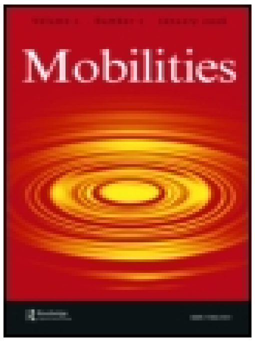

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Constellations of weathering: following the meteorological mobilities of *Bangla* bricks

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ABSTRACT

Using follow-the-thing methods and insights from ethnographic fieldwork, this paper traces the meteorological mobilities entwined within Bangladesh bricks. Following the extended lifecycle of the *Bangla* brick from sediment to clay, from clay to brick and from brick to sediment, and the role that monsoon weathering plays in these processes, reveals complex entanglements of mobilities and materialities. A more-than-human mobilities perspective highlights the myriad human and nonhuman circulations that constitute the brick, as well as the geological, atmospheric and hydrological dynamics that brickmaking sets in motion. Through the becoming and unbecoming of the brick, the paper explores how the mobile materiality of the monsoon is enmeshed within the building blocks of Bangladesh's cities and the infrastructures on which they depend and how, in turn, the mobile materiality of the brick influences monsoonal environments. These intra-active entanglements trouble perceived dichotomies between society and meteorological forces and highlight the agentive role of weather systems in social worlds.

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Brick; mobilities; weather; monsoon; follow-the-thing; Bangladesh

Introduction

This paper follows Bangladesh bricks, or *Bangla* bricks, to explore how monsoon weather is embedded within built environments. This is an attempt to engage with the non-human agencies that co-produce urban materialities, particularly the role that weather plays in the production and transformation of materials. As Neimanis and Walker (2014) have argued, weather is not just a backdrop to human activity, the ebb and flow of meteorological life works through and across bodies and materials. Paying attention to the meteorological mobilities that contribute to the making and unmaking of bricks reveals the liveliness of the material world, the dynamic properties and capacities of matter and the active role of nonhuman agencies. This is inspired by more-than-human (Whatmore 2006), new materialist (Fox and Alldred 2019) perspectives that are attentive to the co-constitutive role of nonhumans in the production of the world. With this in mind, I argue that bricks are the emergent result of a continual 'dance of agency' (Pickering 1995, 21), a reciprocally transformative back and forth in which human and nonhuman agencies are mutually and emergently productive of one another.

Landscapes, places and things are increasingly understood to be outcomes of intersecting processes and flows, material and non-material, human and nonhuman (Jones 2011). The mobilities paradigm (Sheller and Urry 2006) in particular has sought to challenge static approaches that dominated the social sciences, arguing that flows and movement define sociality. A particular characteristic of mobilities research is its focus on the movements of multiple materialities, both

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human and nonhuman (Adey et al. 2014). By examining ‘different mobilities and their complex combinations’, the paradigm directs attention to ‘the many incessant, forceful, vital and vibrant movements’ which underpin and shape our worlds (Merriman 2016, 558). Nevertheless, in their introduction to the recent ‘Anthropocene Mobilities’ special issue, Baldwin, Frohlich, and Rothe (2019) argue that nature and the environment have remained largely at the peripheries of mobilities research, claiming that the movements concerning the paradigm are mostly to do with humans. Rather than being the material substance through which mobility is mediated, the dynamic Earth is rendered inert.

This lack of attention to the environment includes weather systems, which have perhaps been considered ‘too banal, physical or “unsocial” to include in accounts of mobility systems’ (Merriman 2012, 9), thereby diminishing their contributions. Although weather may have occupied an ‘absent-presence’ (Vannini et al. 2012, 362) in mobilities research, and in social research generally (Ingold 2005), mobilities thinking provides a way of exploring and acknowledging the ways in which weather, as a form of nonhuman agency, is entangled within social worlds. Meteorological forces themselves are both products of and drivers of mobility, as Vannini et al. (2012, 373) write, ‘weather is sheer movement’. Arising from ‘relational movements’ (Jones 2011, 2287) of the earth, weather patterns shape the spaces they operate within through their movements, including local topographies, ecologies, cultures and economies. Indeed, as the anthropologist Ingold (2007, 33) points out, people weather their lives by moving alongside atmospheric patterns and in the process ‘bind the weather into substantial living forms’. With this in mind, he argues that weather should be thought of as a field of moving materiality which continually gives rise to things and contributes to their dissolution. As meteorological mobilities are entwined with the materials that constitute our environment, he encourages us to ‘follow the forces and flows of material’ that bring forms into being (Ingold 2010, 10). In doing so humans might gain a deeper appreciation of how materials are caught up in the currents of the weather-world.

In the ‘Anthropocene Mobilities’ special issue, Baldwin, Frohlich, and Rothe (2019, 292) argue further that the advent of the Anthropocene means that social scientists can ‘no longer afford to ignore the dynamic earth,’ as social and political life are ‘too tightly tethered to the Earth System.’ To engage more deeply with the *geos*, they propose attending to the ways in which human and nonhuman forms of mobility are interlinked, and suggest utilising Clark and Yusoff's (2017, 3) concept of ‘geosocial formations’ to do so. In response to this provocation, I explore the diverse agencies entangled in the production of *Bangla* bricks, with emphasis on the generative movements of the monsoonal weather-world they are enmeshed within. Taking inspiration from Ingold, I pay attention to the continual generation and transformation of materials that constitute the brick through ‘processes of admixture and distillation, of coagulation and dispersal, and of evaporation and precipitation’ (Ingold 2007, 7). Mobilities thinking, particularly the work of Tim Cresswell (2010), provides a way of exploring these intra-active processes, prompting consideration of: the forces that constitute movement; notions of speed and rhythm; how mobility is channelled in time and space; and sensory aspects of mobility. By perceiving the brick as a ‘constellation of mobility’ (Cresswell 2010, 17), connected with flows of varying kinds, I reveal that the built environment of Bangladesh is ‘inextricably bound up with the biophysical forces that transform energy and materials in an active process of co-production’ (Taylor 2014, 37).

