Chapter 9

Building a Colonial Technoscientific Network: tropical architecture, building science and the politics of decolonization

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The past few years have seen the emergence of an interesting body of new research on tropical architecture. This scholarship focuses mainly on the work of British architects in Africa during the mid-twentieth century. It examines a broad range of social, political, and cultural issues in the production of tropical architecture and engages in important debates on themes such as (post)colonialism and the politics of (de)colonization, and internationalization versus regionalism.[1] The emergence of tropical architecture was linked to key figures such as Maxwell Fry, Jane Drew, and Otto Koenigsberger, important metropolitan institutions such as the Department of Tropical Architecture at the Architectural Association, and also landmark events such as the 1953 Conference on Tropical Architecture. There is no doubt that the best of this scholarship situates the production of tropical architecture in the context of complex socio-political relations between the metropole and the colonies, the British Empire and the postcolonial nations. It is, however, largely silent on the technoscientific dimensions of tropical architecture. This oversight is significant given the technical nature of most of the discourses on tropical architecture in the mid-twentieth century.[2]

It has been argued that science and technology are social constructions.[3] I share this view, though not in the epistemologically relativist sense, but in the sense that science and technology are what Donna Haraway calls "situated knowledge"[4] in that what is assumed to be universally true and objective scientific knowledge is necessarily local, mediated, situated, and partial to begin with.[5] In other words, the production of technoscientific knowledge could never be

understood in isolation from the socio-politico-cultural context. Recent scholarship on (post)colonial technoscience has argued that the significance of socio-politico-cultural context is even more accentuated in the production of colonial technoscience. In that context, the asymmetrical development in scientific knowledge and technological power between the colonizer and the colonized was overlaid with similarly lopsided socio-politico-cultural power-relations in colonial societies.[6] However, it has also been argued that science and technology are inadequately understood through the vagaries of socio-cultural interpretations.[7]

Actor-Network-Theory (ANT), as put forth by Bruno Latour and others, offers a theoretical framework for understanding such a moderate social constructivism. Unlike some other social constructivist views, ANT does not privilege the social in understanding how science and technology are constructed. ANT emphasizes the heterogeneous ensemble that shapes science and technology, taking into account both the social and the non-social forces, the human and the non-human actants.[8] In doing so, ANT addresses the accusation of relativism as raised in the controversies surrounding the social constructivist view of technoscience.[9] Furthermore, it also provides a way to account for how specific technological infrastructures of instruments, tools, and manuals are deployed to facilitate the production of technoscientific facts. Drawing on these insights, I hope to add to the scholarship on modern tropical architecture in the mid-twentieth century by examining how architectural technoscience was shaped by, as well as shaped, the complex socio-political configurations at the end of the British Empire. In this chapter, I will focus on the technoscientific dimensions of tropical architecture by studying what has, at best, been peripheral in recent scholarship on tropical architecture – the work of the Tropical Building Division (TBD) of the Building Research Station (BRS).

In the first part of the chapter, I study the 1945 proposal to set up the Colonial Liaison Unit (CLU), the predecessor of the TBD, for the purpose of conducting research on colonial housing and building problems. I show that the proposal, in terms of its organizational structure, research methodologies, and underlying assumptions, was based on the established model of colonial scientific research in tropical medicine and tropical agriculture. I also show that the proposal was an inextricable part of a colonial development regime, in which technoscience became an instrument of development. I will then focus on the work of the CLU and the TBD in the second part of the chapter. Their work in producing and maintaining technical standards for tropical building in the British Empire/Commonwealth entailed what is conceptualized as network building in ANT. ANT and the idea of network building rework certain entrenched assumptions in the understanding of modern tropical architecture, particularly the local versus global, universal science versus local crafts binaries. Specifically, this paper problematizes the regionalism discourse that views tropical architecture as a place-based architecture rooted in the cultural-climatic specificities of a region. Likewise, this paper also interrogates the universalizing and diffusionist discourse of modern architecture that sees tropical architecture as no more than a "natural" variant,

acclimatized to the tropics.[10] I also argue that the network built has Foucauldian power-effects, in that it enabled the metropole to become a center of calculation in the network through the accumulation of power-knowledge. In the third section of the chapter, I illustrate the specificities of how such a network actually facilitated the accumulation of knowledge and the attendant power through the production of immutable mobiles by studying CLU and TBD's research on climatic design and thermal comfort. I argue that by privileging climate in the knowledge of place, the research on climatic design facilitated "action at a distance."

The colonial research model: the proposal for colonial housing research

The Tropical Division of BRS had its origin in the recommendations put forward by the Colonial Housing Research Group in 1945.[11] The Group was formed in around 1944 to advise the CO on housing in the colonies.[12] It was chaired by I. G. Evans, the acting director of BRS, and it involved key colonial experts such as Professor D. B. Blacklock of Liverpool School of Tropical Medicine, who authored a book on the "empire problem" of housing in the 1930s,[13] and Major Granville St. John Orde Browne, the labor advisor to the CO and a renowned expert on colonial labor issues.[14] In their report, the Group recommended making a coordinated effort in housing research to deal with the immense housing problems in the colonies. Valuable work on housing research was being carried out in many of the colonies, they noted, but those efforts were dispersed and uncoordinated. The knowledge gained from these efforts in a colony was thus not available to those in other colonies, leading to the inefficient and uneconomical duplication of work. To deal with this problem, the Group made two recommendations – the establishment of a center, which the Group called the Colonial Housing Bureau, for the collection and dissemination of information concerning colonial housing research in the metropole, and the setting up of regional research establishments in the colonies. The center in the metropole was to be a depository in which data such as "type plans, reports on various materials and on the performance, cost and suitability from various points of view of various designs might be accumulated and be available for consultation."[15] The center would also be disseminating the knowledge accumulated to the various colonial departments through the publication of periodical digests. A Colonial Liaison Officer was subsequently appointed by the Colonial Secretary to take charge of this metropolitan center, that is, the CLU. Besides establishing the metropolitan center, the Group also recommended the setting up of four regional research centers in the periphery, with the West Indies, East Africa, West Africa, and Malaya being mentioned as the probable locations for the regional centers.[16]

These recommendations were significant in several different ways. First, they were the first time that a major coordinated effort matched by a large sum of funding was made by the Colonial Office (CO) to deal with the much-neglected problem of colonial housing. Of course there had been earlier efforts

that addressed the colonial housing problems. For example, in the early twentieth century, various initiatives were undertaken by the municipal and colonial governments in different parts of the British Empire to improve housing conditions for certain segments of the "native" population through the Improvement Trusts.[17] However, the earlier efforts were smaller scale local initiatives at the municipality level which tended to be underfunded and/or were not supported by strong political will. The new concerted effort taken to address the colonial housing problem prompted a senior staff member of CO to remark in 1947 that: "Colonial Housing and Building, hitherto a Colonial Office Cinderella, has suddenly come very much on the tapis here."[18] Alongside the efforts of the Colonial Housing Group, other housing initiatives, such as the appointment of Professor William Graham Holford as the Honorary Town Planning Advisor to the Secretary of State for the Colonies and the setting up of a Housing Advisory Panel, were also made in the 1940s.[19] The position on housing taken by the Colonial Housing Research Group that the "general economic development must be pursued concurrently with improved housing" reflects the official view following the passing of the Colonial Development and Welfare Act (CDWA) in 1940.

