vegetation, hydrology, and soils. In the Middle periods, we see even more clearly how food choices affected practices of land use, agriculture, and regional settlement, practices which in turn had serious consequences for soils, hydrology, and vegetation. These were complex process with many variables, but food choices did play a significant role in shaping land use, agriculture, and regional settlement. The drive to produce culturally-valued rice and other irrigated crops, in particular, changed slopes, soils, and watercourses; the expansion and intensification of grazing (among other factors), led to vegetation removal in watersheds above reservoirs and villages.

Let us consider, in very broad strokes, the sequence of change from the early 14th century when the city of Vijayanagara was founded,

to the later 16th century when it was rapidly abandoned after a military defeat. While there had been earlier towns in the region, the city was established in a place that had never been particularly large or politically significant. Our survey work around the city, in what we term the Vijayanagara metropolitan region, revealed that in the 14th century, there was a primary focus on intensive irrigated agriculture, almost certainly oriented around the production of rice. These fields, watered by river-fed canals, lay close to the core of settlement along the river. While there was some more extensive farming early in the history of the city, the focus was clearly on the perennially irrigated zone.

The massive expansion of the urban population in the early 16th century was accompanied by a building boom. Not only did residential areas rapidly expand, in some cases engulfing older villages to create a vast megalopolis, but new (and very large) temple complexes, walls, roads, and other public structures were also constructed, changing the layout of both the city and, to a large extent, the region. Supplying the urban population required dramatic restructuring of agricultural production. This early 16th century agrarian expansion assumed at least two major forms: (1) first, there were significant extensions of the perennially irrigated areas of 'wet' agriculture; (2) even more striking, this period saw the extension of dry farming and reservoir-assisted farming across a large area around the city, especially the plains and valleys to the east, west, and south of the urban core. Runoff-fed reservoirs did not, for the most part, support rice or other 'wet' crops but rather (when they worked as planned) made dry farming more secure and in some (few) cases allowed multiple cropping. Although the authors of texts were overwhelmingly interested in areas of perennial irrigation, most places and a great many people lived in a world organized around runoff-fed reservoirs and/or dry farming and grazing. There is thus good reason to believe, based on evidence of settlement locations and agricultural features, that the early 16th century saw many more people engaging in risky and marginal economic strategies such as dry farming and grazing.

What were the environmental consequences of this history? By the early 16th century, when the city was home to several hundred thousand people, problems of erosion and subsequent reservoir

sedimentation were already very severe. Silt build-up in reservoirs was a serious problem, leading to reduced holding capacity, breaching, and in some cases, flooding[35]. Once again, colluvial sedimentation was severe, caused, at least in part, by the deforestation and erosion of the rocky granitic hills, especially those south and east of the city along with the higher metamorphic Sandur range to the south. These hills had not been a major focus of prehistoric settlement, unlike those nearer the river and north of the river whose histories I have already discussed. This time, however, the sediment washed off the hills was more of a problem. Local capacity for desilting already-built reservoirs was stretched, sometimes to the limit, and after the abandonment of the city and the political restructuring this entailed, arrangements for reservoir maintenance appear to have fallen into disorder. Of the hundreds of reservoirs we have documented, virtually all have been breached, sometimes repeatedly. There are, further, clear regional patterns of siltation which show that the magnitude of the problem was variable, a consequence of both physical and political factors.

Contemporary dams, too, face many of the same difficulties as ancient tank systems. The Tungabhadra dam, for example, which was completed in 1954, has lost more than a third of its capacity due to siltation[36]. In terms of safety, the consequence of a dam breach would be catastrophic. Like the flood of 1851 which breached the dam of the 16th century Daroji reservoir, washing away its eponymous village, a breach of the Tungabhadra reservoir would threaten the town of Hospet, among other places[37].

