Environmental History of Botanical Exchanges in the Indian Ocean World

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ABSTRACT

Much of the environmental history literature on plant transfers has centred on European agency and on the effects on both Old and New Worlds colonised and inhabited by European powers over the past five centuries. The emphasis on European agency obscures, or diverts attention from, prehistoric botanical exchanges, *i.e.*, plants transferred by human agency from one region to another thousands of years ago. While these exchanges may not have constituted 'ecological imperialism' the plants transferred nevertheless had significant impacts on the landscapes and societies they entered and in which they became established. This paper focuses on food crop exchanges in the Indian Ocean World. It draws on recent interdisciplinary research in archaeobotany and palaeoclimatic studies to illustrate the plant transfers that took place between eastern Africa, southern Asia and mainland and Island Southeast Asia between 2500 BCE and 100 CE and to explore how these arrivals may have transformed host societies and environments.

KEYWORDS

Botanical exchanges, environmental history, ecological imperialism, Indian Ocean

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INTRODUCTION

Popular knowledge of the environmental history of plant transfers has been dominated by two types of narratives, one centred on 'ecological imperialism' and the other on 'ecological nationalism'. Both narratives rely, implicitly or otherwise, on representing plant transfers and associated environmental change through the framework of Europe's historical development and domination of the world over the past five centuries. While ecological imperialism focuses on how European colonial expansion and associated transfers of biota contributed to environmental destruction and alteration of pre-existing 'Old' and 'New' World societies,[1] ecological nationalist narratives tend to highlight how various native or introduced plants were considered vital for modern state identities and nation-building following the European trajectory of economic development.[2] The inherent Eurocentrism in these narratives tends to obscure the fact that plant transfers have been an integral part of human history, extending over several millennia through the quotidian interactions of provisioning and exchange between peoples in every part of the world. These transfers and exchanges of plants within and across regions may not have followed the historical logic of the development of European civilisations, imperialism[3] or modern nation-building, but were undoubtedly crucial in reshaping the environments and societies where they took place. The key issue, though, is whether current frameworks in environmental history can move beyond the teleological structure of Eurocentric and nationalist narratives to provide richer and more nuanced understandings of the histories of plant transfers and ecological transformations in different regions of the world.

To answer this question requires us to reflect briefly on environmental history as a disciplinary practice. 'Environmental' history arose during the 1970s as both a critique of historiography that neglected to contextualise human actions in relation to the environment and a concern for the consequences of human impact on the environment in terms of degradation and loss of biodiversity and natural habitats.[4] A notable, and perhaps unintended, outcome of this combination of concerns is the focus on the last three to four hundred years, or the 'modern' period, as the predominant time-frame for describing the rapid and irrevocable changes wrought by human agency.[5] The emphasis on modernity as the driving

1. See Crosby [1972] 2003, 1986.
2. Sivaramakrishnan and Cederlöf 2005.
3. Brockway 1979, Grove 1995, Drayton 2000, Schiebinger and Swan 2005; for more recent examples, see Merson 2000, Parry 2004.
4. Our reflections on environmental history as a disciplinary practice are necessarily limited by the scope of this essay. For more comprehensive reviews of the discipline, see Beinart and Coates 1995, Cronon 1990, Hughes 2001, McNeill 2003, Mosley 2006, Simmons 1993, White 1985, Worster 1994.
5. See Thomas (ed.) 1956, which served as a precursor for academic engagement with environmentalism.

force of environmental change has meant that many of the implicit assumptions associated with this concept have been reproduced in environmental history narratives. Modernity is seen as the intellectual product of Europe that imbues history with a sense of universalism and progress; it is the inexorable force that drives capitalism and European colonisation across the world and draws non-European societies into its ambit by destroying their traditions and environments. These assumptions have tended to infuse most environmental history narratives with a teleological structure that is inevitably limited to describing the effects of European agency in the destruction or transformation of environments.[6] However, by presenting environmental change in this manner, such narratives preclude the possibility of developing a more nuanced understanding of the longer-term interactions between human histories and the histories of their physical and material worlds. Putting human history 'back' into its environmental context requires a conscious effort to step outside teleological or 'Whiggish' frameworks and focus instead on what White calls 'spatial history', a framework that enables a more dynamic understanding of how environments as relational spaces have been produced and reshaped over time through movements 'of people, plants, animals, goods, and information'.[7]

From a 'spatial history' perspective, therefore, environmental histories of botanical exchanges need to incorporate, at the very least, analyses of spatiotemporal change in biogeography, climate and human activity in order to understand the impacts of plant transfers in particular places or regions over time. Each of these processes can be studied at very different spatial and temporal scales and cannot be easily extrapolated from one scale to another.[8] The integration of such spatio-temporally diverse evidence within the narrative frame of environmental history raises three critical questions. First, what kinds of evidence or knowledges should be included for framing the narrative? Second, at what spatial scales can these knowledges be effectively integrated? And third, where in time should the narrative begin?

This paper attempts to address these questions by tracing the environmental history of botanical exchanges, primarily food plants, across the Indian Ocean. We focus on the movement of food plants because these provide the clearest link between human history, historical patterns of environmental change and the histories of landscape transformation. Our aim is twofold: first, to illustrate the Indian Ocean world as a spatiotemporal analytic frame that enables us to see beyond the 'ecological imperialist', colonial or nationalist perspectives of plant transfers; and second, to provide a broad sketch of the patterns of food plant exchanges between three major territorial zones of the Indian Ocean

6. For similar critiques of world history see Finley 1975, Goody 2006; one reviewer of this paper observed that nationalist histories were more likely to be 'Whiggish' than teleological; also see Tyrrell 1999.

7. White 2010, p. 3; also see Terrell and Welsch 1997.

8. Rangan and Kull 2009.

world – eastern Africa, southern Asia and Island Southeast Asia – from the third millennium BCE to the first century CE, *i.e.*, well before the recorded entry of 'Europeans' in this maritime arena. We focus on a limited number of plants that have become central to the everyday food repertoires of regional cultures around the Indian Ocean. We draw on recent evidence from interdisciplinary research in archaeobotany, ethnobotany and palaeoclimatic studies to assess approximate timing of introductions to these regions, possible reasons for transfers and pathways of diffusion and the ways in which these food plant exchanges may have reshaped agricultural landscapes of these regions.

FRAMING PLANT FLOWS IN HISTORY

No review of the environmental history of botanical exchanges can begin without recognising the important contributions of Alfred Crosby on the transfers of biota between the Old and New worlds through what he termed 'the Columbian exchange' and 'ecological imperialism'.[9] Crosby, a pioneer in integrating demographic and biological factors into the environmental history of European expansion across the globe, argues that European colonisation of the 'New World' (the Americas and Australasia) was facilitated in large part by the 'Old World' (Eurasian) biota – domesticated and wild plants, animals and germs – that accompanied colonists and settlers. He points to the fact that the flows of Old World biota far exceeded those from the new, and that this asymmetrical flow and successful establishment of European biota in settler colonies effectively created neo-Europes.[10]

Crosby's arguments are persuasive largely because they follow the 'modernist' teleological narrative of environmental history that we alluded to earlier but, as a result, overlook a number of important historical issues.[11] For instance, while discussing the Columbian Exchange he mentions how New World plants supported the 'Old World demography',[12] but fails to recognise their fundamental importance in furthering European mercantile expansion and colonial control in tropical Africa and Asia between the sixteenth and nineteenth centuries CE.[13] As Beinart and Middleton point out, Crosby's concept of ecological imperialism has little purchase when the spatial frame for examining plant flows during the era of European imperialism is broadened to include the 'Old World' tropics of Asia and Africa.[14] They note that large numbers of plants and trees were chosen