The equal emphases on both economic development and the welfare of the natives, through provision in areas such as health, education, and housing, was seen by the British officials as a disavowal of any intention to merely exploit the colonies more efficiently.[20] This emphasis on welfare and its implementation through comprehensive provision set the CDWA apart from earlier development schemes. Previously, development priorities had been unambiguously economic in focus, although the British administrators did pay lip-service to their mandate of taking care of the welfare of the natives and "civilizing" them as a way to legitimize colonial rule.[21] But the new post-1940 concern for the welfare of the natives did not merely arise from the "benevolence" of the British imperial government. Rather, welfare was seen as an antidote to the "disorder" in many colonial territories. After all, the CDWA was formulated primarily to deal with what the British called "disturbances" – both labor unrest and anti-colonial nationalist movements – in the colonies.[22] Central in this shift was the report of the West India Royal Commission, which was submitted in 1939 but it was so controversial that it was not published until 1945. The recommendations of the West India Royal Commission led to the establishment of CDWA. Some of the earliest large scale colonial housing initiatives, including research, were undertaken in the West Indies in the early 1940s under Sir Frank Stockdale, the Comptroller for Development and Welfare, and his town planning advisor Robert Gardner-Medwin.[23]

Secondly, the recommendations made by the Colonial Housing Group were shaped by prior models of colonial scientific research. This is perhaps not unexpected, as the Group consisted of members from the CO, the Crown Agents, and also experts from organizations that had previously been engaged in colonial research, such as the Liverpool School of Tropical Medicine, the Imperial Institute, and the Department of Science and Industrial Research (DSIR).[24]

Following the practice adopted for the Imperial Agricultural Bureau, the proposed Colonial Housing Bureau was to be attached to an existing metropolitan institution working on similar problems. In this case, the Bureau was to be attached to BRS, which was first established in 1921 as part of the DSIR to carry out scientific research on building materials and construction methods in order to address post-First-World-War housing shortages.[25] The regional research establishments in the colonies were also to be modeled after the metropolitan model. After the group's report, two BRS officers, at the request of the CO, visited the British West African colonies from December 1946 to January 1947. They submitted a comprehensive proposal on the establishment of a West African Building Research Station along the lines of the BRS.[26]

Methodologically, the Group proposed that colonial housing research follow that of colonial nutrition. Michael Worboys has noted that British colonial nutrition research in Africa followed the technical problem-solving approach in which the problem of undernourishment was isolated from the larger socio-economic conditions of poverty and turned into a specialized medical problem that required professional expertise to solve.[27] As a result, the prescribed solution for the colonial nutrition problem overlooked the larger structural conditions that caused poverty and undernourishment in the first place.[28] In a not dissimilar manner, the Group proposed that housing research be compartmentalized into different spheres of specialization and the colonial housing bureau should concentrate on the "study of the more physical and material aspects."[29] This was despite the Group's recognition that "[h]ousing research … is not a mere matter of materials and construction" and "without a broad medico-sociologico-economic background of knowledge, house design and the planning of housing schemes are bound to suffer."[30]

Even though the colonial model of research was derived from the metropolitan model, there was a major difference between them. It has been noted in the case of tropical medicine that there was a division of labor between the specialist research work in the metropolitan institutions to discover the causes of tropical diseases and the general practitioners in the colonies treating the diseases.[31] A similar hierarchical division of labor was also assumed between the center and the periphery in the proposed organization of building research institutions.[32] It was stated in the Group's report that the primary roles of the regional centers would be to "act as local centres of information, and to carry out those investigations which must necessarily be done on the spot." In contrast, "[c]ertain other investigations of a specialist character or of a more long-term or general nature might well be undertaken in [Britain]" at metropolitan institutions such as the BRS and the Imperial Institute.[33] This center–periphery division of labor in scientific research corresponded to the prevailing view of center–periphery economic relations, in which tropical colonies in the periphery produced raw materials for industrial production in the temperate metropole.[34] From the perspective of world system theory, such a welding of peripheral tropical production to metropolitan temperate industrialization means that the tropical

economy was caught up in a relationship of dependency on the temperate economy – not only subjected to their economic exploitation and vulnerable to the fluctuations of their economic cycles, but also perpetually relying on their capital and expertise.[35]

Thirdly, underlying the Group's recommendation is a fundamental faith in the transformative power of science and technology, especially in terms of how the application of technoscientific knowledge would enable socio-economic development and provide for welfare. Recent scholarship in social studies of science, especially in relation to colonial technoscience, has argued that scientific research has never been a disinterested pursuit for its own sake.[36] Instead, colonial technoscience has been understood as an instrument of economic development; to further the exploitation of natural resources by increasing the productive capacity of soil and identifying the properties and potential commercial uses of natural resources. State-sponsored colonial scientific research was first initiated in a systematic manner in the late nineteenth century after Joseph Chamberlain became Colonial Secretary in 1895. Chamberlain championed "constructive imperialism" to develop the "immense estate" of Britain's colonial territories. His years as Colonial Secretary marked the beginning of the shift from the *laissez-faire* approach towards Colonial economies in the Victorian era to a more systematic approach of economic planning and development that subsequently shaped the CDWA.[37] Other than providing loans and grants to the colonies for infrastructural projects of railway, port, and road construction, the CO under Chamberlain also organized and funded scientific research in tropical medicine and agriculture to alleviate colonial health and agricultural problems. Initiatives related to Chamberlain included the founding of the Liverpool and London Schools of Tropical Medicine, the Imperial Department of Agriculture, and the appointment of Patrick Manson as medical advisor to the CO.[38]

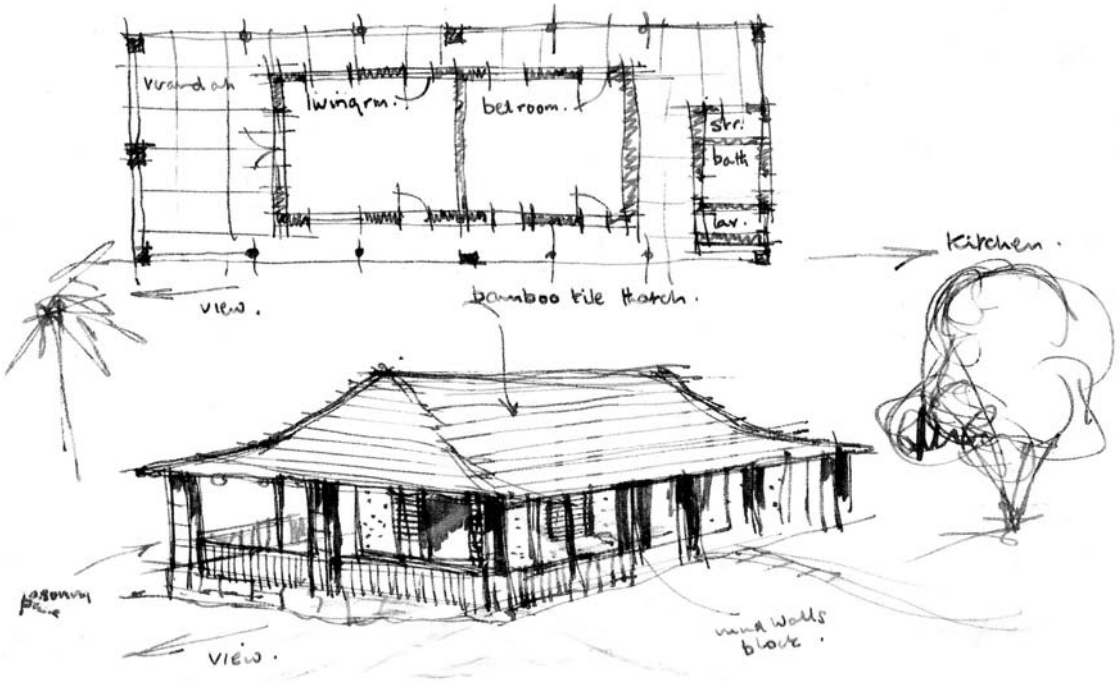
Later in the mid-twentieth century, with more funding from the CDWA and following the recommendations of Lord Hailey's *African Survey*, technoscientific research on British colonial problems was further intensified and broadened. Its scope expanded beyond the traditional fields of medicine, agriculture, and geology to include, among other areas, social sciences, economics, veterinary, fisheries, road building, and, of course, building. Colonial housing research was thus part of the broader expansion in colonial research in the mid-twentieth century.[39] Furthermore, with the beginning of the end of the British Empire, and the shift into a new "world order" defined by Cold War politics and the division into "developed" and "underdeveloped" countries, development expanded beyond the confines of the British Empire. Development was internationalized under the aegis of the United States and new development agencies, such as the World Bank, the International Monetary Fund, and the various United Nations development organizations.[40] The faith in science and technology of this new development regime was even greater than before. This was exemplified in United States president Harry Truman's Point Four Program in which he promised that the developed countries, as led by the United States, would use their technical

knowledge to help the underdeveloped countries eradicate poverty and its attendant social problems. That became manifested in the many technical assistance and technology transfer schemes rendered by the developed world to the developing one. The faith in technoscience brought about the expansion of technoscience into every possible social field, creating new forms of knowledge where there were none, elaborating new objects, concepts, and theories, so much so that these technoscientific development discourses "colonized reality."[41]

Network building: the work of the Tropical Building Division

After an almost-three-year search, George Anthony Atkinson was appointed as Colonial Liaison Officer in June 1948. After Atkinson's appointment, each British colony was to assign a technical officer as his correspondent in order to facilitate his work of collecting, organizing, and disseminating information on colonial housing and building. Atkinson was also appointed as housing advisor to the CO. Atkinson's appointment was for an initial period of three years and it was funded by the CDWA and administered through the Social Service Department. Atkinson was deemed suitable because of his overseas work experience, specifically his war-time experience working with the Royal Air Force Airfield Construction Service in West Africa, North Africa and the Middle East.[42] (Figure 1) Atkinson's scope of work extended beyond the original proposed focus on colonial housing to include colonial building in general. That was because, besides social housing,

Figure 1
The bungalow George Atkinson designed and built for himself at the Waterloo Airfield in Sierra Leone, 1941. Source: George Atkinson.