We have documented the environmental effects of Middle period land use with both textual and archaeological evidence, information usefully supplemented by analysis of sediment, pollen, and charcoal from both Middle period and earlier reservoirs. Pollen records from the canal-fed Kamalapuram reservoir, built in the 14th century and still in use today, present a regional record of past vegetation, a picture supplemented by work on smaller facilities whose pollen catchment area is smaller[38]. In general, these paleovegetation records show an overall loss of woody vegetation during the 14th century as the city grew, and a rebound of trees and shrubs – a woodland resurgence – following the abandonment of the city in the late 1500s. The years of

urban growth saw the virtually complete deforestation of the Sandur Hills and a highly-modified open vegetation of fields and open scrub. What does this rebound look like? Some of it is clearly caused by the expansion, perhaps unintentional, of cultivated taxa like *Pheonix (*date palms), while some is apparently a rebound in the woody vegetation of the Sandur Hills, a range of higher, metamorphic hills both geologically and botanically distinct from the granitic Hampi-Daroji inselbergs. Thus, forests did come back, but they were not exactly the same as before. In another pollen record, from Kadebakele, we see this same pattern of forest loss and renewal, this time atop one of the granitic inselbergs. Here, too, the post-urban forest was somewhat different, with a 16th century loss of the woody creepers the hill had previously supported. Some environmental changes, thus, appear to have been irreversible.

Certainly, by the end of the 16th century we can see that this region had already undergone significant transformation at human hands; this transformation was thoroughgoing and included plants and animals, slopes, soils, and waterways. Imaging that environmental conditions at the end of the 17th century, when the Ceded Districts passed into British hands, constituted some sort of 'precolonial baseline' is patently absurd in this case. Even at the time the city of Vijayanagara was just getting started, regional environments had already been thoroughly humanized. The entangled socionatural histories that created these landscapes had, however, already been forgotten if indeed they were ever known. Landscape features such as accumulated sediment at the foot of a hill had become naturalized, their human faces hidden to later generations.

The drive to grow rice in semi-arid environments, environments marginal even for dry farming, had profound consequences for hydrology, soils, and vegetation, consequences that continue to be significant to contemporary farmers. This is an enduring legacy in part because many older facilities continue to be used – the vast majority of in-use reservoirs in northern Karnataka were build during the Middle period. Even if this were not the case, however, older landscape transformations continue to matter, each change contingent on past histories, some short-lived, some apparently irreversible. Flora and

fauna, soils (structure, location, fertility), hydrology, even to some extent geomorphology have changed in concert with human history. While they were not the only agents of change to be sure, humans in southern India were effective biological and geological agents, even prior to the industrial revolution.

Discussion and Prospects

In considering this very long record of change, we can see that South Indian landscapes, like many others, have for a very long time been humanized places, outcomes of both human and non-human actions and forces. The role our species has played has varied, with measures such as overall population size a relatively poor and indirect index of outcomes more proximately related to land use. Land use decisions (and outcomes) are complex, not least because people act partly in response to cultural and social imperatives of *consumption*, for example the desire for and valorization of rice. With the expansion of social differentiation and stratification, it became increasingly possible for some people to exert their desires in ways that had profound consequences for landscapes as well as for the lives of others. In the story of environmental transformation we must not forget the parallel story of power relations. Not all people did, or do, eat rice, and the contemporaneous contrast between the water, labor, and capital-intensive forms of agriculture and longer-standing forms of dry farming are nearly as stark as those between the diets of the affluent first world and the struggling parts of the third world today. Human-to-human social relations, then, are a critically important factor in determining what kinds of environments we create. The impact of our species on the earth, then, is inflected by more than just sheer numbers. How people arrange themselves in space and, critically, the nature and extent of social and status-based differences in consumption – from rice to granite counter tops – these play a major role as well.

When we argue today that our consumption choices have implications for food security, for sustainability, even for global change, we might remember that this has always been the case. In South Asia, humans have been a part of the 'natural' environment for more than 72,000 years and have made a noticeable mark on the landscape ever

since the beginnings of agriculture, between 8000 and 3000 B.C.E., depending on location. Here, humans have demonstrably been both geological and biological agents, forces, for better or worse, alongside many others, in shaping today's landscapes. Why should we care about this, especially as we contemplate an uncertain future? One can think of several reasons.

For one, the fact that our ancestors, too, both preserved and destroyed natural environments might make us feel a little less special, which is probably not a bad thing. The arrogance of the notion of a contemporary 'Anthropocene' is that only we today can shape global environments, most notably global climate. But the Holocene has long been the Anthropocene. We are not uniquely problematic destroyers of nature, in contrast to people in the past who always lived in harmony with the natural world. We've all had our ups and downs. This identity can be empowering. If past people were intrinsically closer to nature than we are, or wiser, or better, then possibilities for positive action seem all that much more difficult.