9. Crosby 1972, 1986.
10. Crosby 1986.
11. One reviewer of this paper referred to critiques of ecological imperialism as 'becoming something of a small industry'.
12. Crosby [1972] 2003, pp. 165–207.
13. Braudel 1981, Dasgupta and Pearson 1987.
14. Beinart and Middleton 2004.

and moved (along with unwanted 'weedy' companions and pests) between the Americas and various parts of the 'Old World' tropics. And while these exchanges occurred within the rubric of European mercantilism and colonialism, they did not necessarily produce 'neo-Europes' in these regions; indeed, in most cases it was quite the opposite.[15] Slaves transported from Atlantic Africa to the Americas arrived at their new sites of chattel labour with food and medicinal plants that had been carried as shipboard provisions,[16] as did Asian indentured and bonded labourers who were transported to various colonies in Africa, the Pacific and the Americas.[17] Beinart and Middleton argue that if the biological properties (and ecological behaviour) of plants were to be factored into the analysis then Crosby's concept of ecological imperialism would be further weakened and only applicable to a few specific locations. They conclude by calling for more interdisciplinary effort to incorporate biological and ecological science research into environmental history so as to better reflect the varying outcomes for plant species transferred across different locations.

Although it is common to hear calls for more interdisciplinarity in environmental history, Pawson and Dovers rightly argue that the epistemological differences between the social, biological and ecological disciplines pose significant intellectual and practical challenges.[18] That is to say, scholars in each of these disciplines think about and understand the world in culturally distinctive ways through their discursive practices, languages and types of evidence.[19] Pawson and Dovers observe that while it is common to present multiple disciplinary narratives regarding a particular environmental issue and leave it to the reader to make connections between them, it is far more difficult to find 'deeper' forms of interdisciplinarity where there is 'a willingness to see how others ask different questions, the ways in which they construct and interpret evidence and how they represent their findings'.[20] They draw attention to four points of intersection around which interdisciplinary work might occur in environmental history. The first is clearing the ground, *i.e.*, going beyond acknowledging epistemological differences and rigorously examining the starting assumptions and modes of constructing knowledge. They note that if this is not done, then the inherent biases of discipline-based evidence are likely to be reproduced, misunderstood and misrepresented in interdisciplinary work, examples of which can be seen in various environmentally determinist narratives of history.[21] Other points of

15. Brockway 1979, Mintz 1986, Arnold 2000, Livingstone 2002.
16. Carney 2001, Carney and Rosomoff 2009.
17. Tinker 1974, Ghosh 2008.
18. Crosby reflects on several of these in his preface to the 30th Anniversary edition of *The Columbian Exchange*; see Crosby [1972] 2003, p. xx.
19. Pawson and Dovers 2003.
20. *Ibid.* 62.
21. There are innumerable examples, past and present, of environmental determinist explanations of Europe's historical development, why societies are rich or poor, advanced

intersection that they mention are: spatial scale and locale; time and change; and environment, agency and process.

The four points outlined by Pawson and Dovers overlap with the questions we raised at the outset about framing the environmental histories of botanical exchanges. Namely, what kinds of disciplinary evidence do we seek to integrate, and at what spatial and temporal scales do we bring such evidence together to develop a richer perspective on botanical exchanges and their impacts on host societies and environments? There is no doubt that we need to take into account the different epistemologies, biases and spatio-temporal understandings embedded in the evidence provided by diverse disciplines which seek to explain socio-environmental change. But while doing so, we also need to ask how we might recognise and integrate historical evidence offered by knowledges that are 'non-disciplined' and often described as 'indigenous', 'traditional' or 'folk' ways of knowing. These kinds of knowledges are a fundamental part of what Braudel describes as *material life*, 'the life that man throughout the course of his previous history has made a part of his very being, has in some way absorbed into his entrails, turning the experiments and exhilarating experiences of the past into everyday, banal necessities'.[22] Common examples of this 'taken for granted' material life are found in folk beliefs and associated rituals, storytelling and other cultural practices that are linked to seasonal activities such as farming, harvesting and gathering forest produce, and to particular crops, plants, animals, insects and environments. These 'alternative' knowledge forms may carry rich information about histories of plant transfers and environmental change in regions and places but are rarely regarded as sources of 'real' historical 'facts' or 'hard' scientific 'evidence'. They may be mentioned in passing as curious vignettes of folk legends and nature myths in some environmental history narratives; however, they are often regarded as peripheral to, or outside the historical frame and of lesser value than, archival records or artefacts that offer evidence of technological advancement.[23] This kind of distinction between 'folk knowledge' and 'real fact' can lead environmental history narratives to reproduce, consciously or otherwise, the paradigm that Eric Wolf aptly called 'Europe and the people without history'.[24]

What is the most appropriate spatial scale for reflecting the richness of diverse historical evidence of botanical exchanges and consequent environmental transformations? Pawson and Dovers point out that there is no single or privileged scale for environmental history, and that the themes of historical inquiry usually determine whether the spatial scale of the narrative is national,

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or backward. See Blaut 1999 for a robust critique of environmental determinist and Eurocentric interpretations of world history in Diamond 1997 and Landes 1998.

22. Braudel 1977, p. 8.
23. Adas 1989, Scott 2009.
24. Wolf 1982.

sub-national, localised or global.[25] While this is a generally valid point, we need to acknowledge that particular institutional spatial scales – usually colonial and/or national – have tended to dominate environmental history narratives of plant transfers and exchanges. This is in large part because archival records usually reflect the interests of institutions that generate and compile the information and the spatial scales at which administrative activities take place.[26] For instance, most of the historical accounts of botanical exchanges that emphasise the primacy of European agency in transforming environments around the world rely primarily on archival records of colonial institutions and their economic and administrative networks, thereby effectively reproducing colonial spaces and the idea that colonial institutions were the prime agents of environmental change.[27] Conversely, historical narratives of plant transfers or introductions that draw on evidence produced by particular ecological models (such as succession and climax, or invasion biology) tend to reproduce the implicit 'world views' and spatial scales of cause and effect to illustrate the impact of botanical exchanges on 'native' landscapes or host environments.[28]

Similar issues arise regarding the choice of temporal scale for tracing the history of botanical exchanges. Plants have been transferred and exchanged by humans around the world since well before colonial or national archives existed, and their presence in landscapes and everyday cultures accentuates the problem of how the boundary line separating 'history' from 'prehistory' is established in environmental history narratives. As Cronon points out, references to prehistory often serve as framing devices for establishing a kind of 'primitive' backdrop for nationalist or colonial narratives of environmental transformation.[29] Archaeology can be seen as providing the most reliable empirical and datable information for what Carl Sauer calls 'the meeting of natural and cultural history',[30] and in renegotiating the boundary line differentiating history from prehistory. But here, too, inherent disciplinary biases towards evidence of 'civilisation' in the form of monuments or written records can obscure understanding of botanical exchanges or domestications in agricultural contexts and settlements that have patchy material records.[31] In these situations, narratives of archaeological prehistory inevitably resort to conventional ecological- or ecological imperialism-style models (along with their implicit world views regarding historical progress) of invasion by a technologically advanced culture and its inevitable dominance