CDWA was also funding other schemes that involved the building of schools, hospitals, and offices. Moreover, there was the "recognition of the difficulty of separating the physical problems of building from those of general housing and planning policies in the overseas territories."[43]

Other than the aforementioned "discovery" of colonial housing problems in the 1940s, another impetus behind the appointment of a Colonial Liaison Officer was the need to control the escalating costs of building construction in the colonies, especially those sponsored by CDWA funds.[44] Although the escalating costs of building construction could be partially accounted for by the shortage of building materials in the immediate postwar years, the CO also attributed the cause to the lack of well-defined minimum building standards, which led "imperceptibly to somewhat extravagant schemes." To reduce cost, the Secretary of State went as far as expressing his anxiety that "colonies should avoid the error of constructing buildings of a more permanent character than circumstances warrant."[45] As a result, one of the earliest tasks for Atkinson was to formulate minimum standards for building in the tropics.[46] Here, standards referred not to standard plans for building types such as bungalows and barracks, which have been in existence in the British Empire since the nineteenth century.[47] Standards here should rather be understood in relation to building science research. According to Sir Frederick Lea, the director of BRS from 1946 to 1965, scientific methods were first systematically applied to building research from the 1920s with the establishment of the BRS in order to overcome the limitations of a building industry that was largely craft-based.[48] Traditional craft which depended on rules of thumb established through generations of trial and error was deemed inadequate in keeping up with the array of new construction materials that industrialization brought about. Lea argued that "[w]ith new materials tradition could be no guide and its blindfold application to them was a gamble"[49] that supposedly caused many building failures. In contrast to craft, the application of scientific methods to building research sought to achieve *predictability* in performance and *replicability* in different sites and contexts.[50] To accomplish that, not only were new building standards required, it also "infer[red] the dissemination of the knowledge gained, a new outlook and new methods in architectural and technical training and a new conception of the fundamentals of architecture on the part of its practitioners."[51]

Building standards would be useless if they were not adhered to outside the building research stations where they were formulated or if they were not adopted by people besides the building scientists who formulated them. For standards to work, the knowledge gained from building research has to be disseminated, the building industry has to be trained to follow established norms of practices, and new tools and instruments may be required. In other words, building standards have to remain constant when circulating between different sites and situations – such as building research stations, construction sites, architectural studios, and building material factories – and different people – such as building scientists, architects, building contractors, and building material

suppliers. In many ways, a building standard approximates what Bruno Latour calls immutable mobile, an entity that is mobile, stable, and combinable in that it is an entity that could circulate without distortion, corruption or decay. According to Latour, immutable mobile only remains immutable and combinable *inside* the network.[52] Producing building standards thus entails network building, that is, bringing the heterogeneous elements of people and things, institutions and practices from different sites, which were needed to sustain the standard, into alignment.[53]

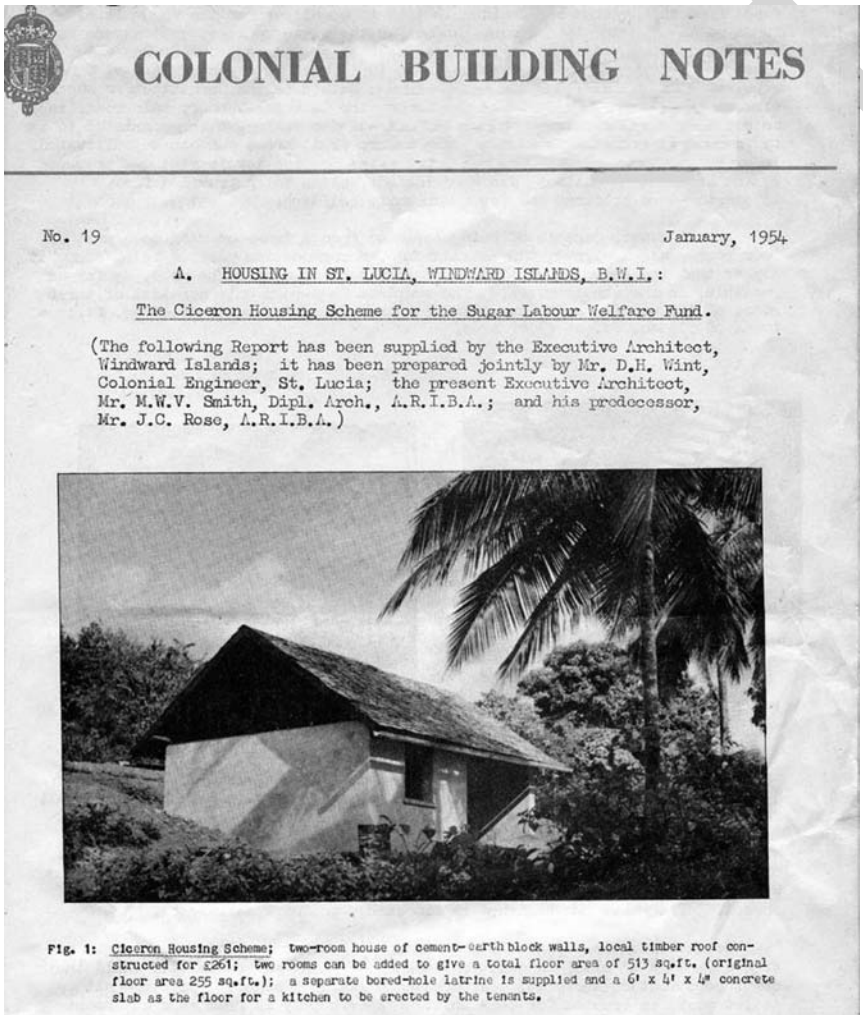
The work undertaken by Atkinson after his appointment as Colonial Liaison Officer could be understood along the lines of network building. Besides acquiring information from his correspondents, Atkinson also traveled extensively to visit the different colonial territories. At these places, he would carry out diverse activities, such as survey and advise on the colonial building developments, lecture and publicize the work undertaken in colonial building research, and encourage the setting up of building research stations.[54] Besides that, Atkinson also publicized the work of colonial building research by publishing extensively in different periodicals linked to the building industry – from metropolitan architectural journals such as the *RIBA Journal*, the *Architectural Association Journal*, and the *Architectural Review*,[55] to trade journals such as *Prefabrication*,[56] to regional architectural journals such as *Quarterly Journal of the Institute of Architects of Malaya*,[57] to journals on society and politics such as *African Affairs*.[58]

One of Atkinson's main tasks as Colonial Liaison Officer as spelt out in the Secretary of State's circular was the publication of a periodical digest disseminating the information and knowledge of colonial building gathered at the Unit. The periodical digest later took the form of *Colonial Building Notes* (1950–8), which was renamed *Overseas Building Notes* (1958–84) (Figure 2) in 1958 in view of the changing geopolitical landscape of the decolonizing British Empire. These periodicals, which were published at irregular intervals varying from a month to a few months, consist of various types of article that covered a wide range of topics. They range from description of various exemplary building schemes in the British Empire/Commonwealth, to summaries of the latest building research findings, to bibliographies and reference lists on key subjects, to technical guides on various topics. The topics covered could be classified into three main overlapping areas – information on exemplary building and planning schemes in the tropics; building construction materials and building methods for the tropics; and climatic design, especially in terms of sun-shading, natural ventilation and thermal comfort.[59] By 1984, when *Overseas Building Notes* ceased publication, 191 issues had been published and widely circulated. For example, in 1961, the circulation for each issue was about 1400 copies.[60] The Unit also published five issues of *Tropical Building Studies* from 1960 to 1963, each of which was an in-depth research report on a particular aspect of building in the tropics.