This history, too, might help put both current crises and current successes into some historical perspective which can potentially suggest some ways forward, or at least provide some cautionary tales. If we had forgotten, being reminded of the consequences of vegetation destruction and slope destablization in watersheds may make us reconsider some of the dangerous and problematic actions of the present, such as the current forms of large-scale mining for iron and manganese ore in the Sandur Hills. As these hills are literally being blown apart, unstable red sediment has eroded downslope, choking wells, reservoirs, and lungs, in the process staining the walls, fields, and even dogs and children with the red stain of a social and ecological disaster[39]. Like landscape-changing rice paddies, whose product fed only some people, the metalliferous Sandur ores enrich just a few people while their extraction immiserates many more today and for generations to come.

Some of the lessons of the past are less depressing. It appears to be the case, for example, that some locations of high biodiversity, such as the 'islands of diversity' atop granitic outcrops, are partially human-made and are sustained, not damaged, by small-scale grazing and fuel

collection. Evicting people from these landscapes (which also contain significant cultural resources), may threaten rather than protect them. Industrial-scale development like commercial granite quarrying or mining, is much more worrisome, leading to irreversible change. Conservation efforts need to enlist and engage local farmers and herders rather than unjustly blame them for landscape degradation.

Those looking for sustainable agricultural practices may be encouraged by the fact that some forms of irrigated rice production have been incredibly stable for hundreds of years. The expansion of paddy has caused large-scale ecological change, helping some animal species (water birds) and hurting others (grassland and savannah species). Although the expansion of wet rice involved a massive investment in irrigation facilities and changed slopes, soils, and waterways, those transformed landscapes are today 'facts on the ground'. They exist as resources for the present; the successful non-industrial farming practices of the last few thousand years are just as viable today as ever before. As these same fields shift to hybrid paddy and heavy chemical applications, one wonders if this record of sustainable success can continue.

Analysis of the past also shows us that older dams (tanks/reservoirs also have dams or embankments) had more or less the same problems as modern dams, a topic I have discussed elsewhere in more detail. Precolonial reservoirs also inundated people's homes and fields, tended to silt in and breach, and were even objects of corruption and politicking. When social arrangements for reservoir maintenance fell apart, the older system collapsed, but in our very dry study area, dryland reservoir systems were already in bad shape even before the fall of Vijayanagara. However, a few reservoirs in this region have been working well for the last 600 years. Tank restoration schemes can benefit from understanding these local histories of both success and failure.

Finally, we can see that the choices people made about things like where they lived and what they ate had significant impacts on their local landscapes. Our choices, too, have consequences, and in a more crowded and more industrialized world, we see those consequences

even more quickly, giving us less scope for error[40]. We share with Neolithic farmers the fact that our choices and our actions help shape the face the land; *unlike* them we have the analytical tools to look backward and reflect on these choices and actions and, with any luck, use that understanding to make a better future.

Acknowledgments

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Endnotes

[1] The Holocene, or Recent geological period marks the time since the end of the last major glacial period. Humans had been living in South Asia well before this, but it was only in the early Holocene that agriculture was first established, a process that has led to significant landscape transformations. Early agriculture in South Asia was a mosaic process, developing independently in several regions but also linked via transfers of plant and animal taxa and knowledge over long distances. Dorian Q. Fuller, "Agricultural Origins and Frontiers in South Asia : A Working Synthesis". *Journal of World Prehistory* 20, no. 1 (2006), 1–86; Nicole Boivin, D.Q. Fuller, and Alison Crowther, "Old World Globalization and the Columbian Exchange: Comparison and Contrast", *World Archaeology* 44, no. 3 (2012): 37–41.

[2] Humans have transported economically or aesthetically valued plants and animals across the entire world, sometimes also allowing opportunistic travelers such as weeds and 'invasive' species, now fully established in their new homes. It is clear archaeologically that cultigens moved very long distances even in the early Holocene; South Asians were active participants in this exchange. After 1492, New and Old World taxa met with both disastrous and beneficial results, leading to new hybrid ecologies in a non-reversible process of change.

