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ENERGY, SOCIETY AND THE GLOBAL SYSTEM: TOWARDS AN ECOLOGICAL MODEL OF AFRICAN UNDERDEVELOPMENT

Tobias J. Lanz, University of South Carolina

Introduction

Historically, international relations has focused on the interactions between peoples and nations. As an academic discipline it represents a range of intellectual traditions, each of which has made its respective claims to predict, understand and reveal the myriad facets of global social phenomena. Despite this welter of theories and epistemologies, there remains a remarkable degree of commonality in the conceptualization of the world system—a perspective in which the state and market are seen as the main constituents.1

While the state and market are important in understanding international relations, there exist factors which are equally important in determining the course of world events. Religion, culture, race, ecology and population are significant, yet, due to their amorphous nature, they are difficult to define and understand. This makes them far more tedious objects of study than governments, corporations and international organizations. Moreover, concepts such as demography and ecology are relatively new to the lexicon of international studies, and have yet to be fully integrated into conventional academic frameworks. However, the importance of these non-institutional factors cannot be denied, especially if one examines social phenomena outside of the Western experience.

Despite the significance of these non-institutional factors they have not figured very prominently in the contemporary academic discourse, which remains firmly embedded in a "rational-institutional" paradigm. To examine the world within these narrow parameters obscures many of the broader material and social patterns that profoundly influence the more observable "micro" processes of state formation, market expansion and technological proliferation. An analytical framework which can contextualize these institutional phenomena within
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the broader social and material contours may provide added perspectives on social change and international relations, especially in the developing world, where institutional disintegration, social upheaval and environmental disasters have become commonplace and often fall outside of the orbit of conventional frameworks of explanation.

This article presents an alternative conceptualization of social phenomena which focuses on the relationship between ecology, energy and social development. It uses the case of Africa to illustrate and support this framework.

Ecology, Society and Development

At the broadest level of analysis the study of African social phenomena must be contextualized within parameters that incorporate physical factors. Understanding the lay of the land, climate, natural resource endowments and their distributions provides the basic framework from which to draw more elaborate empirical and theoretical conclusions about the human condition on this vast continent.

Geography and Population

The environment of Africa is difficult. As the driest continent on earth, it is characterized by the Sahara Desert in the north, the Kalahari semi-arid thirst land the Namib Desert in the south. Adjacent to these expansive arid zones, lie equally extensive grasslands and semi-deserts which occupy over half of the continent's landmass. While not as arid as the great African deserts, these savanna ecosystems are subject to the intermittent and often unpredictable movement of tropical air masses, yielding cycles of drought and famine. The only areas of high and consistent rainfall are found in the tropical forest zones which occupy the West African coast and expand inland throughout the Congo basin. While these three climatic regions differ significantly in terms of moisture and vegetation, they do share common geographic features which have influenced social change and history—they possess generally poor soils and unnavigable rivers.
The lack of fertile soils may be the most significant factor in determining the structure of African societies. From a geological perspective the continent is a huge metamorphic block which has endured intense tropical heat and rainfall for millions of years. As a result, most of Africa's fertile soils have been eroded, leaving a base of highly oxidized and infertile laterite soils. Fertile soils, which can sustain permanent agricultural development, are uncommon in Africa. Some of the few exceptions are the alluvial deposits found along the Nile and Niger river basins, the volcanically derived soils of the East African and Cameroon highlands and the temperate soils of South Africa, which evolved under less intense climatic conditions. In general climate and geology created conditions which have been suitable primarily to agrarian subsistence economies—shifting cultivation in the higher rainfall areas and pastoralism in more arid regions. Historically, areas of complex socio-political development and population density have been confined to those few areas on the continent which possessed abundant water and/or soil resources. Ironically, these resource rich regions also became the focus of external politico-economic agents, namely Europeans, who seized them for settler colonization and/or plantation and mineral development.

Since the European colonial era, during which time the global political economy spread across the continent, many of the traditional relationships between society and natural resources have changed. Modern material expansion, with its dual dynamic of population and consumption growth, has been the motive force in this transformation. In the African case, population growth has been the more salient of these two trends. The population of sub-Saharan Africa in 1996 was about 600 million people, and is expected to reach 1.3 billion by the year 2025 with the current growth rate of three per cent. Compounding this demographic explosion is the related phenomenon of urbanization in which half of the current rural population will have migrated to cities by the year 2025. Historically, geographic factors have played an important role in determining the form and direction of African social development. Given recent demographic changes, questions now emerge as to how the strictures of climate, vegetation and soil will accommodate these new pressures.
Various academic disciplines have tried to bring order and understanding to the issues surrounding population and natural resources. The biological sciences were the first to explore social development from an ecological perspective. Utilizing the concepts of population dynamics and carrying capacity these models defined social processes as synonymous with ecological processes, which subjected society to the same nomothetic scientific laws that governed the movement of mass and energy. As such, ecological models developed the notion of limits to growth and explored the implications of human over-expansion with respect to the supportive capacity of social systems and ecosystems alike. Despite their important contributions to the study of nature and society, ecological models also tended to be rigidly deterministic, reducing all social phenomena to the flow and accumulation of energy, thereby obscuring the social and cultural factors that mitigate and direct human development.