Atkinson took on educational initiatives too. From around 1950 to 1961, he helped to organize short courses for overseas officers – architects, civil engineers, and quantity surveyors – in government service.[61] Atkinson also taught

at the Department of Tropical Architecture at the Architectural Association.[62] In addition, the Unit provided advisory services to the different colonial governments and to special committees working on building projects funded by the CDWA. They included the Inter-University Council for Higher Education in the Colonies and the Colonial University Grants Advisory Committee, which were building universities in colonies like the Gold Coast, Uganda, the West Indies, and Nigeria, including the well-known example of University College at Ibadan. The Unit also provided consultancy services to British architects and builders who wished to work or were already working in the colonial territories. For example, Architects Co-Partnership in Nigeria collaborated with the Unit to make a "strenuous enquiry into the performance of each successive building" it designed.[63]

One of the most important aspects of the Unit's and Atkinson's network building entailed assisting the establishment of regional building research



COLONIAL BUILDING NOTES

No. 19 January, 1954

A. HOUSING IN ST. LUCIA, WINDWARD ISLANDS, B.W.I.:

The Ciceron Housing Scheme for the Sugar Labour Welfare Fund.

(The following Report has been supplied by the Executive Architect, Windward Islands; it has been prepared jointly by Mr. D.H. Wint, Colonial Engineer, St. Lucia; the present Executive Architect, Mr. M.W.V. Smith, Dipl. Arch., A.R.I.B.A.; and his predecessor, Mr. J.C. Rose, A.R.I.B.A.)

Fig. 1: Ciceron Housing Scheme; two-room house of cement-earth block walls, local timber roof constructed for £261; two rooms can be added to give a total floor area of 513 sq.ft. (original floor area 255 sq.ft.); a separate bored-hole latrine is supplied and a 6' x 4' x 4" concrete slab as the floor for a kitchen to be erected by the tenants.

Figure 2
Cover of *Colonial Building Notes*.

stations in the colonies, as envisioned in the Colonial Housing Group's recommendations, and also maintaining contacts and sharing research findings with these research stations. As discussed earlier, the West African Building Research Institute was established in Accra in 1952 following the recommendations of two BRS officers. A proposal was put forward in 1948 to establish a building research station in the West Indies but the lack of funds in the CDWA ended any hope of its establishment.[64] A similar proposal in Malaya was at least partially fulfilled in the form of a Design and Research Branch within the Public Works Department, but not an autonomous building research station.[65] Other than the building research stations in the colonies, two other building research stations were established in the British dominions in the early 1940s following the BRS model – the National Building Research Institute in South Africa in 1942, and the Commonwealth Experimental Station in Australia in 1944.[66] The other prominent building research station then was India's Central Building Research Station, established in 1947 under the Council of Scientific and Industrial Research and initially based at the Thomason College of Engineering at Roorkee.[67]

Network building was more than gathering and disseminating information through publication, training expertise through educational work, or establishing a technical infrastructure through the building of research stations. According to Latour, network building also entails a series of translations of interest and the enrollment of allies so that more entities (both human actors and nonhuman actants)[68] participate in the construction of fact, slowly transforming "a claim into a matter of fact." By translation, Latour meant "the interpretation given by fact-builders of their interests and that of the people they enroll" so that associations and alliances can be formed to control the actions of others and make them predictable.[69] Latour's articulation of interest tends to refer narrowly to only economic self-interest. Although that is problematic,[70] we could easily expand on the notion of interest by being more attentive to how there are other forms of vested socio-politico-cultural interests, which according to Pierre Bourdieu are often interconvertible to economic interests.[71] Active translation of interest and enrollment of allies is quite apparent in Atkinson's various writings and published speeches. Atkinson articulated the benefits of building research in different ways, catering specifically to the interests of his targeted audience. In his famous speech to an audience consisting mainly of British architects at the Architectural Association in April 1953, Atkinson impressed on his audience the abundant building opportunities available in the tropics and the importance of acquiring the appropriate technical expertise of building in the tropics if they wished to seize these opportunities.[72] However, when Atkinson was lecturing in Singapore, he shifted his earlier emphasis on how technical knowledge would privilege the metropolitan architects to show that it would instead benefit the local building scene. He noted that the establishment of a regional building research center in Malaya would mean that "results of research and technical development throughout the World can be applied to Malayan conditions" and the station could also be "where problems, particular to Malaya [could] be

studied."[73] In another instance, when Atkinson was writing in a trade journal for the building prefabrication industry, he reviewed the existing building techniques and the state of the building industry in the colonies and advised on the opportunities available to the British manufacturers for exporting their prefabricated buildings to these places.[74]

Other than enrolling human actors, Latour also argued that nonhuman actants are crucial to the construction of facts. By nonhuman actants, Latour referred to entities such as tools, instruments, or even something as simple as a graph. These tools or instruments might be critical in the conduct of an experiment so that a hypothesis could be proven, and the graph might help one visualize particular data and facts. In the case of building science and the work of the CLU of the BRS, instruments such as the heliodon and graphical representations such as the sun-path diagram and thermal comfort charts were especially important in the attempt to enroll more architects in the construction of tropical building science. As Henry Cowan, the self-professed first professor in building science, noted, "the average architect is receptive to visual demonstrations, but that he does not respond well to mathematical treatment."[75] The heliodon (Figure 3), which was invented by A. F. Dufton and H. E. Beckett of the BRS in 1928,[76] is one such instrument that provides effective visual demonstration. It is a powerful "device for determining the natural lightings of rooms, and the shadows cast on, and by, buildings."[77] It shows the daylight level and the shadow cast three-dimensionally by simulating the sun with a light bulb, the Earth's surface with an adjustable flat board, and the building with a model. The heliodon was designed to allow it to simulate the sun's position for all latitudes for all days of the year and all the sunlight hours of a day. It is thus a useful design aid that could be used to predict various aspects of building performance related to sun-shading and sunlight penetration.

Most of the works described above were of course not undertaken by Atkinson alone, as the CLU expanded fairly rapidly after his appointment as Colonial Liaison Officer in 1948. In 1951, an assistant architect and an experiment officer were appointed. Later on in 1954, a senior architect and a town planner were added to the Unit. Three years later, a tropical paint research fellow was

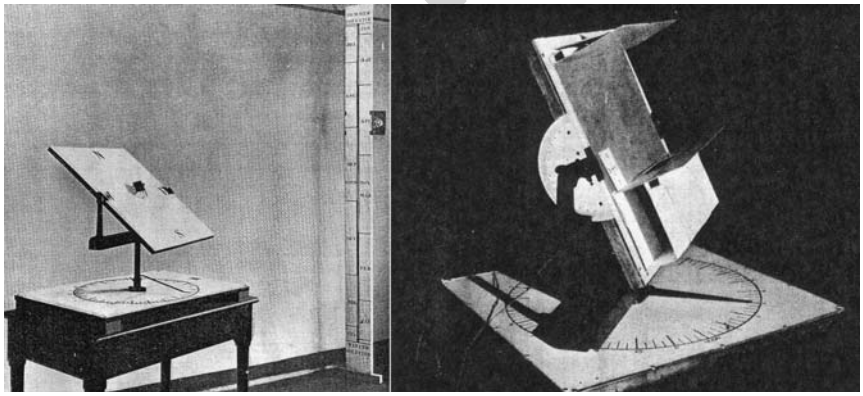


Figure 3
View of the components of a heliodon (left) and close-up view of the heliodon with a model attached (right). Source: *Colonial Building Notes*.

appointed to specifically investigate the performance of paints suitable for tropical buildings. In 1956, the Unit applied unsuccessfully for funds to expand and carry out research in areas such as building climatology, thermal conditions, natural ventilation, daylighting, and the use of solar energy in the tropics. In 1959, it made another failed application for funds to study the field conditions of thermal discomfort. However, in the same year, the Unit was renamed as TBD, one of the three tropical units in DSIR. The other tropical units were the Tropical Products Institute and the Tropical Unit in Road Research Laboratory.[78] The change in name reflected the change in emphasis from a "colonial" focus on dependent countries and countries in the British Commonwealth to a broader "tropical" coverage that included countries newly independent and even those outside the Commonwealth. In 1960, the unit came under the administration of the Department of Technical Cooperation as it took over the former functions of the CO. In the same year, the division expanded from wholly advisory work to conducting some research work of its own.[79] Due to changes in British foreign policy and its administration of development aid as the Empire gradually dissolved in the 1960s, the TBD similarly underwent many changes in the 1960s. In 1964, it came under the administration of the Ministry of Overseas Development, and the division was renamed as the Overseas Division in 1966.[80] These changes signaled the shift of the division's focus away from the tropics and perhaps marked a decline of its influence on tropical architecture. As noted earlier, a great amount of work is involved in building and sustaining a network. "Vigilance and surveillance have to be maintained," or the contingent alignment of heterogeneous "elements will fall out of line and the network will crumble."[81] Despite its subsequent decline, the Overseas Division of BRS and its predecessors nevertheless played an important part in providing the technoscientific foundation for tropical architecture in the British Empire/Commonwealth for about two decades. At this point, it is perhaps pertinent to ask, what did the network achieve besides enabling the circulation of immutable mobiles? What were the other effects of the network?