25. Pawson and Dovers 2003: 65.
26. Comaroff and Comaroff 2001, Sivaramakrishnan and Cederlöf 2005.
27. See for example Grove 1995, Drayton 2000.
28. Ellis 1996; a classic example of applying population biology models to historical explanations of biological 'invasions' is Elton 1958; see Davis 2009 for a succinct summary of the different 'world views' and spatial scales of models used in invasion biology.
29. Cronon 1992: 1365.
30. Sauer 1952, p. 2.
31. Wolf 1982; Carney and Rosomoff 2009; Fuller and Boivin 2009: 33.

and replacement of weaker pre-existing social groups.[32] A predominant example is the farming/language macro-dispersal model in archaeology that is based on the conviction that 'languages, genes, and cultures move hand in hand to invade and replace' existing societies.[33] This model is commonly used to explain the prehistoric spread of Indo-European language speakers from Eurasia, Bantu speakers across sub-Saharan Africa and Austronesian 'out of Taiwan' speakers across Island Southeast Asia and the Pacific.[34] Although some scholars regard the model as 'simple and testable',[35] it ignores, or fails to incorporate, old and new evidence suggestive of multiple sites of plant domestication and indigenous development of food cultivation practices in these regions.[36] Consequently, as Donohue and Denham point out, the farming/language dispersal model imposes the 'people without history' paradigm onto prehistory by overlooking possible ways in which pre-existing social groups in these regions may have interacted with each other and influenced the cultivation 'packages' and languages of invading groups that subsequently established their dominance in numbers and in the exercise of social power.[37]

From our perspective, therefore, environmental histories of botanical exchanges need to develop new analytic perspectives that look for evidence outside the conventional archival sources or socio-ecological models of biological 'imperialisms' and 'invasions'.[38] While Crosby's analytical contributions have been invaluable in broadening the spatial scale of enquiry for examining the biological and cultural transformations wrought by European colonial expansion across the New World, they are less useful in understanding the longer pre-European history of botanical exchanges in these and other regional worlds that may not have been imperialistic in intent but nevertheless were critical in transforming landscapes, cultures and societies involved in these interactions. The longer-term processes of environmental change need to be seen through the geo-historical analytical lens of *region formation*, which focuses on differing paces and varying intensities of exchanges and interactions that together produce a distinctive and stable spatio-temporal world. These processes include: 1) the spatial practices of everyday life, centred around relationships within and between countryside and city, biophysical and built environments and between neighbouring localities; 2) interregional movements and flows of people, plants, capital and resources; 3) regionalisation resulting from the intensification of interactions between places through institutional networks; and,

32. Diamond's *Guns, Germs and Steel* is a classic example that popularises this model.
33. Oppenheimer 2010.
34. See for example, Renfrew 1987, Bellwood and Renfrew 2002, Diamond and Bellwood 2003, Bellwood 2005.
35. Cox and Lansing 2010.
36. Terrell 2000, Fuller 2007, Donohue and Denham 2010.
37. Donohue and Denham 2010.
38. In addition to Crosby 1986, see McNeill 2001.

4) the emergence of regionalism, *i.e.*, a shared spatial imagination, identification or sense of belonging to a particular world produced from the exchange and intermingling of cultures and practices.[39] A classic example of this kind of geo-historical perspective is Fernand Braudel's accounts of the Mediterranean world as a distinctive region formed through varying intensities and extent of connections between diverse cultural realms from prehistory to the seventeenth century.[40] So too is Carl Sauer's attempt to trace the prehistory of regional worlds or agricultural 'hearths' through human dispersals, transfers, exchanges and domestications of plants and animals in the pre-Columbian Americas, as well as in the 'older' worlds of Africa, Eurasia and southwest and southeast Asia.[41]

Recent developments in archaeobotany that combine palaeoclimatic studies, phylogenetic analysis and ethno-linguistic studies have been at the forefront in questioning many of the conventional wisdoms regarding prehistoric plant dispersals, domestications and diffusions from the usual 'core' civilisational regions of Mesopotamia and Eurasia.[42] These studies provide exciting examples of interdisciplinary work that both tackle the biases and data constraints within disciplines and develop new spatio-temporal frameworks of analysis for linking climatic fluctuations, movements of peoples, diversification and selective experimentation with particular plants or animals in particular regions and periods of time. In other words, they offer alternative ways of tracing processes of experimentation and evolution of the environmental histories of distinctive socio-technic ecological regions connected by varying intensities to other regional worlds. The following sections draw on these interdisciplinary insights to provide a broad outline of the pre-European environmental history of botanical exchanges in the Indian Ocean world.

INDIAN OCEAN PLANT TRANSFERS IN PREHISTORY

The Indian Ocean is perhaps the oldest 'human' ocean in global history, with evidence of material exchanges, cultural movements and interactions extending back at least 8,000 years before present, if not longer.[43] The littoral and maritime regions extending across from eastern Africa, the Arabian Peninsula, the Indian subcontinent, to mainland and Island Southeast Asia, along with networks of interactions with inland groups have been part of a distinctive, broader regional formation that we might call the Indian Ocean World. Within this regional world, the Arabian Peninsula and the Indian subcontinent have served as 'halfway

39. See Rangan and Kull 2009.
40. Braudel 1972, 2001.
41. Sauer 1952; also see J. Sauer 1993.
42. See the following section for more detailed references to these studies.
43. Mookerji 1912, Villiers 1952, Dasgupta and Pearson 1987, McPherson 1993, Pearson 2003,Vink 2007.

houses',[44] or anchors and staging points not only for the movements of peoples and trade across the Eurasian landmass, but also for maritime trade and interactions with eastern Africa, mainland and Island Southeast Asia.[45] Emerging archaeobotanical evidence indicates that coastal sites in peninsular Arabia and India may have served as centres of agricultural experimentation and diffusion for plants moving across the Indian Ocean from both eastern Africa and Island Southeast Asia.[46] The prehistory of early interactions, botanical exchanges and movements between these different parts of the Indian Ocean world formed the context of emergence for the complex maritime trade described in first century CE Roman sources such as the *Periplus Maris Erythraei*.[47]

The main physical phenomenon shaping the complex trade and cultural interactions of the Indian Ocean world is the seasonally changing wind pattern known as 'monsoon' that enabled seafarers to venture beyond coastal movements and undertake long-distance open-sea voyages. Although the Periplus attributes the 'discovery' of the monsoon to a Greek navigator called Hippalus, there is sufficient prehistoric evidence from various parts of the Indian Ocean world to indicate that early seafarers were well aware of the seasonal wind patterns before the arrival of either Greek or Roman navigators in this maritime arena.[48]

The monsoon phenomenon in the Indian Ocean region is related to the differential warming of air over land and sea. The heating up of the subcontinental land mass during the northern hemisphere summer causes air to rise and creates a low pressure system that results in a steady wind of moist air from the ocean to the low pressures developing over the land between June and September. The axial rotation of the Earth deflects the wind so that it blows from the southwest toward the Indian subcontinent and mainland Southeast Asia and is hence known in these regions as the Southwest monsoon. The wind pattern reverses during the northern hemisphere winter, blowing instead from the northeast high altitude Eurasian land mass across the Indian Ocean between October and March, and is known as the Northeast or retreating monsoon. The retreating monsoon diverges and changes direction on crossing the equator, blowing from the northwest towards Island Southeast Asia and northern Australia.[49] The monsoon currents contribute to seasonal upwelling off the southern Somali coast and the Horn of Africa, the Yemeni and Omani coast, the Malabar coast of southwest

44. The term is from Chaudhuri 1985 who refers to the Indian subcontinent as 'halfway house' for the vast, reticulated networks of trade across the Indian Ocean; archaeobotanical and historical research indicates that the Arabian Peninsula also served a similar role; see Boivin and Fuller 2009.
45. Chaudhuri 1990, Hourani 1995, Horton 1997.
46. Weber 1998, Blench 2003, Korisettar 2004, Fuller 2006, Boivin and Fuller 2009.
47. Schoff 1912, Miller 1968, Ray 2003, Boivin and Fuller 2009.
48. Mookerji 1912, Villiers 1952, Kirk 1962, Dasgupta and Pearson 1987, Horton 1997, Pearson 2003, Ray 2003.
49. Krishna Kumar *et al.* 1999, Saji *et al.* 1999, Schott and McCreary 2001, Wahl and Morrill 2010.