[3] In the widespread and catastrophic mid-Holocene European elm decline, an interactive process of disease, climate, and human action may be implicated. See A.G. Parker, A.S. Goudie, D.E. Anderson, M.A. Robinson, and C. Bonsall. "A Review of the mid-Holocene Elm Decline in the British Isles", *Progress in Physical Geography* 26, no. 1 (March 1, 2002), 1–45.

[4] Wu, Tong, Michael Anthony Petriello, and Yeon-su Kim. "Shifting Baseline Syndrome as a Barrier to Ecological Restoration in the American Southwest", *Ecological Restoration* 29, no. 3 (2011), 213–216.

[5] This is discussed more fully in K.D. Morrison, *Environmental History Reimagined: Nature and Culture in South Asia*, (Delhi: Permanent Black, in preparation).

[6] Elsewhere I discuss the need for multiple kinds of archives for environmental history, including both textual and material records. See K.D. Morrison, "Opening Up the Pre-Colonial: Primeval Forests, Baseline Thinking, and Other Archives in Environmental History", in M. Rangarajan and K. Sivaramakrishnan (eds.), *Shifting Ground: People, Animals, and Mobility in India's Environmental History*, (Delhi: Oxford University Press, in press).

[7] Gadgil, M. and R. Guha, *This Fissured Land: An Ecological History of India,* (Berkeley: University of California Press, 1992); M. Gadgil and R. Guha, *Ecology and Equity: The Use and Abuse of Nature in Contemporary India*, (New York: Routledge, 1995).

[8] I am not arguing that there was no 'colonial ecological watershed' in some parts of South Asia but rather there were *many* 'watershed' moments in South Asia's environmental history, including precolonial ones. The impact of colonialism on local environments and peoples was not uniform nor were all colonical changes unprecedented.

[9] Indeed, this is precisely the argument explicitly made in Gadgil and Guha 1992. See some discussion of this in Morrison, in press, and in Archana Prasad, *Against Ecological Romanticism*, (Delhi: Three Essays Collective, 2003).

[10] This discussion draws on several research projects and thus numerous published articles and books. Overviews of this work can be found in K.D. Morrison, *Fields of Victory: Vijayanagara and the Course of Intensification*, (Delhi: Munshiram Manoharlal, 2000), K.D. Morrison, *Daroji Valley: Landscape History, Place, and the Making of a Dryland Reservoir System*, (Delhi: Manohar, 2009), C.M. Sinopoli and K.D. Morrison, *The Vijayanagara Metropolitan Survey: Volume 1,* (Ann Arbor: Anthropological Papers of the Museum of Anthropology, University of Michigan, 2007), K.D. Morrison, Seetha N. Reddy, and Arunima Kashyap, "Agrarian Transitions in Iron Age Southern India: Social and Environmental Implications", in V. Lefèvre (ed.), *South Asian Archaeology 2012*, (Paris: Agence France-Muséums, in press); and C.M. Sinopoli, K.D. Morrison, and R. Gopal, "Late Prehistoric and Early Historic South India: Recent Research along the Tungabhadra River, Karnataka", *Antiquity*, 82/317 (2008), http://www.antiquity.ac.uk/ProjGall/sinopoli/index.html.

[11] *sensu* J.C. Scott, *Domination and the Arts of Resistance: Hidden Transcripts*, (New Haven: Yale University Press, 1992).

[12] For critiques of ecological romanticism see S.S. Sinha, S. Gururani, and B. Greenberg, "The "New Traditionalist" Discourse of Indian Environmentalism", *Journal of Peasant Studies*, 24/3 (1998), 5-99; K. D. Morrison, "*Dharmic* Projects, Imperial Reservoirs, and New Temples of India: An Historical Perspective on Dams in India", *Conservation and Society,* 8/3 (2010), 182-195; and Prasad 2003, among others. Gadgil and Guha 1992, while a critically important contribution in many ways, is an excellent example of the romantic position.