Spatially, as Latour noted, a network "indicates [that] resources are concentrated in a few places – the knots and the nodes – which are connected with one another – the links and the meshes: these connections transform scattered resources into a net that may seem to extend everywhere."[82] Within the network, events, places and people could be turned into abstract, transportable, and combinable information – that is, immutable mobiles. This information could then be circulated from one point of the network to another, often from the edges or peripheries of the network to the nodes or centers, facilitating the accumulation of knowledge at these centers. According to Latour, the accumulation of knowledge is also the accumulation of power because it allows a point, or a few points, in the network to become center(s) of calculations which can act on distant places because of its familiarity with things, people, and events there. Cycles of accumulating knowledge will create and reinforce an asymmetry of power between the centers and the peripheries of the network, thus allowing the

centers of calculation to dominate others. Even as such an understanding of the working of the technoscientific network reinforces the insight of the world system theory on center–periphery relations, this understanding is not based on the capitalist logic of production but on technoscientific practices. Moreover, unlike the world system theory, ANT does not conceive the center as a fixed or static entity. As the center of calculation is formed through network building, theoretically it could be surpassed or replaced by another center emerging from the periphery of the original network that builds a better and stronger network. In the case of the TBD, its role as a center of calculation in the field of tropical architecture declined in the 1960s, when the British Empire was coming to an end with many of its former colonies gaining independence. The original technoscientific network became much weaker, if not disintegrated, with decolonization. Without the accumulation of knowledge through the network, TBD could not function as a center. In the next section, I will use case studies of the TBD's work on climatic design and thermal comfort to illustrate how immutable mobiles actually work in the technoscientific network of tropical architecture to facilitate the accumulation of power at the center of calculation.

(Im)mutable mobiles: the case of climatic design and thermal comfort

Climatic design came into common usage in the architectural discourses of North America and Europe during the mid-twentieth century. Prominent among those discourses were the "Weather and the Building Industry" conference organized by the Building Research Advisory of the United States National Academy of Science in 1950,[83] and other publications such as Jeffrey Ellis Aronin's *Climate and Architecture* (1953), Olgyay Brothers' *Design with Climate*, and B. Givoni's *Man, Climate and Architecture* (1969). These developments in North America represented some the earliest attempts to establish climatic design on a seemingly neutral technoscientific basis devoid of the moral and racist undertones of earlier colonial discourses on climate and design. These North American developments paralleled the European – that is, primarily British, French and German – development of modern tropical architecture. Tropical architecture was seen by many as the natural extension of climatic design to the conditions of the tropics. The common rhetoric of both tropical architecture and climatic design states that the primary function of architecture is to serve as a shelter for man from the elements of nature. Thus, the need to design in response to climate is an ontological truth. Normative history of tropical architecture does not question this rhetoric. Instead it adds to it by tracing the emergence of tropical architecture to the formal precedents in the works of the masters of modern architecture – from Stamo Papadaki and Le Corbusier's use of the *brise soleil* (sun breaker) in their works in the hotter climates, to Lucio Costa and Oscar Niemeyer's Brazilian architecture, to Paul Rudolph's Florida Houses.[84] In this narrative of diffusion, tropical architecture as pioneered by these masters then came to influence

British architects such as Maxwell Fry and Jane Drew through publications and the networks of associations such as MARS (Modern Architecture Research Group) and CIAM (*Congrès International d'Architecture Moderne*).

There are a few problems with this normative narrative. First, it ignores the prior history of "climatic design" in the British Empire. Climate, especially the hot and humid tropical variant, and its influence on the built environment has featured prominently in British colonial architectural discourses for more than a century prior to the mid-twentieth century. For much of the nineteenth and early twentieth centuries, the prevalence of miasmic theories of disease transmission and other related environmentalist discourse meant that a lot attention was channeled towards modifying the built environment in order to mitigate the supposedly pernicious effects of the torrid tropical climate on white men. As a result, systematic bodies of knowledge on building in the colonial tropics were developed from the early nineteenth century and they were especially apparent in the design of building types such as bungalows, barracks, and hospitals.[85] The colonial environmentalist discourse on climate was not simply a neutral scientific knowledge describing natural phenomena, it was entwined with the politics of colonial governance and the related constructions of race, culture, and civilization.[86]

Secondly, climatic design, as we know it in the mid-twentieth century, was a new concept, premised on the availability of comprehensive climatic data and not the discovery of some ontological truth. For example, in North America, the comprehensive climatic data – hourly readings of wet and dry bulb temperatures and wind velocities at 110 weather bureau stations – used in a climatic design manual was only available in 1935, and the raw climatic data only became useful in 1938 when they were recorded on IBM punch cards and analyzed.[87] For the British colonial context, gathering and analyzing such comprehensive climatic data from such vast territories and varied geographies was difficult. As late as 1955, a technical officer of the Colonial Liaison Section, BRS, reported that they, along with other Colonial Liaison Sections under the DSIR, were "handicapped by the lack of climatological information for overseas territories."[88] The technical officer was reacting to the responses to their circular sent out to the various colonial meteorological organizations requesting climatological data for the colonies.[89] Most of the colonies replied that they did not have consistent meteorological and climatological data. In extreme cases like the Western Pacific and the Leeward Islands, they had "neither the staff nor the instruments to supply the data required."[90] Even for the colonies where there were summaries of existing data, those data presented many limitations. For example, effective temperature, required to ascertain thermal comfort, could not be calculated because "the summarized records of the different variables do not refer to the same observation hour."[91] In order to obtain proper climatological data, CLU tried to collaborate with the other colonial sections in DSIR. Initiatives were also made to coordinate and collaborate between the meteorological services of the different territories, both within the British Commonwealth, and between the French, Belgian, and British colonies in Africa.[92]

Despite the lack of comprehensive and precise climatological data, more systematic climatological data collection did take place through the technoscientific network that the CLU and George Atkinson built. With the preliminary data, they were able to produce a simple overview of the idea of climatic design in the tropics by putting together existing knowledge on climatology and the limited climatological data, as summarized in a graph (Figure 4).[93] Atkinson classified the tropics into three principal climatic types – warm and humid, hot and dry, and upland. In the graph, the three climatic types were represented by the examples of Freetown in Sierra Leone, Kano in Nigeria, and Nairobi in Kenya. Juxtaposed onto the graph is a zone that represents that of the thermal comfort zone. The thermal comfort standard used in the graph was based on studies done on summer conditions in the United States, presumably because no conclusive study had been done in the tropics yet. Based on the differences between the three climatic zones and the thermal comfort standard, Atkinson provided basic design guidelines on the features of buildings in the three climatic zones. For example, for the hot and humid climate, high humidity was the main cause of discomfort. Thus, the design guidelines called for buildings in the hot and humid tropics to be as open as possible, well-ventilated, and oriented towards the direction of the prevailing wind.