India and the seas between Island Southeast Asia and northern Australia, all of which have been areas of regular and productive fishing from a very early period.[50] These consistent wind patterns, along with similarly oscillating ocean currents, were familiar to Indian Ocean seafarers and enabled them to combine coastal and open sea voyages to travel between East Africa, Arabia, the Indian subcontinent, mainland and Island Southeast Asia. The long-term and regular patterns of littoral and maritime interactions prior to the arrival of ancient Greek and Roman navigators, and continuing well into the eighteenth century, have been described as 'empires of the monsoon' or the 'monsoon exchange'.[51] Maps drawn by sixteenth and seventeenth century European cartographers often sought to convey this sense of bustling activity and exchange around the Indian Ocean (see Figure 1), a reflection perhaps of Braudel's observation that the sea not only separates but also connects and unites cultures around it.[52]

FIGURE 1. *Nova Tabula India Orientalis* c. 1690, prepared by the Dutch map-maker Carel Allard (1648–1709), circa 1690, nla.map-nk1578; Courtesy of the National Library of Australia.

50. Forbes 1995, Goddard and Graham 1999, Black *et al.* 2003.
51. Hall 1996 refers to 'empires of the monsoon', while McNeill 2001 calls it the 'monsoon exchange'.
52. Braudel 1972.

Attempts to trace maritime botanical exchanges between different parts of the Indian Ocean world face three kinds of problems. First, the archaeological record for past agricultural economies, cultural practices and interactions with non-agricultural groups can be remarkably patchy with significant gaps in evidence.[53] Second, as we mentioned earlier, dominant models of farming/language dispersal tend to overlook the possibility that both 'migrant' and 'settled' social groups may have chosen from or adapted parts of each others' 'packages', rather than the wholesale replacement of the latter by the former.[54] Third, most archaeological and anthropological models of material and botanical exchanges have mainly focused on territorially-based pathways within Eurasia and the Americas or coastal corridors,[55] thereby tending to overlook the possibility of long-distance transoceanic exchanges via open sea voyages, despite old and new evidence for the existence of shipping and seafaring technology in the Indian Ocean.[56] However, recent archaeological scholarship has made significant headway in tracing early botanical exchanges in the Indian Ocean world by combining different disciplinary methods and techniques such as radiocarbon dating, archaeobotany, phylogenetic analysis, and ethno-linguistics.[57] Tables 1 and 2 outline the evidence emerging from this research for prehistoric botanical transfers from East Africa to the Indian subcontinent and in the reverse direction from Island Southeast Asia and the Indian subcontinent to Africa. Table 3 lists food plants in the Indian subcontinent that have been identified as being of African origin but for which material evidence is either lacking or not clearly established.[58]

A striking aspect of Table 1 is the possible arrival of sorghum towards the end of the Mature Harappan phase (between 2500 and 2000 BCE) in the Indus Valley and of pearl millet during the Late Harappan phase (2000–1700 BCE) in the semi-arid regions of present-day northwest India across Saurashtra, Kutch and Rajasthan. Recent archaeobotanical evidence from the Tilemsi valley in present-day Mali in West Africa indicates that domestication of pearl millet occurred around 2500 BCE, and two varieties of the crop with differing grain

53. van der Veen 1999, Neumann *et al.* 2003, Blench 2003, Fuller 2007, Boivin and Fuller 2009, Donohue and Denham 2010.

54. Fuller 2006, 2007, Boivin and Fuller 2009, Donohue and Denham 2010.

55. See for example Kroeber 1948, Rands and Riley 1958, Willey 1985; also see Sauer 1952, p. 36.

56. Sorenson and Johannessen 2009, Sauer 1993; also see Mookerji 1912; Kirk 1962, Kobishchanow 1965, Mahdi 1999, Ray 2003, Torrence 2010 for evidence of ancient shipping and seafaring technology in the Indian Ocean world.

57. See Kajale 1989, Blench 2003, 2009, Fuller 2003, Fuller and Madella 2009, Donohue and Denham 2009, De Langhe *et al.* 2009, Perrier *et al.* 2011.

58. For a broad overview of African crop plants, see National Research Council 1996–2008. For purposes of maintaining focus on botanical exchanges, we have not included animals in the tables and discussion, but see Fuller and Boivin 2009 for a discussion of animal exchanges.

TABLE 1. Food plants of African origin in the Indian subcontinent.

Latin name	**Selected common names in English and Local languages***	**Earliest Indian occurrence**
Sorghum bicolor	**Sorghum**; *Jowar (Hin), Cholam (Tam)*	ca.2500–2000 BCE (Weber 1998), ca.2000–1700 BCE (Fuller 2007).
Pennisetum glaucum	**Pearl millet**; *Bajra (Hin), Kombu (Tam)*	ca.2000–1700 BCE (Fuller 2007, Manning *et al*. 2011).
Lablab purpureus	**Hyacinth bean**; *Sem (Hin), Valpapdi (Guj) Avaraikkai (Tam)*	ca.2000–1700 BCE (Fuller and Boivin 2009).
Vigna unguiculata	**Cowpea**; *Lobia (Hin), Chowli (Mar), Karamani, Thatta payir (Tam)*	ca.1500 BCE (Fuller 2007).
Eleusine coracana	**Finger millet**; *Ragi (Kan, Tel, Mal), Kodra (Hin), Kurakkan (Sinh), Keazhvaragu(Tam)*	ca.1500–1000 BCE (Fuller 2007, Boivin and Fuller 2009).

* Guj – Gujarati, Hin – Hindi, Kan – Kannada, Mal – Malayalam, Mar – Marathi, Sans – Sanskrit, Sinh – Sinhala, Tam –Tamil, Tel. – Telugu

sizes were diffused across Africa and into the Indian subcontinent by 2000 BCE.[59] The earliest evidence of hyacinth bean is during the Late Harappan phase, while cowpea and finger millet appear towards the end of the Late Harappan phase (1500 BCE) in the eastern Indus and upper Ganges regions. These are only fragmentary glimpses into the past; the archaeobotanical record is more coherent from 1200 BCE onwards in peninsular and southern India.[60]

Table 2 highlights the complexity of botanical exchanges that have occurred between Island Southeast Asia, the Indian subcontinent, and East Africa. The geographical and chronological dimensions of banana domestication are very complex. Several major cultivar groups have been identified, resulting from multiple and diverse hybridisations among and between different species, subspecies and derived cultivars of *Musa acuminata* (A genome) and *Musa balbisiana* (B genome). The multiple domestications of *Musa* bananas occurred in numerous locales from New Guinea to peninsular India. Existing archaeobotanical and genetic evidence points to the probability that hybridisation of major cultivar groups had already occurred in Island Southeast Asia and New Guinea before being transported elsewhere.[61] Many important cultivar groups, including the West African plantains (AAB) and East African highland bananas (AAA), trace part of their ancestry to New Guinea. The earliest recorded finds in South Asia of wild bananas are seeds of *Musa balbisiana* and (potentially) *Musa acuminata* in

59. Manning *et al.* 2011.

60. Fuller 2006; Weber 1998 provides an earlier date (between 2500 and 2000 BCE) for the appearance of finger millet in the archaeobotanical record for the Indus Valley, but this date is still in question due to limited and inadequate material evidence.