[13] Morrison, 2009; K.D. Morrison and M.T. Lycett, 2014, "Constructing

Nature: Socionatural Histories of an Indian Forest", in S.B. Hecht, K.D. Morrison, and C. Padoch (eds.), *The Social Lives of Forests: The Past, Present, and Future of Woodland Resurgence*, (Chicago: University of Chicago Press), pp. 148-169.

[14] Korisettar, Ravi, P.C. Venkatasubbaiah, and Dorian Q. Fuller. "Brahmagiri and Beyond: The Archaeology of the Southern Neolithic", in S. Settar and R. Korisettar (eds.), *Indian Archaeology in Retrospect, Volume I, Prehistory*, (Delhi: ICHR, 2001), pp. 151-237.

[15] Morrison 2009; P.G. Johansen, "Landscape, monumental architecture, and ritual: a reconsideration of the South Indian Ashmounds", *Journal of Anthropological Archaeology* 23/3 (2004), 309-330.

[16] Boivin, N., "Landscape and Cosmology in the Southern Indian Neolithic: New Perspectives on the Deccan Ashmounds", *Cambridge Archaeological Journal*, 14/2 (2004): 235-57; Morrison 2009; Johansen 2004.

[17] Korisettar, et al. 2001; D.Q. Fuller, "Ceramics, Seeds and Culinary Change in Prehistoric India", *Antiquity,* 79 (2005), 761-777.

[18] Boivin, N., D.Q. Fuller, and A. Crowther 2012.

[19] Chen, S., B.Z. Lin, M. Baig, B. Mitra, R. J. Lopes, A. M. Santos, D.A. Magee, et al. "Zebu Cattle Are an Exclusive Legacy of the South Asia Neolithic", *Molecular Biology and Evolution* 27, no. 1 (September 21, 2009), 1–6.

[20] Korisettar, et al. 2001, p. 5.

[21] Morrison 2009; K.D. Morrison, M.T. Lycett, and M. Trivedi, " Megaliths and Memory: Excavations at Kadebakele and the Megaliths of Northern Karnataka", in D. Klimburg-Salter (ed.), *South Asian Archaeology 2010*, (Vienna*:* University of Vienna, in press).

[22] Morrison, K.D., Seetha N. Reddy, and Arunima Kashyap, in press, "Agrarian Transitions in Iron Age Southern India: Social and Environmental Implications", in V. Lefèvre, (ed.) *South Asian Archaeology 2012*, (Paris: Agence France-Muséums, in press)

[23] Andrew, M. Bauer and K.D. Morrison, "Water Management and Reservoirs in India and Sri Lanka, in H. Selin, (ed.) *The Encyclopedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, Second Edition, (New York: Springer Verlag, 2008), pp. 2213-4.

[24] Bauer, A.M. and K.D. Morrison, "Assessing Anthropogenic Soil Erosion with Multi-Spectral Satellite Imagery: An Archaeological Case Study of

Long Term Land Use in Koppal District, Karnataka," in D. Frenez and M. Tosi (eds.), *South Asian Archaeology 2007*, (London: British Archaeological Reports, 2013), pp. 67-76; this analysis is presented in greater detail in A.M. Bauer, "Socializing Environments and Ecologizing Politics: Social Differentiation and the Production of 'Nature' in Iron Age Northern Karnataka", Ph.D thesis, (University of Chicago, 2010).

[25] Advanced Spaceborne Thermal Emission and Reflection Radiometer, from NASA earth science. See Bauer, 2010 for details.

[26] Bauer 2010.

[27] Gopi Sundar, K.S., "Are Rice Paddies Suboptimal Breeding Habitat for Sarus Cranes in Uttar Pradesh, India?" *The Condor* 111, no. 4 (2009), 611–623; K.S. Gopi Sundar and Swati A. Kittur. "Methodological, Temporal, and Spatial Factors Affecting Modeled Occupancies of Birds in the Perennially Cultivated Landscapes of Uttar Pradesh", *Landscape Ecology* 27, no. 1 (2012), 59–71.

[28] See for example, Michael, Damian R., Ross B. Cunningham, and David B. Lindenmayer. "A Forgotten Habitat ? Granite Inselbergs Conserve Reptile Diversity in Fragmented Agricultural Landscapes", *Journal of Applied Ecology* 45 (2008), 1742–1752; and Manfred Kluge and Burkhard Budel. "Inselbergs: Vegetation, Diversity, and Ecology", in *Tropical Biology and Conservation Management. Volume IV,* (New York: UNESCO Encyclopedia of Life Support Systems, 2013).