This effective overview of climatic design seems to do a few things. First, the complex tropics seem to become "knowable" through three principal climatic types. In privileging climate, the complex socio-political conditions of the tropics, especially the highly politicized problems regarding anti-colonial struggles, emerging nationalism, and problems of development, could seemingly be overlooked as part of this technical focus on climate. Knowing the climate almost

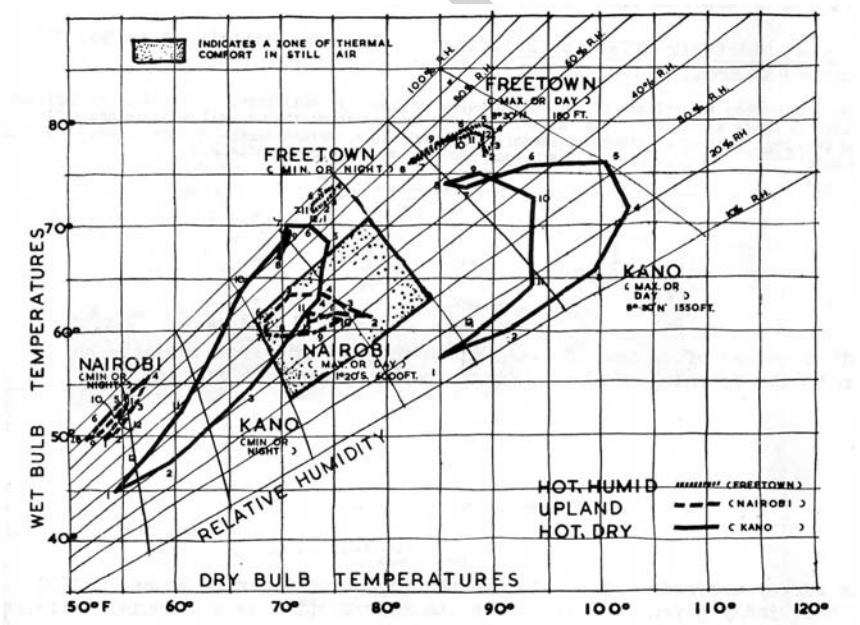


Figure 4
Thermal comfort graph.
Source: ***Colonial Building Notes.***

takes the place of knowledge about the locality through the reduction, simplification, and standardization of a complex life-world into a set of climatic parameters. Secondly, knowing locality through climate might peculiarly mean that socio-politically diverse entities such as Freetown and Singapore could be conveniently grouped together because they both share the characteristics of hot and humid tropical climate. Thirdly, by representing the climate and the question of climatic design through a simple graph, which works like an immutable mobile in that it is highly transportable and is stable, climatic design facilitates "action at a distance on unfamiliar events, places and people."[94] In other words, for the British architects in the metropole, this graph, along with the related expertise on tropical building science available in what ANT would call the "center of calculation," allowed them to produce tropical architecture without even needing to travel to the colonies. Given this, it is no wonder that the special issue of *Architectural Review* focusing on Commonwealth architecture in the tropical Commonwealth featured mainly tropical architecture "*designed in England* by English architects (as in the case of many of those in West Africa) or designed by architects of English origin, largely trained in England or America, who practice locally."[95]

A postcolonial network of power-knowledge

By studying the formation and transformation of the TBD at the BRS in this chapter, I traced how building science research on tropical building problems was organized – especially how housing problems were framed and solutions proposed, and how building science research activities expanded in the British Empire. I focused on what was previously a peripheral institution in the history of tropical architecture and I explored the roles played by much overlooked non-human actants, that is, the instruments, graphs, and numerical standards of tropical architecture. In doing so, not only did I rectify the tendency to ignore technoscientific knowledge and practices in architectural history, I also demonstrated how an imperial technoscientific infrastructure facilitated the emergence of tropical architecture in the British Empire. Besides the aforementioned, this chapter also overlaps with and, I hope, contributes to two key current discussions related to the fields of tropical architecture and Third World modernism.

The first discussion concerns what I called the "geopolitics" of tropical architecture and critical regionalism.[96] In the past few years, certain accounts have hailed tropical architecture as a variant of critical regionalism and endowed it with a capacity to resist the homogenizing forces of globalization.[97] In these accounts, climate is seen as a key attribute of a place and thus an important part of any place-based culture. As a subset of climatic design that deploys strategies of passive cooling, that is, non-mechanical means of cooling, tropical architecture is thus seen as an expression of the distinctively rooted culture of the tropics, just as the hermetically sealed architecture mechanically cooled by the air-conditioner

is deemed to be the homogenizing force that erodes the place-conscious culture.[98] In contrast to the above view, it has also been argued that tropical architecture was a product of mid-twentieth century internationalism.[99] According to this view, mid-twentieth century tropical architecture in places such as West Africa was made possible by an international network of architects, institutions, and publications, with their attendant knowledge regime.

From the ANT perspective, such a conception of the global and local/regional as opposing forces, with the former seen as the macro homogenizing structural forces imposed from above and the latter understood as the micro resisting forces countering from below, is flawed. This a priori conception of the global and local ignores how the global and local are interconnected via a network.[100] As Latour has argued, all knowledge is local. Even the purportedly universal, abstract technoscientific knowledge, or what James Scott called *episteme*,[101] started off as local knowledge in that it was produced in a specific site using specific instruments, deploying carefully calibrated techniques and under particular conditions. This local knowledge was then made "global", that is, it became an immutable mobile and could circulate to other sites and situations without distortion, through network building and a series of translations. As I have shown earlier, building standards produced by BRS only became "global" after much work. To ensure the *predictability* in performance and *replicability* in different sites and contexts, regional building research centers with the required testing facilities and measuring instruments were established, and local correspondents with the necessary expertise were assigned to provide Atkinson with local information. Atkinson also had to travel extensively to survey and understand different colonial situations, and he had to translate interests and enroll allies in his various talks and writings addressing the different groups of people connected with the building industry. It was only after all this work that locally produced building standards could behave like immutable mobiles. Latour compares such a network to the railroad model. He notes that the railroad is neither entirely local nor global. On the one hand, it is local at all points in that it has the same infrastructure of railway stations, tracks, and workers at the different locations in the network. On the other hand, it is global in that it could take one from a city or town to another city or town. However, it is not sufficiently global to take one anywhere, as there has to be railway track and stations for the train to travel and stop.[102] Seen as such, tropical architecture is only global insofar as an existing socio-technical infrastructure is in place. Tropical architecture, however, could not be considered strictly local because it is also, to a certain extent, an immutable mobile that could be replicated elsewhere within the socio-technical network.

The second discussion concerns our understanding of power in relation to colonial and postcolonial architecture. I have earlier situated the work of the TBD in relation to the larger changes in the relationship between the metropole and the colonies/periphery in the British Empire/Commonwealth in the mid-twentieth century because of decolonization and the attendant geopolitical

shifts. I have argued that, in spite of the depoliticized technoscientific discourse, mid-twentieth century tropical architecture recast prior asymmetrical power-relations between the metropole and the colonies in new ways, through the production and accumulation of technoscientific knowledge. Using ANT, I showed that, through network building and attendant accumulation of technoscientific knowledge and power, the metropole became a center of calculation. I further illustrated this using the specific case of climatic design and thermal comfort. Power has become a key analytical theme in the scholarship on many colonial and postcolonial architectural histories following the emergence of postcolonial studies and its use of Foucauldian theories. However, the scholarship, as rooted in traditional art history's approach, relies mainly on formal analysis; and social, cultural and political effects are too easily correlated with formal causes. The focus tends to be on buildings as what Sibel Bozdoğan has called "visible politics"[103] in another context, that is, a highly visible and politicized image of power. As a consequence, this scholarship directs its attention towards the more visible, spectacular, and monumental public buildings – the train stations, town halls, banking headquarters, and exhibition pavilions. This scholarship tends to fall into what Arindam Dutta described as "the linear theme of power-display-knowledge … [which] is patently inadequate to understanding the *informal* skeins of power."[104] In addition to an emerging body of scholarship on the built environment that attends more closely to the more nuanced Foucauldian conception of how power is spatialized, for example in relation to biopolitics and governmental rationality,[105] I propose that the combination of the ANT approach with the Foucauldian notion of power-knowledge in this chapter constitutes another way in which power could be conceptualized in relation to postcolonial architecture.

In short, this chapter contributes to the understanding of Third World modernism in two main ways. First, critical regionalism, which has hitherto been the conceptual category deployed in standard modern architecture history to incorporate Third World modernism into what is essentially still a Eurocentric narrative, is seen as inadequate for grasping the complex geopolitics of how Third World modernism could be understood. I am not advocating that local–global, Third World–First World and other related geopolitical binaries be simply discarded or transcended. Rather, what is necessary for understanding Third World modernism is to rethink the binaries through the concepts of network, circulation, and translation. Next, this chapter argues that Third World modernism should be studied based on a more nuanced understanding of power. Power should not be simply conceptualized as something that resides with certain political entities and is typically displayed as a form of oppressive dominance in highly visible nationalist projects, as is common in the current scholarship on Third World modernism. Power should also be understood as something more pervasive, ubiquitous and productive, shaping knowledge and practices linked to the production of the larger built environment.