61. Fuller 2007, Fuller and Madella 2009, Donohue and Denham 2009, Denham 2010.

Sri Lanka during the Pleistocene-Holocene transition. A later record of a banana phytolith comes from the Indus Valley during the Late Harappan phase (2000–1700 BCE).[62] Despite the difficulties of obtaining phytolith and microfossil remains of these plants in the humid tropics, there is evidence that triploid AAB banana cultivars in Africa may have been present in Cameroun in West Africa around 800–300 BCE. The presence of AAA cultivars in the East African Great Lakes region seems less well established, with limited evidence from before 2000 BCE and more evidence emerging in the first millennium CE.[63] However, both West and East Africa have a high number of their respective AAB and AAA cultivars, which indicates long periods of selection and cultivation, in turn suggestive of earlier and differing pathways of arrival across the Indian Ocean.[64]

TABLE 2. Food plants from Island Southeast Asia and the Indian subcontinent to Africa.

Latin name	**Selected common names in English and Local languages***	**Earliest African occurrence**
Musa spp.	**Banana**; *-konde (all languages of western equatorial forests*), *ògèdè (Igbo)*	Cultivated AAB plantains in Cameroun ca.800–300 BCE (Kleiman 2003; Mbida *et al.* 2001; Blench 2009; Neumann and Hildebrand 2009); Fuller and Madella 2009 indicate presence of banana in Kot Diji Indus valley ca.2000 BCE.
Cocos nucifera	**Coconut;** *nazi (Swahili)*	No pre-Swahili data from archaeobotany, but maybe in peninsular India ca.1800–1500 BCE (Achaya 1994); fibre and wood used in construction of maritime vessels around the Indian Ocean; presence in East Africa recorded in the *Periplus Maris Erythraei* around 60 CE (Schoff 1912, Ray 2007); coastal distribution in E. Africa may suggest arrival or introduction ca.500 BCE onwards.
Colocasia esculenta	**Taro;** *boyna (Malo, Ethiopia, 36 cultivars, 29 of which are of the eddoe type), ede (Igbo), koko (West Central Africa), maduma (Bantu)*†	No pre-CE data from archaeobotany; genetics suggest multiple domestications in northeast India, SE Asia and New Guinea (Lebot *et al.* 2004, Denham 2010); possible introduction in Africa from ca.1000–500 BCE.
Dioscorea alata	**Greater, or water yam**; *obuna (Igbo), yame (African yams, distinguished from water yam)*	No data from archaeobotany; genetics and phytogeography suggest domestication in New Guinea with spread to SE Asia (Martin and Rhodes 1977; Malapa *et al.* 2005; Denham 2010) in early Holocene; possible arrival in Africa ca. 1000–500 BCE.

* We have limited the list of local names to the languages of regions where the plants have the earliest records of presence.

† Werner 1968, Williamson 1993, Blench 2006, Fujimoto 2009.

62. Kajale 1989, Fuller and Madella 2009, Perrier *et al.* 2011.
63. Mbida *et al.* 2001, Neumann and Hildebrand 2009, Perrier *et al.* 2011.
64. de Langhe 1995, Vansina 2004, de Langhe *et al.* 2009.

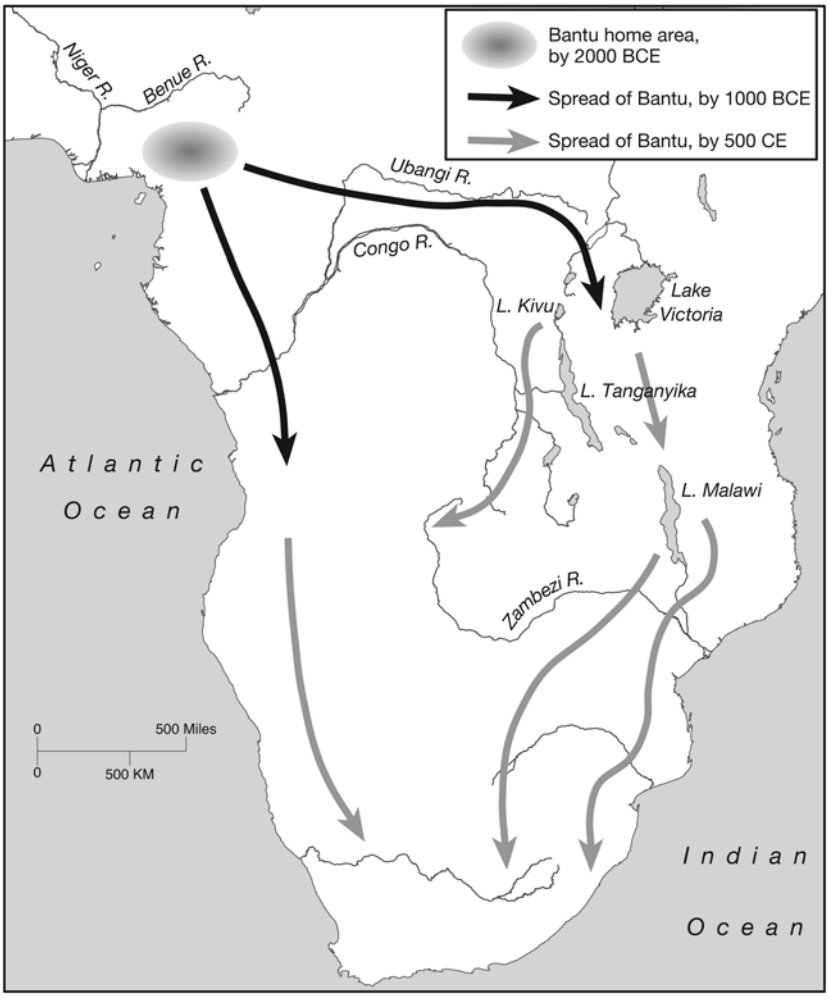

FIGURE 2. Pathways of Bantu movement across continental Africa.
Source: Authors 2011.

TABLE 3. Other food plants possibly transferred from Africa to the Indian subcontinent from prehistory to the first millennium CE, drawn from Achaya 1994.