Weather and bricks

From its earliest beginnings brickmaking has been bound up with the weather. Emerging between 10,000 and 8,000 BC, bricks are one of the oldest known building materials (Campbell and Pryce 2003, 13). Bricks were formed in relation to weather, created to provide protection from prevalent climatic conditions and insulation from cold and heat (Fernandes, Lourenco, and Castro 2010). Bricks also respond to and produce weather. Their hygroscopic properties enable them to absorb moisture from the air and release moisture into the air (Minke 2006, 16), making earthen bricks adaptive to and productive of changing climatic conditions. 'Unlike many other hard building materials, bricks breathe, almost as living beings. Their open cell structure makes them wind-proof but breathable. They also offer superb insulation – helping interiors remain cool during a hot summer and warm in cold winters' (Cruickshank 2019, no page). By regulating the microclimates of human habitation, bricks mediate relations with weather and climate.

As well as being a response to weather and reactive to weather, bricks are also entangled with weather through their production. The making of bricks possibly originated from observing the changing properties of soil through the seasons, cycles of wetting and softening, drying and hardening in response to changing weather patterns. Historically, brickmaking was an inherently seasonal activity due to its reliance on the abundant heat of the sun. Bricks were made by hand, sun-dried and fired in clamps. As the entire process was carried out in the open air, it was dependent on weather but also subject to its uncertainties (Watt 1990, 29). Writings by Vitruvius from the first century BC references this seasonality: 'the proper seasons for brickmaking are the spring and autumn, because they then dry more equitably' (Gwilt 1862, 43), the quality of bricks being influenced by the time of year and length of drying time. For several thousand years brickmaking remained unchanged until the development of new technologies in Europe and America towards the end of the nineteenth century transformed the sector (Heierli and Maithel 2008, 29). Brickmaking became large-scale, capital-intensive and highly-mechanised, diminishing its seasonality.

Relations between weather and brickmaking are still apparent in the monsoonal terrain of Bangladesh, and much of South and Southeast Asia (Brickell et al. 2018, 35; Lundgren-Kownacki et al. 2018). In these regions brick fields only operate during drier months, the season of production being determined by the monsoon. The word monsoon, originating from the Arabic *mausim* meaning season, was traditionally used by mariners in the Indian Ocean to refer to reversals of wind direction at fairly fixed periods in the year (Toussant 1966, 8–9). These periodic changes in the wind are created by atmospheric circulations, produced by solar heating and seasonally contrasting temperatures between land and ocean. As the immense Himalayan mountain range grows warm during spring the air rises, drawing in flows of moist air from the oceans to the south. As the air rises, heavy clouds of water vapour form which cool and condense over land as they travel, producing rain (Figure 1). As the sun retreats and winter approaches oceans remain warmer than land and wind direction reverses, carrying rains towards the Indian Ocean. Arising from 'dynamic interactions

Figure 1. Monsoon clouds over Bangladesh. Credit: Author.

between atmosphere, oceans and continents' (Clemens et al. 1991, 720), including the spinning earth, changing distribution of heat between land and sea and the seasonal movement of the sun, the monsoon is a mobile phenomenon generated by 'planetary mobilities' (Szerszynski 2016, 614).

The resulting oscillations between wet and dry seasons profoundly influence the temporality and materiality of the Indian Subcontinent, a 'mobility region' (Szerszynski 2016, 614) defined by the monsoon. For Bangladesh, nearly eighty percent of the country's annual rainfall falls during monsoon months, with little rainfall the rest of the year (Shamsuddin, Harun, and Katimon 2012, 266). Variations in rainfall create enormous hydrological fluctuations. From November to March only a fraction of the land is covered in water, from June to September waters swell to cover almost half of the country. Human and nonhuman activities respond to these fluctuations, adjusting to the recurrent transformations of the environment. Through these adjustments monsoon rhythms become entangled with social processes, materialities and practices in a multiplicity of ways, permeating and shaping ways of life and lived environments. In turn, these ways of life and lived environments permeate and shape monsoon weather patterns, forming complex 'intra-active' (Barad 2007, 151) relations. Exploring the lifecycle of the brick within this monsoonal landscape reveals the mutual worlding that Neimanis and Walker (2014, 558) refer to as 'weathering', a process of becoming in which bodies, materials, places and the weather are inter-implicated.