Acknowledgements

I am grateful to Greig Crysler and Anthony D. King for their insightful comments on the earlier version of this chapter.

Notes

1 Notable among this scholarship are Mark Crinson, *Modern Architecture and the End of Empire* (Aldershot: Ashgate, 2003); Hannah Le Roux, "The networks of tropical architecture," *The Journal of Architecture*, 8 (2003); Rhodri Windsor-Liscombe, "Modernism in late imperial British West Africa: the work of Maxwell Fry and Jane Drew, 1946–56," *Journal of the Society of Architectural Historians*, 65, no. 2 (2006).

2 See the many technical textbooks and manuals of tropical architecture produced in the mid-twentieth century, for example Miles Danby, *Grammar of Architectural Design, with Special Reference to the Tropics* (New York: Oxford University Press, 1963), Maxwell Fry and Jane Drew, *Tropical Architecture in the Dry and Humid Zones* (London: Batsford, 1964), Georg Lippsmeier, Walter Kluska, and Carol Gray Edrich, *Tropenbau/Building in the Tropics* (Munchen: Callwey, 1969), David Oakley, *Tropical Houses: A Guide to Their Design* (London: Batsford, 1961).

3 David J. Hess, *Science Studies: An Advanced Introduction* (New York: New York University Press, 1997).

4 Donna Haraway, "Situated knowledges: the science question in feminism and the privilege of partial perspective," *Feminist Studies*, 14, no. 3 (1988).

5 Latour made a similar argument, stating that all knowledges are local, except that the purportedly "universal" knowledge is one that has the "shape of a network transporting back and forth immutable mobiles to act a distance." Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge: Harvard University Press, 1987), p. 229. Such a standpoint epistemology seeks to negotiate between the dichotomy of objectivism and relativism. ~~[MEANING?]~~ It objects to the reductive idea of objectivity-as-transcendence, or the "god trick of seeing everything from nowhere." Haraway, op. cit., p. 581.

6 Warwick Anderson, "Introduction: postcolonial technoscience," *Social Studies of Science*, 32, no. 5/6, Special Issue: Postcolonial Technoscience (2002); Michael A. Osborne, "Introduction: the social history of science, technoscience and imperialism," *Science, Technology & Society*, 4, no. 2 (1999); Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton: Princeton University Press, 1999).

7 Stephen J. Collier and Aihwa Ong, "Global assemblages, anthropological problems," in *Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems*, Aihwa Ong and Stephen J. Collier (eds), (Malden, MA: Blackwell Publishing, 2005).

8 Actant is used in place of actor of the classical social theory of Parsonian functionalism so that the non-human actants could be attributed with the agency of shaping technological outcomes.

9 The recent so-called "Science Wars" between the natural scientists and the social scientists is a case in point. A group of natural scientists accused social scientists in STS of assaulting rationality and objectivity, caricaturing it as an "antiscience movement" and its exponents as "postmodern" relativists and "science bashers." For an overview of the "Science Wars," see Andrew Ross, "Introduction," *Social Text* 46/47, Science Wars (1996).

10 For a related critique of tropical architecture as a "natural" variant, see Jiat-Hwee Chang, "Tropical variants of sustainable architecture: a postcolonial perspective," in *Handbook of Architectural Theory*, Greig Crysler, Stephen Cairns, and Hilde Heynen (eds), (London: Sage, forthcoming).

11 "Housing research in the colonies: report by the Housing Research Group" enclosed in CO dispatch dated 4 December 1945. PRO CO927/6/7, *Housing Research in the Colonies: Proposal to Establish a Housing Research Centre in West Africa*.

12 PRO CO1005/1, *Colonial Housing Research Group: Minutes and Papers*.

13 D. B. Blacklock, *An Empire Problem: The House and Village in the Tropics* (London: Hodder & Stoughton Ltd, 1932).

14 Anthony Clayton, "Browne, Sir Granville St John Orde (1883–1947)," in *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004). An example of the type of detailed report Browne published on colonial labor problems is G. St. J. Orde Browne, *Labour Conditions in Ceylon, Mauritius, and Malaya* (London: HMSO, 1943).

15 ~~Ibid.~~

16 Ibid.

17 For the work of the Bombay and Calcutta Improvement Trust, see Robert K. Home, *Of Planting and Planning: The Making of British Colonial Cities* (London: Spon, 1997), pp. 85–116. For the Singapore Improvement Trust, see J. M. Fraser, *The Work of the Singapore Improvement Trust 1927–1947* (Singapore: Singapore Improvement Trust, 1948).

18 J. G. Hibbert in a letter dated December 19 1947. CO927/6/7, *Housing Research*.

19 Ibid.

20 Frederick Cooper, "Modernizing Bureaucrats, Backward Africans, and the Development Concept," in *International Development and the Social Sciences: Essays on the History and Politics of Knowledge*, Frederick Cooper and Randall M. Packard (eds), (Berkeley: University of California Press, 1997).

21 For a history of British colonial development, see Michael A. Havinden and David Meredith, *Colonialism and Development: Britain and Its Tropical Colonies, 1850–1960* (London: Routledge, 1993).

22 Frederick Cooper and Randall M. Packard, "Introduction," in *International Development and the Social Sciences: Essays on the History and Politics of Knowledge*, Frederick Cooper and Randall M. Packard (eds), (Berkeley: University of California Press, 1997).

23 PRO CO927/7/1, *Proposals for Building Research Programme in the British West Indies and British Guiana*. Frank Stockdale, Robert Gardner-Medwin, and S. M. de Syllas, "Recent planning developments in the colonies," *RIBA Journal*, 55 (1948). Gardner-Medwin was to become an expert on housing in the tropics and the Roscoe Professor of Architecture at Liverpool University. Norman Kingham, "Obituary: Professor Robert Gardner-Medwin," *The Independent*, July 8 1995.

24 Besides Evans, Blacklock, and Browne, the Group consisted of Mary Blacklock of Liverpool School of Tropical Medicine; R. H. Burt of CO; C. Y. Carstairs, secretary of the Colonial Research Committee; S. E. Chandler and S. J. Johnstone of the Imperial Institute; R. W. Foxlee, deputy chief engineer to the Crown Agents for the colonies; and W. H. Kauntze, deputy medical advisor, CO. For the work of the Crown Agents, see "Work of the Crown Agents," *The Crown Colonist*, Preliminary Number (1931). For the Imperial Institute's involvement in colonial research, see Michael Worboys, "The Imperial Institute: the state and the development of the natural resources of the colonial empire, 1887–1923," in *Imperialism and the Natural World*, John M. Mackenzie (ed.) (Manchester: Manchester University Press, 1990). For British imperial research on tropical medicine, see Douglas Melvin Haynes, "The social production of metropolitan expertise in tropical diseases: the Imperial State, Colonial Service and Tropical Diseases Research Fund," *Science, Technology & Society*, 4, no. 2 (1999).

25 BRS, *The Building Research Station: Its History, Organization and Work* (Garston, Watford: BRS, 1954); F. M. Lea, *Science and Building: A History of the Building Research Station* (London: HMSO, 1971).

26 The two BRS officers were R. W. Nurse and A. W. Pott. CO927/6/7, *Housing Research*, PRO DSIR4/2524, *Establishment of a Building Research Station on the Gold Coast*.

27 Michael Worboys, "The Discovery of Colonial Malnutrition between the Wars," in *Imperial Medicine and Indigenous Societies*, David Arnold (ed.) (Manchester: Manchester University Press, 1988).

28 Arturo Escobar also makes a similar argument about the development discourses and practices in the mid-twentieth century. See Arturo Escobar, *Encountering Development: The Making and Unmaking of the Third World* (Princeton: Princeton University Press, 1995).