Latin name	Selected common names in English and Indian languages*	Rough estimates of early presence in the Indian subcontinent (All page references are to Achaya 1994)
Abrus precatorius	**Jumbie bead**; *Gunji, krsnala, rati (Sans, Hin)*	Between 3000 and 1500 BCE in Harappan sites (p.14, p.195); mainly used as measure of weight. *Rati* is still used today as equivalent weight measure for gold and diamonds; 1 rati is roughly equal to 0.12gm.
Macrotyloma uniflorum, previously classified as Dolichos biflorus	**Horsegram**; *Kulthi (Hin), Kollu (Tam), Hurali (Kann), Ulavalu (Tel)*	1800 BCE in Daimabad, Tekkalakota (p.189), also Korisettar 2004; Achaya claims that two-thirds of the 242 species of *Dolichos* are native to Africa, and that India may have been a secondary centre for domestication. Reclassification as *Macrotyloma uniflorum* may alter this assessment. Fuller 2007 indicates domestications in Indian savannah zones from Rajasthan to peninsular India with widespread evidence from 2000 to 1500 BCE.
Tamarindus indica	**Tamarind**; *Imli (Hin), Puli (Tam)*	Identified as native to the Sudan region with longstanding presence in the subcontinent. Early Munda words for tamarind were adopted in Sanskrit and referenced in Vedic literature from around 1600 BCE (p.204, 206); also see Burkill Vol. 5, 2000 and National Research Council, *Lost Crops of Africa* Vol. 3, 2008.
Momordica charantia, *Momordica balsamina*	**Bitter melon, bitter gourd**; *Karela (Hin), Pavakkai (Tam)* **Balsam apple**; *Bimba (Sans)*	Mentioned in early Jain literature and Valmiki's Ramayana (p.204) and in Patanjali (p.36), roughly between 400 and 200 BCE; African transfer questioned in Fuller 2007, who identifies origins in Himalayan foothills; Schaefer and Renner 2010 indicate long-distance dispersal of *Momordica* from tropical Africa to Asia some 19 million years ago.
Hibiscus esculentus, Abelmoschus esculentus	**Okra/gumbo; lady's finger**; *Bhindi (Hin), Vendaikkai (Tam)*	No date available but is mentioned in medicinal treatise maybe around 400 CE (p.202); African origins questioned in Fuller 2007, who indicates domesticated hybrid of Gangetic *A. tuberculatus* x *A. ficulneus* of semi-arid/western peninsular India.
Guizotia abyssinica	**Niger noog, niger**; *Kalatil, ramtila (Hin), Hucchellu, gurellu (Tel)*	No date available, originates in eastern Africa from same area as finger millet and sorghum, but perhaps came across much later (p. 197).
Citrullus lanatus	**Watermelon**; *Tarbuz (Hin)*	No date available but has ancient Munda names (p. 202), and hence may have arrived from Africa before 1700 BCE (pre-Sanskrit).
Cyamopsis tetragonoloba	**Guar bean, cluster bean**; *Gawaar (Hin, Mar), Gokarakaya (Tel), Gorikayi (Kan), Kotthavarai (Tam)*	No date available but ancestral species *C. bengalensis* most likely from Africa; 'Arab traders may have introduced the plant from Africa to South India' (p. 193).

Cucumis melo	**Musk melon**; *Kharbuz (Hin)*	No date available, but is said to have 'exploded in terms of variety when it came from Africa to India' (p. 202).
Hibiscus sabdariffa	**Hibiscus, red roselle**; *Lal ambadi (Hin)*	No date available; Achaya notes that it may have been domesticated for eating under the Nuclear Mande culture in Sudan as early as 4000 BCE; *var. altissima* developed as source of fibre (p.202).

* Guj – Gujarati, Hin – Hindi, Kan – Kannada, Mal – Malayalam, Mar – Marathi, Sans – Sanskrit, Sinh – Sinhala, Tam –Tamil, Tel – Telugu

The arrival of domesticated taro cultivars and Southeast Asian yams on both the Indian subcontinent and Africa is equally complex. Both plants appear to have origins from northeast India to Southeast Asia, which suggests that they may have been part of very old cultivation systems in the wetter forest transition zones extending from eastern India to mainland and Island Southeast Asia.[65] Based on ethno-linguistic evidence rather than the limited archaeobotanical evidence, Blench (like Murdock before him) has suggested that bananas, taro and Asian yams may have arrived as a 'package' from Southeast Asia to West Africa roughly around 1000 BCE and that their cultivation allowed communities to exploit the equatorial rainforests more effectively.[66] Other scholars have favoured this hypothesis by linking the arrival of the banana-taro-greater yam package with the southward and eastward expansion of Bantu speakers from their linguistic homeland in Cameroun through the central African rainforest and eastward to the African Great Lakes region from 1000 BCE onwards (Figure 2).[67]

Table 3 illustrates the complexities of attempting to distinguish origins of plants that have a longstanding presence in all three main areas of experimentation and exchange in the Indian Ocean world. The list is derived from Achaya's survey of Indian food, which identifies these plants as originating in Africa,[68] but there is little evidence from archaeobotany to indicate when they may have arrived in the subcontinent and how they may have been integrated into regional cropping systems and food repertoires.[69] However, in the case of some plants like the jumbie bead (which has both African and Southeast Asian varieties) and the tamarind (from the Sudan region), ethno-linguistic evidence from early Munda languages suggests that these were present in the Indian subcontinent well before or during the Early Harappan period. Most of the other plants mentioned in Table 3 have distinctive names in language groups across western and southern peninsular India, which may indicate integration into regional foodways from 1200 BCE onwards to the first century CE.[70]

65. Fuller 2006, Denham 2010.
66. Blench 2009, following Murdock 1959.
67. Ehret 1998, 2002; Carney 2001, Kleiman 2003, Carney and Rosomoff 2009.
68. Achaya 1994.
69. Vishnu-Mittre 1970, Fuller *et al*. 2001, Achaya 2002, Korisettar 2004.
70. Achaya 1994, 2002; Fuller 2007.

MOTIVATIONS AND OUTCOMES OF BOTANICAL EXCHANGES

The preceding section indicates that botanical exchanges across the Indian Ocean have involved both littoral and maritime movements across remarkable distances and of varying intensity, with archaeobotany and ethno-linguistics providing evidence for some of these from at least 4000 BCE onwards. These exchanges, albeit limited, offer new glimpses of past worlds of social interaction and raise many interesting questions and possibilities for research that move beyond existing frameworks and models of environmental history. In particular, three broad questions arise from looking at these botanical exchanges in the context of the Indian Ocean world. First, what kinds of factors or processes might have motivated the transfers, exchanges, and adoption of these plants in their new locations? Second, what might have been the pathways or modes by which these plants were transported? Third, how did these exchanges contribute to transformations of landscapes and social organisation in different parts of the Indian Ocean world?

Factors influencing plant exchanges

Recent efforts at regional syntheses of palaeoclimatic and palaeoecological studies provide important insights regarding the influence of climate and sea level change on agriculture, settlement and maritime activity in the western Indian Ocean.[71] In broad terms, the monsoonal system and intensity have changed since the Pleistocene and fluctuated substantially during the Holocene. Following the end of the Younger Dryas period (roughly between 10,900 and 9500 BCE) which produced colder and drier conditions across much of the northern hemisphere,[72] the Early to Mid-Holocene was characterised by generally warmer and wetter conditions, but punctuated by several dry episodes in the region. The Early Holocene wet phase extended roughly from 9000 to 6500–6200 BCE, while the Mid-Holocene wet phase, which was lesser in intensity, occurred between 6000–5800 BCE to about 2500 BCE. There were several intervening dry events during these two wet phases around 6200 BCE, 5000 BCE, 4500 BCE, 3300 BCE and 2200 BCE, which had differential impacts or lag effects across the region. However, a number of studies indicate that the 6200 BCE, 3300 BCE and 2200 BCE dry events were marked by weakened monsoonal activity across west and east Africa and west and south Asia.[73] The past 4500 years from about 2500 BCE onwards, and particularly after the major dry event around 2200–2000 BCE, have been characterised by near-modern conditions of

71. Boivin and Fuller 2009; also see Fuller 2006, Madella and Fuller 2006.
72. Behringer 2010.
73. Gasse 2000, Wirrmann *et al.* 2001, Staubwasser *et al.* 2002, Staubwasser and Weiss 2006.