Following-the-brick

The observations outlined in this paper arise from ethnographic fieldwork in Bangladesh. My approach is informed by material culture studies and follow-the-thing methodologies (Cook 2004), which focus on the spatio-temporal and material lives of things and objects. Whilst acknowledging that nonhuman things have life histories and mobilities of their own, studies of 'things-in-motion' have generally focused on human and social contexts (Appadurai 1986, 5). In following the materiality of the brick, I develop the follow-the-thing methodology from a more-than-human, new materialist perspective. This involves moving beyond human-centric capital-driven commodity chains to consider the agency and mobility of the environments that bricks emerge from and are enmeshed within, with an emphasis on monsoonal weather patterns. With weathering in mind, and partly inspired by Edensor's (2012a, 2012b) studies of urban stone, I take an extended view of the brick, that includes its geological origins as well as its sedimentary afterlife. Following-the-thing before and after it becomes a defined entity allows me to include the environmental mobilities that play an agentive role in its becoming and unbecoming. This approach destabilises the thing itself and shows that the brick is just a moment in the circulation and assembling of matter (Gregson et al. 2010, 848). As certain aspects of the brick's lifecycle are unfollowable (Hulme 2017) I rely on informed speculative description to draw attention to the lively, material, more-than-human dimensions of the brick's lifecycle.

To write this paper I have drawn on a range of resources, including historical texts, scientific literature, geological accounts, online information, newspaper articles, conversations and interviews, fieldwork observations and my own embodied encounters with monsoon environments. Fieldwork for this research was carried out between February 2018 and October 2019, as part of a research project exploring relations between changing monsoon climates and rapid urbanisation in South Asia. Fieldwork consisted of three visits to Bangladesh during the dry season, monsoon season and post-monsoon season. During these visits, I spent time at a brick kiln on the outskirts of Dhaka, and observed clusters of kilns on the banks of the Meghna River south of the city. I spoke with brickfield workers and owners, brick suppliers and distributors, architects and planners, representatives of agricultural research organisations, and environmental activists. Travelling around the country at different times of year enabled me to perceive connections between bricks and the materiality of a monsoonal terrain.

During my visits, I used techniques from sensory ethnography (Pink 2015, xi) to develop an attunement to the mobilities and materialities of weather and brickmaking. Embodied experiences of moving through monsoonal landscapes on roads in various states of repair in different seasons allowed me to appreciate the physicality of changing mobilities, particularly the effect of mud during the rainy season. Breathing in dust and particulates expelled by the brickfields during the dry season, gave me a visceral understanding of the toxic mobilities catalysed by the brick. Standing on top of burning brick kilns in the intense heat of the dry season enabled a corporeal awareness of the hardships endured by seasonal workers. Audio-visual recordings helped me to perceive and analyse rhythms, flows and interconnections, highlighting that each phase of brickmaking has its own sounds, speeds, textures, movements and rhythms. Each task creates its own temporal pattern and embodied interaction, a complex choreography between bodies and materials within which multiple rhythms are intertwined. These experiences helped me to develop an appreciation of the material and processual aspects of bricks as everyday materials.

Bricks of Bangladesh

Bricks are immediately apparent on visiting the megacity of Dhaka (Figure 2). Brick kilns and brick fields proliferate along the river banks surrounding the city, their towering chimneys emerging from the low-lying riverine terrain. Piles of bricks are transported in overladen boats along urban waterways and are carried in precarious mountainous stacks by day labourers onto the many construction sites that punctuate the city. Bricks are used for buildings and infrastructure alike. Even Louis Kahn's iconic National Assembly building (1962–1983) rises up from a base of red *Bangla* bricks, surrounded by a moat signifying the country's aquatic landscape. The foundations and surfaces of the city's roads and pavements are also made from brick, although they often go unnoticed as they are pounded by trucks, bicycle wheels and feet. During the drier months brick dust infiltrates the air, coating buildings, plants, surfaces and lungs; during wetter months, monsoon rains dampen the dust, cleansing surfaces and atmospheres alike. Bricks form a ubiquitous, ever-present part of the urban landscape; their visibility and mobility an indicator of rampant urbanisation.

Although clay fired bricks are now an omnipresent part of Bangladesh's built environment, studies of vernacular architecture suggests they were not part of indigenous house building practices (Ahmed 1991, 41). Brick making emerged in the Indian subcontinent during the third millennium in the cities of the Indus Valley (Campbell and Pryce 2003, 33), however, the majority of

Figure 2. Piles of clay fired Bangla bricks. Credit: Author.

domestic architecture in Bangladesh was traditionally formed from unfired earth, alluvial soils being a plentiful resource (Ahmed 1991, 33). Use of sun-dried bricks was largely restricted to institutional, royal and religious buildings during Sultanate and Mughal periods (Ahmed 1991, 118; Chapman and Rudra 2015, 23), the extensive use of fired bricks only becoming more widespread during the colonial period. The arrival of the British saw increased reliance on bricks for domestic and institutional buildings and large-scale infrastructures such as irrigation canals and railways (John 2018, 34). As bricks became an essential part of imperial attempts to control and extract resources from monsoonal regions, greater demand triggered a transformation from artisanal production to industrialised mass production. Increased production prompted new labour arrangements and technologies, such as the Bull's Trench Kiln, an oval shaped structure designed for continuous operation (John 2018, 39–40). Over time, clay fired bricks became part of the fabric of everyday life.