[29] Overviews of recent research on Vijayanagara can be found in J.M. Fritz and G. Michell (eds.), *New Light on Hampi*, Marg Publications, 53/1 (2001) and A. Verghese and A.L. Dallapiccola (eds.), *South India Under Vijayanagara: Recent Research in Art and Archaeology*, (Delhi: Oxford University Press, 2010).

[30] Wagoner, P.B., 1991 "Architecture and Mythic Space at Hemakuta Hill: A Preliminary Report", in D.V. Devaraj and C.S. Patil (eds.), *Vijayanagara Progress of Research 1984-1987*, (Mysore: Directorate of Archaeology and Museums, 1991), pp. 142-148.

[31] See note 10.

[32] Morrison, K.D., "Coercion, Resistance, and Hierarchy: "Local Processes and Imperial Strategies in the Vijayanagara Empire", in S. Alcock, T. D'Altroy, K. Morrison, and C. Sinopoli (eds.), *Empires: Perspectives from Archaeology and History*, (Cambridge: Cambridge University Press, 2001), pp. 253-78.

[33] Of course, there was a great variety in forms of preparation and this would not have been universally true. For example, millets may be prepared in balls of boiled flour such as the *ragi mudde* of parts of Karnataka and Andhra Pradesh. One is struck, however, by the moistness of many of the rice-based preparations, a kind of 'wetness' (sometimes contained within smaller rimmed bowls) that brings to mind the flooded paddy itself.

[34] While we have some information on hunting in the Neolithic and Iron Age (e.g. A.M. Bauer, P. Johansen, and R.L. Bauer, "Toward a Political Ecology in Early South India: Preliminary Considerations of the Sociopolitics of Land and Animal Use in the Southern Deccan, Neolithic Through Early Historic Periods", *Asian Perspectives* 46/1 (2007), pp. 3-35. R.L. Bauer, *Animals in Social Life: Animal Use in Iron Age Southern India*, (Saarbrücken: VDM Verlag, 2007); Kelly Wilcox, "New Insights on the Ritual Use of Animals in the South Indian Iron Age (1200 B.C.E.-300 B.C.E.) Faunal Analysis at Kadebakele", in V. Lefèvre (ed.), *South Asian Archaeology 2012*, (Paris: Agence France-Muséums, in press), and less from the Early Historic, it is a serious lack that we know next to nothing about the procurement of wild plants and animals by Middle period people, especially, one would imagine, poorer people. This is the case simply because archaeological work on these later periods rarely attends to such matters; our own excavations have not yet been in these later deposits.

[35] Morrison 2009, 2010.

[36] Mollinga, P.P., *On the Waterfront: Water Distribution, Technology, and Agrarian Change in a South Indian Canal System*, (Delhi: Orient Longman, 2003), and see J. Janmat, "Calculating the Cost of Irrigation-Induced Soil Salinization in the Tungabhadra Project", *Agricultural Economics*, 31 (2004), 81-96.

[37] Morrison 2009.

[38] Depending on size and forms of sediment recruitment, the pollen record preserved in a water body will reflect a smaller of larger vegetation catchment. A regional record is reported in K.D. Morrison, "Pollen Analysis from the Kamalapuram *Kere",* in J.M. Fritz, T. Raczek, and R. Brubakaer (eds.), *Vijayanagara: Archaeological Exploration 1990-2000; Papers in Memory of Channabasappa S. Patil,* (Delhi: Manohar and AIIS, 2005), while Bauer 2010 documents a somewhat smaller area whose vegetation history diverges in important ways from the larger region.

[39] See for example, Bageshree S., "Sandur is Green this September, but...",

The Hindu, September 25, 2011.
http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/sandur-is-green-this-september-but/article2483824.ece, accessed May 21, 2013.

[40] Guha, Ramachandra and Rukun Advani, *How Much Should a Person Consume? Environmentalism in India and the United States,* (Delhi: Permanent Black, 2006).