The importance of social and cultural factors in mediating the interactions of population on natural resources has been captured in numerous anthropological perspectives, most notably cultural materialism. Like ecological models, this approach examines the significance of material factors in social structure and process, yet it recognizes that different cultures "adapt" themselves to material conditions in a number of ways, with varying social, technical and ideological consequences. These approaches have been especially important in examining agrarian societies by providing elaborate examinations of the development of social structures and functions in response to material pressures. While these analyses contextualize population and resource problems within discrete socio-cultural parameters, they examine social change from the standpoint of internal adaptation and regulation, which makes these models less useful in examining social change from macro (both regional and global) socio-ecological levels—levels at which external factors are more critical in affecting social change.

Within the various Marxian and liberal theories of social change, population and resource issues have generally been conceptualized in utilitarian terms—as instruments of material progress. These world views define society and nature as undifferentiated entities, which can be
rearranged and redirected by institutions, technologies and ideas in the service of social development. As universal theories of social change, both Marxism and liberalism envision a world in which science and reason can overcome cultural and ecological restraints to create social unity and stability. Within these frameworks, demographic and environmental problems are viewed as consequences of improper rational management and control. Development is not limited by population and ecology, but rather by the lack of constant technical and social innovation, through which higher levels of human consciousness and material benefits can be realized.

Given the contradictory and seemingly irreconcilable visions articulated by these schools of thought, it is useful to develop concepts and relationships which can build upon their contributions and insights, while transcending their differences. Rather than trying to force a universal materialist or a particularistic cultural model of society and nature, both of which tend towards determinism, perhaps it is more useful to examine social structure and process from the perspective of energy systems, an idea which incorporates both ecological factors and social-cultural characteristics as two components of a single system in which the flow and accumulation of energy is the defining and unifying feature. Since energy access, control and conversion are universal to all social development, the concept of energy is a useful analytical tool because it provides an objective basis from which to examine and understand social phenomena through time and space.

Specifically defined, energy systems consist of energy sources (the natural resources of an ecosystem), energy converters (technologies) and social structures (states, markets, laws, and cultural norms) which mediate the flow and distribution of energy within society. Broadly speaking, the world can be divided into two basic energy systems—the traditional system and the modern system. The traditional system is based on biotic energy sources (the water-wood-wind complex), minimal technologies and the extensive reliance on human and animal labor as the primary energy converters. In contrast, the modern system is based on non-biotic (industrially created) energy sources (the oil-coal-nuclear complex) which relies extensively on complex technologies to extract and convert energy.

While all industrial societies are dependent upon non-biotic energy and agrarian societies are more dependent on biotic forms, they are
not mutually exclusive social entities, as most societies represent a convergence of modern and traditional energy systems. Thus, it is the degree to which a society (or nation-state) has integrated non-biotic energy that determines its level of development or modernization. From this standpoint, the nations of Europe, North America and Japan are considered developed because they rely almost exclusively upon non-biotic energy sources. In contrast, much of the Third World, including Africa, relies greatly upon biotic energy forms, which renders them as either underdeveloped or developing societies depending on their respective levels of non-biotic energy utilization. When examined within the context of energy systems, one of the few incontrovertible laws of social development is that when societies modernize, they "move up" the energy scale, which means they are able to access, accumulate and convert ever greater amounts of energy.

As energy throughput increases so does the dependence upon elaborate and expansive social structures to mediate energy flows. Because energy production, distribution and consumption require expansive infrastructure, all modern societies are more deeply integrated and interdependent with the state and market than their traditional agrarian counterparts. This degree of integration is due to the relationship of energy to social structure. The lower the quality and quantity of energy, the less extensive the political and economic desire for direct control. Thus, in traditional societies, peasant communities are essentially energy self reliant, utilizing local resources such as wood, water etc. This allows them a considerable degree of autonomy from systematic political and economic controls. In contrast, modern energy systems are highly dependent upon the continuous flow of externally derived energy, which necessitates the integration of state and market at every stage of the energy process.

As all social reproduction and material progress is highly dependent upon a secure and abundant flow of energy, the desire to control energy sources and energy technologies becomes an overriding political-economic preoccupation in the modern energy system. To meet these energy demands this system is inherently expansive in nature, a dynamic which creates numerous disparities with respect to traditional systems which are far more localized in scope and structure. At the regional level these disparities are readily observable in the relationship between urban and rural areas. Densely populated urban areas, with their
greater resource demands establish an almost parasitic relationship with surrounding rural areas—requiring constant streams of resources to fulfill their energy needs. At the global level, the process of transformation from traditional to modern energy systems has similar effects. Nations that are positioned higher on the energy scale are able to translate their wealth into political and economic power which allows for systematic access and control over global energy resources. Thus, different rates and levels of energy development lead to changing power differentials between nations and peoples. The result of this disparity may take many forms, but the consequences are the same—energy flows from less developed to more developed energy systems.