Brick making in Bangladesh has grown exponentially in recent times. Today an estimated 7,759 brick kilns produce 34 billion bricks annually (Alam and Barman 2019, 4). The sector, which accounts for approximately 1 percent of the country's GDP and generates employment for more than a million people (Department of Environment 2017, 3), has grown to supply the booming infrastructure and construction industry. Although brick kilns are prevalent throughout Bangladesh they have mushroomed around Dhaka, one of the world's largest megacities. Clusters of brick kilns have sprung up to feed demand for buildings and infrastructure. In Greater Dhaka, there are an estimated 1,000 brick kilns, although numbers are likely to be higher, mostly located along canals and rivers which serve as arteries for transportation (Guttikunda, Begum, and Wadud 2013, 358). As the city's population continues to grow, with a projected population of 27 million by 2030 (UN 2016, 15), so demand for bricks is expected to rise to 60 billion bricks per year within this period (Alam and Barman 2019, 10). As a building material that is deeply entangled with Earth processes, expansion of the brick industry has consequences for humans and nonhumans alike.

My account of the life cycle of *Bangla* brick is divided into three main sections. The section 'Sediment to clay' explores the intersecting meteorological, geological and human mobilities that produce the clay soils which constitute the main raw material for brickmaking, the formation of clay being intimately bound up with weathering. 'Clay to brick' focuses on the dry season production process, engaging primarily with the atmospheric entanglements entailed in brickmaking and the human and nonhuman mobilities that these entanglements set in motion. Finally, 'Brick to sediment' examines the mobilisation of the brick as a component of road infrastructures within dynamic hydrological landscapes, and the mobilities that these infrastructures enable and constrain. Each section focuses on the complex interactions between humans and nonhumans, mobility and materiality and the ways in which these interrelations co-constitute social worlds through weathering.

Sediment to clay: geological mobilities

Tracing the brick to its material origins, begins with weather. Brick making in Bangladesh is reliant on clay-rich soils extracted from the abundant alluvial floodplains of the delta. Although bricks are made from a combination of sand, silt and clay, the essential element for brickmaking is clay. Clay particles lend viscosity and plasticity to soil, enabling it to be moulded into desirable shapes, including the rectangular shape of the brick. The presence of clay also causes concretion, when heated plastic soils are transformed into strong, water resistant vitrified forms. Clays are distributed across the globe and exist in the Earth's crust, ocean sediments and atmospheric aerosols (Ito and Wagai 2017, 2), but the formation of these fine-grained, earthy particles is almost always the result of weathering. Clays are generally found at the surface of the earth at the rock-atmosphere interface (Velde 2008, 8). Most clay materials form when rocks containing the mineral feldspar come into contact with water. When large amounts of water are present, the solids in the rock become unstable and they dissolve. The greater the renewal of water, for example by rain, the greater the dissolution (Velde 2008, 8). These erosive movements alter the feldspar, resulting in the formation of clay particles. Weathering of rock through movement and friction brings clay into being. Like the monsoon, these tiny, dynamic particles emerge from and are generated by mobilities, and once created clay particles themselves become agents of transformation.

The very existence of Bangladesh is reliant on erosion and the mobility of alluvial materials (Rogers and Overeem 2017, 1). The Bengal Delta has been formed through the gradual sedimentation of alluvial soils, deposited by rainwater and flowing rivers and shaped by fluvial and tidal processes. The Ganges, Brahmaputra and Meghna rivers are estimated to carry one billion tons of sediments to the Meghna estuary each year (Brammer 2016, 43). Only a tiny percentage of this sediment is generated within Bangladesh, much of it originating from the highly erodible slopes of the upper Himalayas (Khalequzzaman 2019, no page). The loose structure of these relatively young mountains makes them vulnerable to erosion (Micheaux, Mukherjee, and Kull 2018). The monsoon plays a significant role, with frequent landslides and fluxes of large sedimentary particles occurring during the rainy season (Struck et al. 2015). Through their weathering by monsoon rains, Himalayan sedimentary rocks feed the clay rich soils of Bangladesh's humid floodplains. The soils that form Bangladesh bricks were once part of vast mountain systems, a reminder that materials 'have life histories of their own and may have served time in other structures, living and non-living' (Ingold 2004, 240). As Wilson (2017) writes, through the flux and flow of forces and materials, mountains become bricks, roads and architecture.

To move from the mountains to the delta, clay particles require force and the monsoon acts as this agent of mobility. Monsoonal flows routinely and rhythmically shift millions of tons of water and sedimentary material, rhythm being 'an important component of mobility' (Cresswell 2010, 23). Monsoon rains cause rates of sedimentation and deposition to vary with the seasons. Fluctuations in flow between wet and dry seasons for the Ganges-Brahmaputra-Meghna delta are amongst the highest in the world (Chapman and Rudra 2015, 9). Rivers that flow sluggishly for most of the year 'metamorphose into devastating torrents' during the monsoon, their waters thick with the enormous amounts of sediment they carry (Lahiri-Dutt and Samanta 2013, 8). The rivers that form the Bengal Delta are highly mobile, changing course over time and depositing sedimentary particles as they meander. As well as changing course, they also change size, influencing the spatial distribution of sediments. When swollen with monsoon rains, rivers spread out across their floodplains releasing fine clay particles as the speed of their waters slow, leaving deposits of clay in low-lying areas furthest away from the river (Brammer 1996, 4). Whilst the formation of clay soils is dependent on mobility and friction, periods of settling are required too; stillness, or slowness is also important in worlds of mobility (Creswell 2014, 108). Fluctuating intensities of flow, intersected by periods of settling, contribute to the rhythmic formation of Bangladesh's clay soils.