aridity and monsoonal rainfall patterns marked by droughts of varying duration and intensity occurring in 200 and 800 year cycles.[74]

The major dry events have been regarded as important moments marking shifts in settlement patterns, agriculture and animal husbandry, technological innovation, migration and socio-political upheavals in west Asia and Egypt.[75] However, what is of particular interest for this paper is how archaeobotanical evidence of plant exchanges across the Indian Ocean overlaps with the occurrence of these climatic shifts and events. Sorghum (*Sorghum bicolour*), pearl millet (*Pennisetum glaucum*) and finger millet (*Eleusine corocana*) along with cowpea (*Vigna unguiculata*) and hyacinth bean (*Lablab purpureus*) are five African crop domesticates[76] that are extremely important in dryland farming areas of the Indian subcontinent. Sorghum, which was domesticated and possibly brought under cultivation in eastern Sudan between 3000 and 2000 BCE,[77] first appears in the archaeobotanical record of South Asia during the Late Harappan phase (2000 and 1700 BCE) in the Kathiawar peninsula (Gujarat) and the Gangetic region, and more extensively in peninsular and southern India by 1000 BCE. Similarly, pearl millet, which has evidence of cultivation as far back as 2500 BCE in Mali in West Africa, is found in western India between 2000 and 1700 BCE and in southern India by 1500 BCE. Finger millet, domesticated in the uplands of Ethiopia, may have arrived in the Indus valley sometime during the Mature Harappan phase (2500–2000 BCE)[78] but clearer archaeobotanical evidence is available from 1500 BCE onwards in western and peninsular India.[79] The hyacinth bean, domesticated in savannah-Sahel regions of East Africa, appears in the Indus valley records between 2000 and 1700 BCE; the cowpea, which originates in the forest-savannah margins in West Africa and is likely to have been domesticated as savannahs expanded southwards during dry periods,[80] appears around 1500 BCE and more clearly in the record around 1200 BCE in peninsular and southern India.

In sum, all of these drought-resistant crops seem to have arrived from Africa around or after the major 2200 BCE dry event that marked the beginning of the arid phase of the late Holocene, and seem to have been incorporated into the local and regional repertoire of rainfed millets and legumes cultivated in various parts of the Indian subcontinent. The archaeobotanical records indicate that rather than being adopted as a 'package', these new crops were selectively incorporated into existing local and regional cultivation systems over time. For

74. Staubwasser *et al.* 2003, Hassan 2002, Vernet 2002, Shanahan *et al.* 2006.
75. Hassan 2002, Staubwasser *et al.* 2003, Staubwasser and Weiss 2006.
76. Fuller 2003, Neumann *et al.* 2003, Korisettar 2004, Harlan 2006, Boivin and Fuller 2009, Fuller and Boivin 2009.
77. de Wet 2000.
78. Weber 1998.
79. Fuller 2006, 2007, Boivin and Fuller 2009.
80. Harlan 2006.

instance, in parts of western India such as Rajasthan, Saurashtra and Kutch, sorghum, pearl millet and cowpea were well incorporated into the cultivation system by the last few centuries BCE; in parts of peninsular India, particularly in south Deccan and further into present day Sri Lanka, finger millet, cowpea, and hyacinth bean only became locally important food crops by 500 CE.[81]

In Africa, the major 2200 BCE dry event and subsequent declines in rainfall across the Sahara-Sahel region resulted in the southward expansion of aridity. The tropical forest zone would have presented a barrier for populations seeking to move to areas with more favourable rainfall conditions for cultivation of grain crops.[82] The evidence of the AAB hybrid banana in Cameroun around 800–300 BCE and the high number of these triploid cultivars in West Africa indicates that these may have arrived much earlier from Island Southeast Asia and undergone long periods of selection and cultivation.[83] The viability of banana as a food staple easily cultivated in tropical conditions may have enabled Bantu populations affected by increasing aridity to move further south into the Central African forest zone. Taro and greater yam may have arrived from Island Southeast Asia to Africa around the same period as the banana cultivars. Although some scholars have claimed that these three plants functioned as a 'tropical crop package' that spurred Bantu migration into southern and eastern Africa,[84] it is more likely that these tubers were selectively incorporated by migrating Bantu groups and the communities they encountered into local and regional combinations of pastoral and cultivation systems. Banana, taro and greater yam were well established alongside other African yams and grain crops in distinctive regional cultivation systems across central, eastern, and southeastern Africa by the first few centuries of the first millennium CE.[85]

Modes of transport

The evidence of long distance botanical exchanges across the Indian Ocean leads to the question of the modes of transport that might have been used to move these crops. People of the Western Indian Ocean region have exhibited a maritime orientation of considerable antiquity. Shell middens indicate the presence of littoral communities harvesting marine resources from the early Holocene.[86] The significant rise in sea levels of 5–7m from the end of the 6200 BCE dry event to roughly present levels around 5000 BCE may have influenced littoral communities around the Arabian Sea to develop maritime technology in

81. Farmer 1954; Achaya 1994, 2002; Fuller 2005.
82. Wirrmann *et al.* 2001, Breunig and Neumann 2002, Hassan 2002, Vernet 2002.
83. Mbida *et al.* 2000, de Langhe 1995, de Langhe *et al.* 2009, Neumann and Hildebrand 2009, Perrier *et al.* 2011.
84. Kleiman 2003, Blench 2006, 2009, Carney and Rosomoff 2009.
85. Blench 2009.
86. Boivin and Fuller 2009.

order to venture into deeper waters for fishing and maintaining trading links. In doing so, it is very likely that these maritime groups would have developed an understanding of the monsoon winds and learned to take advantage of them to sail more directly to ports along the coast.[87] Evidence for large bitumen-coated reed boats emerges in the western Indian Ocean around 3000 BCE, followed by plank-built wooden boats by 2300 BCE,[88] indicating that maritime trade and movements may not always have followed the 'coastal corridor',[89] but ventured further out into the Indian Ocean to link small-scale ports of east Africa, the Arabian peninsula, the Persian Gulf and western India with each other and with major Harappan and Mesopotamian centres. The records of sorghum and pearl millet found in Saurashtra during the Late Harappan phase (2000–1700 BCE) may well have been transported directly across the ocean from East Africa to Gujarat. There is no doubt that by the first millennium BCE there was a well-established monsoon-propelled traffic linking ports of the western Indian Ocean across the deep ocean to ports in island and mainland Southeast Asia.[90]

A similar scenario can be envisaged for the movement of tropical food crops from the eastern Indian Ocean region to the Indian subcontinent and east Africa. Sea level rise from the mid-Holocene onwards inundated the Sunda and Sahul shelves, creating the present-day configurations of Island Southeast Asia and oceanic separation of New Guinea from northern Australia. This process is likely to have led communities in these regions to increase maritime interaction in order to maintain social connections and exchange partnerships with each other.[91] Changes in settlement patterns across islands following sea level rise would have also enhanced anthropogenic transfers and exchanges of food crops. Since cultivated banana, taro and greater yam are essentially vegetatively propagated, people moving between the islands and venturing out further would have carried these food crops on their boats and, over time, are likely to have developed different cultivation systems combining these crops in new ways and developing new hybrid varieties. The seafarers of the eastern Indian Ocean, like their western Indian Ocean counterparts would have, through their maritime ventures, understood the monsoonal wind patterns and utilised them to travel across the Indian Ocean for trade and other cultural interactions or new settlement, as in the case of the arrival of Malay-speaking groups in Madagascar by the late first millennium BCE.[92] Some scholars have postulated that the evidence of bananas in West Africa by 800–300 BCE may even suggest that seafarers from Island Southeast Asia journeyed around southern Africa to

87. Horton 1997.
88. Boivin and Fuller 2009.
89. Sauer 1952, Achaya 1994.
90. Mookerji 1912, Mahdi 1999, Ray 2003.
91. Lebot 1999, Mahdi 1999.
92. Hall 1996, Mahdi 1999, Blench 2007.

the Gulf of Guinea.[93] Alternatively, the maritime trade, botanical exchanges and agricultural experimentation with these vegetatively propagated crops among Indian Ocean societies may have led to different pathways of diffusion and adoption across sub-Saharan Africa alongside population shifts and movements of peoples across the continent from 2000 BCE onwards.