29 "Housing Research in the Colonies." CO927/6/7, *Housing Research*.
30 Ibid.
31 Haynes, ~~"The Social Production of Metropolitan Expertise in Tropical Diseases."~~
32 This insistence on the division of labor between "pure science" research in the metropole and the "applied science" research in the colony was also evident in the tense relationship between the two agencies created to advance and apply science in British India – the Indian Advisory Committee of the Royal Society based in the metropole and the Board of Scientific Advice of the Government of India. See Roy MacLeod, "Scientific advice for British India: imperial perceptions and administrative goals, 1898–1923," *Modern Asian Studies*, 9, no 3 (1975). Such a division between the center and the periphery is never really stable, however much the imperialist would like to maintain it, because it is subjected to contestations and internal contradictions. See David Wade Chambers and Richard Gillespie, "Locality in the history of science: colonial science, technoscience, and indigenous knowledge," *Osiris*, 15, special issue on nature and empire: science and the colonial enterprise (2000).
33 CO927/6/7, *Housing Research*.
34 This economic relation is best expressed by Leo Amery, the British Secretary of State for the Colonies in the 1920s. He said: "One of the most striking features of modern industrial development is the marriage of tropical production to the industrial production of the temperate zone. They are essentially complementary regions, and owing to their character and the character of their inhabitants they are likely to remain so." Quoted in Havinden and Meredith, op. cit., 169.
35 For world system theory, see Immanuel M. Wallerstein, *World-Systems Analysis: An Introduction* (Durham: Duke University Press, 2004). For world system theory in relation to architecture and urbanism, see Anthony D. King, *Urbanism, Colonialism, and the World-Economy: Cultural and Spatial Foundations of the World Urban System* (London: Routledge, 1990).
36 See, for example, Roy MacLeod, "Introduction to special issue on nature and empire: science and the colonial enterprise," *Osiris* 15 (2000); Paolo Palladino and Michael Worboys, "Critiques and Contentions: Science and Imperialism," *Isis* 84, no. 1 (1993).
37 Havinden and Meredith, op. cit.
38 Ibid., Worboys, "The Imperial Institute."
39 Sir Charles Joseph Jeffries (ed.), *A Review of Colonial Research, 1940–1960* (London: HMSO, 1964).
40 Cooper and Packard, op. cit.
41 Escobar, op. cit., p. 10. See also Wolfgang Sachs (ed.), *The Development Dictionary: A Guide to Knowledge as Power* (London: Zed Books, 1992).
42 PRO CO927/35/5, *Proposed Colonial Housing Bureau: Appointment of Colonial Liaison Officer to Dsir*.
43 Lea, op. cit., p. 163.
44 See Secretary of State for the Colonies' circular, "Cost of buildings in the Colonies," dated July 27 1948. CO927/35/5, *Proposed Colonial Housing Bureau*.
45 Ibid.
46 George Anthony Atkinson, "Tropical architecture and building standards," in *Conference on Tropical Architecture 1953: A Report of the Proceedings of the Conference Held at University College, London, March 1953*, Arthur Foyle (ed.) (London: University College London, 1953).
47 For the case of the bungalow, see Anthony D. King, *The Bungalow: The Production of a Global Culture*, 2nd edn (New York: Oxford University Press, 1995 [1984]). For the hospital, see Jiat-Hwee Chang, "Tropicalising technologies of environment and government: the Singapore General Hospital and the circulation of the pavilion plan hospital in the British Empire, 1860–1930," in *Re-Shaping Cities: How Global Mobility Transforms Architecture and Urban Form*, Michael Guggenheim and Ola Söderström (eds), (London: Routledge, 2009). For British India's PWD standardization, see Peter Scriver, "Empire-building and thinking in the Public Works Department of British India," in *Colonial Modernities: Building, Dwelling and Architecture in British India and Ceylon*, Peter Scriver and Vikramaditya Prakash (eds) (London: Routledge, 2007).

48 According to Atkinson, prior to the establishment of BRS, building research was carried out in a fragmentary and unrelated manner. Some of the results were published in journals such as *The Builder* and *The Civil Engineer*, etc. Building research was fragmentary because the building industry was dominated by small firms that were resource-poor. Moreover, the industry was characterized by the diversity of fields and it was also further split by the division of labor into different specializations. See George Anthony Atkinson, "Thoughts during the Building Research Establishment's 75th anniversary," *Construction History*, 12 (1996).

49 Lea, op. cit., p. 2.

50 "The Building Research Station: its origin, work and scope," *Journal of the Royal Institute of British Architects*, 43 (1936).

51 Ibid., p. 790. Scientific research in building during the mid-twentieth century should also be understood in relation to the institutionalization of the sub-field of "building science" at the same time. See chapter 4 of Jiat-Hwee Chang, "A genealogy of tropical architecture: Singapore in the British (post)colonial networks of nature, technoscience and governmentality, 1830s to 1960s" (unpublished Ph.D. dissertation, University of California at Berkeley, 2009).

52 Latour, op. cit., pp. 215–57.

53 John Law and John Hassard, *Actor Network Theory and After* (Malden, MA: Blackwell, 1999).

54 See, for example, Atkinson's visit to Singapore. George Anthony Atkinson, "The work of the colonial liaison building officer and building in the tropics," *The Quarterly Journal of the Institute of Architects of Malaya*, 2, no. 1 (1952).

55 George Anthony Atkinson: "British architects in the tropics," *Architectural Association Journal*, 69 (1953), "Building in the tropics," *RIBA Journal*, 57 (1950), "Principles of tropical design," *Architectural Review*, 128 (1960), "West Indian houses," *Architectural Association Journal*, 67 (1952).

56 George Anthony Atkinson: "Building techniques overseas," *Prefabrication*, 1, no. 9 (1954), "Building techniques overseas – II," *Prefabrication*, 1, no. 10 (1954).

57 Atkinson, "The work of the colonial liaison building officer and building in the tropics."

58 George Anthony Atkinson, "African housing," *African Affairs*, 49, no. 196 (1950).

59 Lea describes the research on climatic design as work on "the functional efficiency of buildings in the tropics." See Lea, op. cit., 165.

60 PRO DSIR4/3361, *Tropical Building Division*.

61 Ibid.

62 He was included in the list of lecturers and critics of the 1954 and 1955 Prospectuses for Department of Tropical Architecture at the Architectural Association.

63 D. C. Robinson, "Towards a tropical architecture: the work of Architects Co-Partnership in Nigeria," *Architectural Design*, April (1959).

64 PRO CO927/35/2, *Trinidad: Proposed Establishment of Building Research Station*.

65 DSIR4/3361, *Tropical Building Division*.

66 ~~See the~~ Natal Regional Research Committee and the University of Natal, *Symposium on Design for Tropical Living* (Durban: The University of Natal, 1957); ~~PRO DSIR4/3647, *Council of Scientific and Industrial Research: Establishment of a Building Research Station in India.*~~

67 See DSIR4/3647, *Council of Scientific and Industrial Research*.

68 ~~For some useful clarifications about human and nonhuman actors, see~~ Bruno Latour, "On recalling ANT," in *Actor Network Theory and After*, John Law and John Hassard (eds), (Malden, MA: Blackwell, 1999).

69 Latour, *Science in Action*, p. 108.

70 For an overview of some of the problems of articulating interest narrowly as economic self-interest not covered in this paper, see Corinne P. Hayden, *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2003), pp. 19–29.

71 Pierre Bourdieu, *Practical Reason: On the Theory of Action* (Stanford: Stanford University Press, 1998), pp. 92–123.

72 Atkinson, "British architects in the tropics."
73 Atkinson, "The work of the colonial liaison building officer and building in the tropics," p. 36.
74 Atkinson: "Building techniques overseas", "Building techniques overseas – II."
75 Henry J. Cowan, "The Architectural Science Laboratory," *Royal Institute of British Architects Journal*, 66, no. 12 (1959). Cowan claims that he is the first professor of building science in his autobiography. See Henry J. Cowan, *A Contradiction in Terms: The Autobiography of Henry J. Cowan* (Sydney: Hermitage Press, 1993).
76 The RIBA Joint Committee on the Orientation of Buildings, *The Orientation of Buildings, Being the Report with Appendices of the RIBA Joint Committee on the Orientation of Buildings* (London: RIBA, 1933).
77 George Anthony Atkinson, "Construction and erection of the heliodon," *Colonial Building Notes*, 26, January (1955): 12.
78 DSIR4/3361, *Tropical Building Division*.
79 Ibid.
80 Lea, op. cit.
81 John Law, "Technology and heterogeneous engineering: the case of Portuguese expansion," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Wiebe E. Bijker, Thomas P. Hughes, and T. J. Pinch (eds), (Cambridge, MA: MIT Press, 1987), p. 114.
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