The physical processes that contribute to the making of clay soils are regularly interrupted by human interventions. Farmers tend and work the land, transforming soils into fine-textured, high-yielding matter. As a predominantly agrarian economy Bangladesh is reliant on its soils; in recognition of their vital role Bangladeshi's refer to the soil as mother or *mati* (Sillitoe, Barr, and Alam 2004, 180). However, rapid urbanisation is contributing to soil loss as the country's clay-rich soils are also used for brickmaking (Biswas et al. 2018). Clay is usually mined and prepared near brickfields (Figure 3) but as demand rises it is sourced from other locations, usually farmland. As farmers sell their clay-rich soil to the brick kilns vast amounts are transported to urban areas. The extent of soil removal is unknown but the Bangladesh brick sector is estimated to consume 45 million tons of clay annually (World Bank 2011, 17). Total clay consumption in 2018 was an estimated 3.4 billion cubic feet (Alam and Barman 2019, 5). The production of all urban materiality involves the movement of material from one place to another (Edensor 2012a), but in Bangladesh this is precipitating a crisis. Removal of topsoil results in reduced crop productivity (Roy 2016, no page). Soil takes years to rebuild its fertility and reduced productivity acts as a further incentive for farmers to sell soil (Biswas et al. 2018, 796). As agricultural productivity decreases, movement of people from rural to urban areas is likely to increase, swelling the cities. As urban populations increase so does demand for housing and infrastructure, fuelling construction and demand for raw materials.

Figure 3. Soil preparation for brickmaking. Credit: Author.

Due to the speed of urbanization, removal of topsoil for brickmaking is occurring at a rate that cannot compete with geological cycles. Typically soil formation takes place over extended time-frames, although the time varies depending on latitude and the corresponding weather. In wet tropical areas, where high temperatures and abundant moisture result in stronger weathering processes, soil formation is faster than in temperate areas (Velde 2008, 11). Nevertheless, the formation of soils is still a slow process. Despite the vast amounts of sediment deposited in the Bengal floodplains, it can take twenty-five to fifty years for new alluvium to change into soil (Brammer 2016, 54). This is compounded by the fact that although Bangladesh is regularly flooded, 'most floodplain lands have received little or no new alluvium for several hundred years or more' (Brammer 1996, 26). As a result, a non-renewable resource, on human time-scales, is becoming exhausted. Soil has become a tradeable resource, subject to uncontrolled extraction, bought, sold and transported on an unprecedented scale and speed. The channelling of soils into urban landscapes creating frictions between rural and urban, human and nonhuman.

Clay to brick: atmospheric mobilities

Brick making operates around a monsoonal cycle, beginning in November and ending in April before the first monsoon rains arrive. The monsoon creates a temporal structure as brick-making is timed to coincide with the driest part of the year. Brick kilns in Bangladesh cannot operate during the wet season as frequent rain, high atmospheric humidity and reduced sunlight affects the drying and firing of bricks (Gomes and Hossain 2003, 69). Waters levels rise submerging the brickfields, often situated on low-lying land which is cheaper to buy or to rent due to seasonal flooding. Brick fields become deserted as they transform into pools of water, the slumbering columns of chimneys reflected in their surfaces. Although production ceases during the wet season, monsoon rains are still leveraged to economic advantage. The price of brick increases during monsoon months as brickfields splutter to a stop, reducing supply and stalling construction. Kiln owners and wholesalers stockpile bricks in the dry season when prices are low to sell in the rainy season when prices rise. Stockpiled bricks fired during the dry season are transported to urban centres during the wet season. Waterways swell with the monsoon, their increased depth enabling the smooth passage of boats. Swollen waterways allow boats to be loaded to capacity making transportation more efficient and profitable. The seasonal fluctuation of riverbanks alters the distances that bricks have to be carried; the high-water levels of the wet season reducing carrying costs and wages of labourers who carry bricks from kilns to boats and boats to shore.

During the monsoon boats are also hired to carry soil and coal, the essential raw materials for brickmaking, at much lower costs than land transportation. These materials are mounded and stored on areas of high land adjacent to the kilns ready for the dry season. Clay soils are collected and weathered during the wet season in preparation for the dry season. Open-air stockpiles sit throughout monsoon months, exposed to the action of the atmosphere. Heaps are regularly broken up, cut and turned over so that the atmosphere may penetrate them. During this period of stasis, rainwater spreads through the body of clay, diffusing and softening it, increasing its workability and making it pliable for moulding. The action of wind, rain and air help to homogenize the clay, breaking down harder lumps and agglomerates and washing out unwanted soluble salts. Weathering is used to work the clay, reducing human labour. Once the rains draw to a close, the water levels slowly start to recede, exposing the brick fields and allowing the brickmaking cycle to begin again.

Brick-fields churn relentlessly in the drier months, transforming landscapes and atmospheres. During this period bricks are made by hand, sun-dried, fired and then cooled. Clay is a heavy material that requires a lot of energy to work. Each brick is created through gruelling, repetitive labour, formed by the respirations, pulses and circulations of human bodies. Sand is added to temper the clay before being moulded to increases its plasticity and workability. Tempered clay is then processed, or pugged, to ensure its homogeneity, which prevents bricks from cracking when drying. Once the clay is prepared, moulding can begin. Balls of pugged, tempered clay are thrown forcibly into wooden moulds before being skilfully turned out onto sanded, levelled ground. Moulding is repeated through rhythmic replications producing endless rows of unfired, green bricks which dry in the sun until firm enough to be fired, the drying dependent on circulations of the atmosphere. In the labour-intensive process of brickmaking it is not just the clay that is transformed, people change too, 'their bodies moulded to the daily tasks, their senses attuned to the subtle "voices" of the machines and matter they are working with' (Bennett 2016, 72). Brickmaking is a co-creation of the affordances of matter and human energies, and in the process people are weathered too.