Transformation of regional landscapes

How might these botanical exchanges have contributed to transformations of landscapes and social organisation in different parts of the Indian Ocean world? Our interdisciplinary overview of environmental history covering the past 3000 years draws attention to the power of climatic cycles, not as the sole determining factor, but as the rhythmic context that highlights the processes of transformation of landscapes and seascapes in this region. The rising sea levels, cold and warm periods, wet and dry phases, punctuated by extreme 'events' of varying length appear not so much as overwhelming constraints, but rather as chords (to borrow a musical metaphor) that generate diverse actions and movements of people across land and ocean to reassemble in new ways and forms. Sea level rise not only led littoral societies in the western Indian Ocean to move further inland but also to travel further out into the ocean and establish direct sea links with more distant trading centres. Likewise, the inundation of Sunda and Sahul may have forced coastal communities to move to upland areas of the islands and motivated them to venture further out into both the Indian and Pacific Oceans to settle or trade with societies in more distant locations.

The major 2200 BCE 'dry event' emerges as a 'long conjuncture' extending over several centuries, marking the beginning of the end of larger forms of social organisation in the western Indian Ocean region. For example, the Mature Harappan civilisation comprised large concentrated settlements in the upper Indus valley that declined as smaller settlements emerged to the east and south and coastal trading centres in Gujarat went into ascendancy. Similar patterns of reorganisation seem to occur in the large social agglomerations of Mesopotamia (the decline of the Akkadian and Sumerian Ur III and rise of the Babylonian civilisation) and Egypt (the transition from the Old Kingdom to the First Intermediate Period). And as we sketched out in the preceding section, the 2200 BCE dry event marks the beginning of 200 to 300 years during which long distance exchanges of grains and vegetative crops across mainlands, islands and oceans gather apace and enable new combinations of cropping, agriculture and pastoralism and movements in Saharan and sub-Saharan Africa, peninsular Arabia and India and Island Southeast Asia. These centuries were an era of globalised plant and – though not the focus of this paper – animal exchanges

93. This hypothesis is discussed by Blench 2009 who also refers to earlier ethnomusicology debates on similarities of musical instruments and styles of singing in Indonesia and parts of West Africa; see Jones 1971, Ehret 1998 and Alpers 2007.

that enabled more elaborate and extended linkages between sedentary and mobile and littoral and inland communities in the following millennia. As the *Periplus of the Erythraean Sea* illustrates,[94] by the time the Greeks and Romans entered the maritime world of the Indian Ocean, small and large ports in East Africa, Arabia, peninsular India and parts of Island Southeast Asia were not only linked by the exchange of precious commodities such as tortoise shell, rhinoceros horn, cinnamon, frankincense, myrrh, spices, sugar (from sugarcane) and palm oil, but also by the novel agricultural, pastoral and littoral landscapes composed of different combinations of 'native' and 'introduced' crops, trees and animals brought together during previous millennia. In other words, a hypothetical 'foreign' seafarer entering the ports of the Indian Ocean world in the early centuries of the first millennium CE would have found in the cuisines and cultivated landscapes of the hinterlands differing combinations of a familiar repertoire of grain and vegetable crops representing the oceanic and continental botanical exchanges of the preceding 2000 or so years.

CONCLUSION: BOTANICAL EXCHANGES AND ENVIRONMENTAL HISTORY

The aim of this paper is to explore the environmental history of botanical exchanges in the Indian Ocean world from a *longue durée* interdisciplinary perspective so as to move beyond the conventional narratives based on frameworks of ecological imperialism or nationalism. Although these narratives derive their appeal from invoking ideas of progress in history and their manifestations in various kinds of territorial-institutional chauvinisms – empire, nation-state, locality, civilisation (as in the case of archaeology)[95] – as the driving force for the movement of biota across space, the history of global botanical exchanges indicates that these were much more a part of the quotidian life of people and societies involved in reshaping their landscapes and cultural practices in relation to the rhythms of climatic and vegetation change. Botanical exchanges occurred through different combinations of land, coastal and oceanic movement of peoples. As Boivin and Fuller observe, seafaring and maritime exchange were 'not concentrated in the hands of a few major players, but more diversely composed of distributed networks of agents in contact across a variety of scales'.[96] Plant transfers were not dependent on grand, centrally-organised schemes of great civilisations and diffusion of their agricultural or technological innovation from core to periphery. Nor did they represent some predestined path of progress of societies from hunting-gathering to pastoralism or agriculture. Rather, the

94. Schoff 1912.

95. Or other geopolitical/spatial chauvinisms such as 'area studies'; see Subrahmanyam 1990, Reid 2007.

96. Boivin and Fuller 2009: 165.

emerging evidence from archaeobotanical and palaeoclimatic research points to more complex patterns of adoption and adaptation of new crops by hunting, pastoral and farming groups within regions, and the emergence of more diversified repertoires of foodways.

Looking at botanical exchanges beyond conventional spaces of empire, nation-state and locality draws attention to the need for a more 'amphibious' spatial framework for understanding environmental history.[97] By using the 'Indian Ocean World' as the analytic space for exploring botanical exchanges and their regional outcomes, our paper illustrates the importance of understanding regional and local environmental histories through the relationships and movements between land-based networks and maritime connections. This amphibious perspective opens up new questions about the effects of the 2200 BCE and subsequent dry events on mainland and Island Southeast Asia. What kinds of plants might have moved from South Asia and East Africa to Island Southeast Asia? While the timing of arrival of Austronesians in Madagascar has been the subject of significant research, much less is known about the earlier occupation of the island by African groups and of their seafaring beyond towards Island Southeast Asia.[98] Also, what kinds of return movement or circulation existed between Madagascar and Island Southeast Asia between the arrival of the Malay-speaking groups and the growth of Swahili maritime networks into the southwest Indian Ocean?

Finally, our framework highlights the limited archaeological knowledge about botanical exchanges between the western, central and eastern maritime regions of the Indian Ocean World and the northern and western littoral of the Australian continent. Nationalist and Eurocentric models of historical and archaeological inquiry have perhaps been over-determining factors in the lack of understanding of maritime interactions and environmental history of botanical exchanges that may have brought Australian Aboriginal societies within the ambit of ancient trading networks and interactions of the Indian Ocean World. Moving beyond the parochial constraints of imperial or national archives and drawing on diverse disciplinary sources such as folklore, art, archaeobotany and palaeoecology may help in understanding how northern Australia was integrated into this larger maritime world.[99] European arrival did not mark the 'beginning' of environmental history for Indigenous communities in mainland and island Australia, but rather a process of restructuring, sundering and reorientation of social, botanical and cultural relationships across the Indian Ocean World.

97. Pearson 2007, p. 28.
98. Blench 2007.
99. Denham *et al.* 2009.

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