Firing is the final stage of the brickmaking process. Heat imparts strength and hardness to the brick, converting clay from a soft ephemeral material into a durable, weather-resistant form. Brickmaking is a kind of alchemy, 'the elements of earth and water are transformed by fire into a material that can be more durable than stone' (Cruickshank 2019, no page). Kiln technologies lie at the heart of the firing process and in Bangladesh most bricks are produced using Fixed-Chimney Bull's Trench Kilns (Department of Environment 2017, 4). These modified versions of colonial technologies are designed for continuous production. Batches of bricks are fired and cooled in seemingly endless repetitions. Kilns are tended by workers who feed them with fuel at regular intervals. The structures have no permanent roof, which is why they cannot operate during the monsoon, meaning that kiln top workers are exposed to intense heat from the flames below and from the sun above. Continuous firing intensifies the heat of the dry season, subjecting workers to dehydration, heat stroke, skin and eye diseases (Maithel, Kumar, and Lalchandani 2014, no page). Vitrification occurs between 900 and 1150 °C (Campbell and Pryce 2003, 14), causing clay particles to fuse together. In doing so, firing changes the temporal structure of the clay, producing a material that can outlive the precarious lives of those who bring it into being.

Bricks depend on human labour and the brickfields of Bangladesh on seasonal migrants. Labour migration is partly structured by the monsoon cycle. Men, women and children travel to Dhaka's brick kilns from all over the country. Migrants arrive at the start of the dry season when there is limited agricultural work and return to their home villages at the start of the monsoon season when brickfields stop operating. Workers migrate from the poorest areas which are affected in various ways by monsoonal forces. Some come from *monga* areas which suffer from shortages of rainfall, some from the northern plains and char islands which are subject to flash floods and riverbank erosion, and some from the cyclone and storm surge vulnerable south. Migration is a response to a dynamic monsoonal environment that requires mobility for survival, (Ingham, Islam, and Hicks 2019). The migrant labourers who power the brickfields of Bangladesh are a reminder that not everyone weathers equally (Neimanis and Hamilton 2017, no page). As poverty, ecological degradation and changing weather patterns intensify there has been a dramatic increase in the spatial mobility of Bangladesh's population. A large proportion migrate to Dhaka, the already bursting capital city, which is estimated to receive 300,000 to 400,000 people every year (World Bank 2007, xiii). Urban expansion offers abundant opportunities for labourers who carry sand, bricks and cement, break bricks, and produce building materials for the ongoing production of the city.

Although bricks are essential building materials, and a source of income for many, their production contaminates urban atmospheres (Figure 4). Dhaka has some of the most polluted air in the world, regularly topping global rankings of cities with the worst air quality (Dhaka Tribune 2019, no page). Particulates from the brick fields constitute an estimated 30 to 40 percent of ambient PM2.5 pollution over the Dhaka Metropolitan Area (Guttikunda, Begum, and Wadud 2013, 358). Pollution levels are exacerbated by inefficient kiln technologies, particularly the Bull's Trench Fixed-Chimney kilns (Department of Environment 2017, 11). Plumes of black smoke, blankets of thick smog and clouds of brick dust emitted by the kilns flux with the seasons; the movement of particulates influenced by the movement of the weather. Air quality monitoring has revealed that concentrations peak in December and January, partly due to slow-moving winds that occur during these months reducing dispersion (Guttikunda, Begum, and Wadud 2013, 363). High concentrations of particulate pollution cause an estimated 2,200 to 4,000 premature deaths per year in Greater Dhaka (Saha and Hosain 2016, 491). Tiny airborne particles penetrate the lungs and the bloodstream, causing cardiovascular and respiratory conditions (Khan 2019, no page). Pollutants affect nonhumans too, brick kiln dust dispersed by the wind reduces photosynthesis, hinders plant growth, damages soil and erodes building surfaces (Darain et al. 2013). The very bricks that form the city make it unliveable for humans and nonhumans alike.

Pollutants from the brickfields do not remain confined to urban environments, they also affect atmospheres on a regional scale. The primary source of fuel for brick kilns is coal, most of which is imported. In 2018, an estimated 7.1 million tonnes of coal were consumed by the Bangladesh brick sector, emitting 21.1 million tonnes of CO_2 (Alam and Barman 2019, 5). Through their emission of CO_2, black carbon and tropospheric ozone, brick kilns effect atmospheric temperatures, monsoon

Figure 4. Smog from brick kilns during dry season. Credit: Author.

circulation and rainfall patterns (Mitra and Valette 2017, 23). Such particulates contribute to the Asian Brown Cloud, a mobile atmospheric phenomenon consisting of sulfates, nitrates, organics, black carbon and fly ash, that occupies the air space over much of South Asia and the Bay of Bengal every year (Begum et al. 2011, 115). The brown cloud appears between early December and March, coinciding with the dry season brick-making period, although there are other contributing factors including agricultural biomass burning. This mobile assemblage of pollutants mingles with atmospheric circulations, becoming entangled with meteorological processes. While the monsoon modifies the mobility and severity of the haze by washing pollution particles out of the atmosphere during the rainy season, it seems the atmospheric brown cloud modifies the monsoon, influencing rainfall distribution (Liepert and Giannini 2015, 24). Mobile particles released by the brickfields contribute to changing weather patterns and mobilities of the human and nonhuman lives enmeshed within them. Negative feedback loops between brickmaking and climate are not just restricted to Bangladesh but are also reported in South India (Lundgren-Kownacki et al. 2018) and Cambodia (Natarajan, Brickell, and Parsons 2019) where migrant brick kiln workers are bearing the brunt of climatic changes.

Brick to sediment: hydrological mobilities

After firing, *Bangla* bricks are graded, their classification determined by the evenness of firing, their colour, strength and the presence of cracks or breaks. Depending on their classification, they are allocated for use in a diverse range of buildings and infrastructure. Around 15 to 20 percent of bricks produced in Fixed Chimney kilns are overfired, which can cause defects, so they are broken into small pieces called pickets (Luby et al. 2015, 70). It is incredible to observe the energies that go into the making of bricks only to watch them being broken up, but these brick pieces form a vital part of the built environment. Pickets are used extensively in road construction and form a base for nearly all paved roads in the country (Luby et al. 2015, 70). Thick layers of brick chips are dispersed along the burgeoning highway network. These layers are flattened and compacted by steam rollers before being covered in tarry layers of bitumen. Bricks are used because boulders, gravel and stone are in short supply. As rivers move further from their source the size of material they carry gets smaller, with larger boulders, rocks and stones getting ground down as they are transported. This means that although Bangladesh has an abundance of fine-grained clay, silt and sand it has no stones. Gravel is only available from a few quarries, mostly located in Northern Sylhet (Rahman 2009, 4). The distant location of the quarries leads to high haulage costs, so bricks are used instead. Daily labourers, often migrants, are employed to manually crush bricks. Mimicking the forces of weathering and erosion, brick breakers produce an alternative to the stones that Bangladesh is deprived of by monsoonal flows.

Roads are an indicator of economic development and changing modes of mobility. Historically, the main transport routes in Bangladesh were waterways (Quium and Hoque 2002, 60). As in other places, roads have largely replaced water transportation, partly due to the rise of motorised vehicles and improvement of overland surfaces (Paterson 2014, 327). Construction of 'all-weather roads' is a development priority for Bangladesh as they allow movement in all seasons. The Asian Development Bank recently allocated 200 million dollars to improve the rural road network in Bangladesh as only 40 percent of the rural population currently has access to all-weather roads (Daily Star 2019, no page). Such roads are constructed not to be flooded, sodden or muddy and are partly a response to the sticky, clayey mud that accumulates in the monsoon season making movement difficult. It is somewhat ironic that these roads are formed from the very material that acts to constrain mobility. Once constructed, their presence creates new geographies and lines of relation, facilitating the movement of people, goods and materials. National development plans have placed an emphasis on highway construction to improve connectivity (ADB 2014, x), particularly with the southern coastal districts, paving the way for development and ongoing expansion into the delta.

Figure 5. Road construction using Bangla bricks. Credit: Author.

In the construction of these roads, bricks that have been subject to intensities of heating are used to elevate and protect them against intensities of wetness. Strategies of topographic alteration are particularly important in Bangladesh as two thirds of land is no higher than five metres above sea level (Adams, Dasgupta, and Sarraf 2011, xiii). During the monsoon, water levels swell to inundate almost half the country, hindering terrestrial mobility. As a result, roads are typically constructed to ensure their surfaces lie above wet season flood levels. In this mostly flat delta terrain, even small changes in elevation make a difference. 'All national and regional roads in Bangladesh were designed to be built above the highest flood level … and feeder roads were designed above normal flood level' (Dasgupta et al. 2010, 12). Roads are elevated by layering materials, this typically includes a compacted soil foundation, a sub-base, a road base and a surfacing layer (Rahman 2009, 15), with bricks comprising an important component in these arrangements (Figure 5).

Although roads create new speeds and rhythms of movement, they also contribute to unexpected and unplanned flows and resistances (Merriman 2016). The majority of roads in Bangladesh do not have adequate drainage facilities for flood water (Dasgupta et al. 2010, 14), meaning flows of water and sediment are obstructed. As a result, roads constructed to facilitate human mobilities can hinder and disrupt nonhuman mobilities (Fishel 2019). There is growing recognition that linear infrastructures, which have become pervasive features of anthropogenic landscapes, can affect ecological functions and processes, including the movement of water across landscapes (Raiter et al. 2018). Impacts can be subtle but may extend over large areas, well beyond the direct infrastructure footprint. An example from Bangladesh is the Dhaka-Rajshahi highway which was constructed through Chalan Beel, one of the country's largest wetlands. Although the highway reduced the distance between the capital and Rajshahi by 75 kilometres (Ali 2008, no page), it also dissected the wetland, altering its hydrology. The highway is the most recent in a series of embanked infrastructures, including the colonial era Eastern Bengal Railway line, the construction of which was also dependent on bricks (John 2018, 29). Over time, these structures have significantly obstructed water flows, hastening the silting up of the *beel*, reducing its water-holding capacity and significantly impacting regional ecologies (Iqbal 2019, no page).

As brick-built structures, roads in Bangladesh are prone to processes of 'molecular mobility' (Merriman 2016, 555), slowly eroding over time through a series of often barely perceptible micro-events. Interactions between water and earth are the primary catalyst for their decline. As such, most roads in Bangladesh experience regular deterioration during the rainy season (Figure 6). Seasonal

Figure 6. Weathered road surface and disintegrated bricks. Credit: Author.

fluctuations of wetness cause underlying clay soils to shrink and swell, weakening road foundations. Weathering by monsoon rains creates cracks which allow water to seep inside, small cracks become large potholes which are enlarged by the pummelling of traffic and the action of wind and rain. Water absorption is one of the main causes of road deterioration and the porosity of the brick chips that comprise the primary aggregate material lead to high rates of absorption (Mazumder, Kabit, and Yazdani 2006, 781). Once inside, water acts a lubricant, breaking down particle bonds, a process that is exacerbated when the road is subjected to dynamic human and nonhuman moving forces. As a 'thing of the earth', the brick is 'forever undergoing a process of decay, of crumbling back into earth' in a slow yet relentless process of decomposition (Steele and Vizel 2013, 82). Through weathering and disintegration brick returns to sediment, creating seasonal cycles of maintenance and repair and fuelling the never-ending demand for brick.

Bangladesh already has one of the densest road networks in the world, but the total length is expected to increase by another 25 percent by 2050 (Dasgupta et al. 2010, 13). The costs of road construction are some of the highest in the world (The Independent 2017, no page), partly due to the weathering and seasonal maintenance that occurs during the monsoon. Bangladesh is often cited as being particularly vulnerable to climate change, with monsoon rainfall predicted to intensify (Seneviratne et al. 2012, 147). In a changing climate, the drainage and flooding associated with large-scale infrastructure, as well as their damage through weathering, is likely to worsen. It is estimated that Bangladesh will need up to 5.7 USD billion by 2050 to safeguard key infrastructure such as roads, railways and river embankments against extreme weather events (Adams et al. 2013, 31). But such notions of proofing against monsoon weather perpetuates a deeply embedded dichotomy that society and weather are separate, bounded domains (Taylor 2014, xiii). Weather is presented as external phenomena that humans need to adapt to, with the monsoon increasingly perceived as a threat. Such attempts to externalize weather deny the fact that humans are already entangled in its forces and flows (Neimanis and Walker 2014, 567). Bricks, and the infrastructures they compose, are materializations of these entanglements.

Conclusion

Learning to consider weather patterns, like the monsoon, as vital actors in our entangled mobile world is an urgent necessity in light of increasingly uncertain meteorological futures. Following the materiality of the brick reveals the multiple ways in which the monsoon is enmeshed within built environments in Bangladesh. As more-than-human assemblages, bricks come into being not through human agency alone, but through entanglements of weather and human energies. Weather contributes to the emergence of bricks, their production, use, and dissolution. As this study of *Bangla* bricks reveals, far from being a disconnected backdrop to social life, meteorological forces are co-constitutive of social worlds, moving through them and the materials that compose them. And, just as the weather is involved in the production of the social, so are humans involved in its production; 'we are weather-makers too' (Neimanis and Hamilton 2017, no page), influencing meteorological patterns at local, regional and global scales.

The brick, as a geosocial formation, shows humans to be embedded within Earth processes. Following the single entity of the brick helps to connect geological, atmospheric and hydrological mobilities with construction, migration and transport mobilities. highlighting the material interrelatedness of humans and nonhumans. Perceiving the brick as a dynamic 'meshwork' (Ingold 2010, 3) of unfolding relations between humans and earth systems may help to advance understandings of the role that urban materialities play in processes of planetary change. Of course, bricks are just one of many materials utilised in the production of built environments. Urban spaces include complex assemblages of glass, concrete, aluminium, ceramics, plastic, copper, stone and steel, each with their own trajectories and meshwork of relations. In combination, the manufactured materials, architectural structures, excavations, material deposits and infrastructures that compose built environments form a global-scale 'stratigraphic entity' with a distributed agency of its own, impacting material flows and geophysical cycles (Edgeworth 2018, 19). Analysis of dynamic entanglements between such 'vibrant materials' (Bennett 2010, 23) and intermeshed Earth systems offers a myriad of opportunities for future mobilities studies, with important implications for the Anthropocene.

If humans are imbricated within Earth processes, 'we need to take account of the entangled materializations of which we are a part' (Barad 2007, 384). Just as the earth is not static, neither are the mobile material assemblages that humans co-constitute; they propagate through the environment, 'forming complex and intricate dances and chains of agency' that travel through space and time (Pickering 2005, 10). However, in pursuing anthropocentric agendas and designs, humans often fail to observe how materials work and move in their own ways (Vannini and Taggart 2014, 100). Material assemblages have their own inner dynamics and emergent qualities and their trajectories are unpredictable, which means that no-one quite knows where the dance of agency is going (Pickering 2005, 35). As Clark (2011, 7) points out, 'the nonhumans which play a constitutive role in these arrangements do not necessarily stick to the agendas we set them'. The geosocial formations, of which humans are part, are incorporated within planetary processes and, as such, mobilities analysis must include the manifold movements of the dynamic Earth. As this paper attests, caught up in the flows and fluxes of the weather-world, even something as seemingly static and bounded as the brick is a vibrant, mobile, more-than-human entity capable of changing the geologies, atmospheres and hydrologies of global lived environments.

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