When examined from the concept of energy systems, the development of the state, market and society is conditioned by the quality and quantity of energy. As such, political and economic actors cannot be viewed as objective and autonomous social entities, but rather as integral components in the broader processes of energy transformation. As both agents and beneficiaries of social change, the state and market are key barometers of material development which determine the flow, accumulation and distribution of energy in the modernization process.

Examination of the roles that state and market play in the energy process is crucial in understanding the totality of social and material change. In the African case, like much of the developing world, formal political and economic institutions have endured chronic instability. From a narrow perspective these problems can be considered purely internal and institutional in nature, yet from an energy perspective they can be viewed as structural problems arising out of deeper incompatibilities between local and global energy systems. Moreover, since the state and market in Africa have not been able to initiate and/or benefit from global material development, these failures also raise questions about the roles that non-institutional factors—namely ecology and demography—play in social development.
Energy, Development and the Political Economy of Africa

The State, the Market and Development in Africa

The state and market have been dominant topics in African development since the colonial era. The recent phenomenon of state collapse and market failures has added to an already extensive literature on the problems of state formation and the declining economic position of Africa in the global system. The analysis of these problems has attracted every major theoretical and epistemological approach, each of which has made its respective intellectual claims, yielding an equally great number of explanations and interpretations of the African condition. Most of these explanations follow the conventional Marxian or liberal analysis, in which the analytical focus does not stray far from state, market and society as the main elements of the development matrix. The concept of energy systems helps to broaden this frame of analysis, by examining state and market in a socio-ecological context.

From the basic village chieftancy to the modern bureaucratic state, political governance has revolved around the authoritative allocation of values and resources. Moreover, all political collectivities imbue the allocation and redistribution of goods with cultural and ideological norms to give resource relationships the meaning and reciprocal character which is essential to sustaining a given society. From an energy systems perspective, the role of governing bodies is to unite energy sources and energy converters into energy chains which sustain social reproduction and material development. As energy flows increase, governing bodies expand and differentiate to monitor the concomitant growth and complexity of the social order. The concentration and control of energy is the underpinning of all political power.

The expansion of political collectivities into standardized bureaucracies is a quite ancient phenomenon. All of the great empires of the past based their power upon their ability to harness and control biotic energy sources. Among the most expansive energy systems in human history were hydraulic systems, which were based on the political control of water and agricultural land. These systems employed rudimentary technologies and relied heavily on abundant solar energy and humans or animals as basic energy converters. They were highly successful forms of traditional energy systems which were capable of directing social
development under the auspices of a centralized governing body. Ancient Egypt, Mesopotamia and China are notable examples of societies erected upon and sustained by hydraulic energy. These empires were also the first examples of bureaucracies which could sustain equally vast and far flung populations under a single political authority for centuries. Although individual empires and political regimes have risen and fallen throughout history in these hydraulic systems, their constituent bureaucratic structures still endure into the present.16

In sub-Saharan Africa extensive inland rivers were scarce, and as a result, hydraulic societies never developed. In the African historical experience, political and economic expansion centered around localized resource extraction and long distance trade, and to a lesser degree permanent agriculture. In the western Sahel, the great empires of Songhay, Mali, Ghana and Kanem Bornu are historical examples of political entities founded upon territorial expansion and the maintenance of extensive overland trade routes, especially the lucrative trans-Saharan trade which linked these land-locked empires to the riches of the Mediterranean and the West African coast. Cities such as Gao, Timbuktu and Kano became important urban trading centers in which resource accumulation and subsequent political and economic power was based more on exchange than access to permanent energy resources (namely water or soil).17 Similarly, on both the east and west African coasts, political and economic development was also dependent largely on external trade.18 This trade was based primarily on luxury goods and resources which were extracted from forest and savanna. For centuries these societies were supported by the expansive global trade in precious metals, spices, ivory and slaves.

Despite their political and cultural influences, these and similar African empires did not rest upon permanent energy sources such as hydraulic energy or extensive fertile soils. Rather they relied on the energy wealth that was acquired through trade and to a lesser extent from agricultural surpluses extracted through territorial expansion. These societies were extensive rather than intensive with respect to energy accumulation and transformation. Trade played the critical role in energy access and distribution. Once the volume of trade was reduced, these societies had little local energy wealth to draw upon. In the Sahel, they were relegated to isolated and thinly spread vegetative and soil resources. In the rainforest zone the fragile ecology yielded loosely connected
systems of hunting, gathering and shifting cultivation. As subsistence systems these biotic complexes yielded relatively low resource returns per labor or technical investment—energy flows which were wholly inadequate to sustain densely populated and complex societies. Thus, as the influx of wealth through trade shifted and lessened over time and space, many of these empires could no longer sustain themselves and simply collapsed and fragmented into local subsistence socio-economies.\textsuperscript{19}

The only energy systems in Africa which were able to support large populations over time, while sustaining their biotic integrity, were those found in the few fertile agriculture regions which are scattered throughout the continent. Important historical examples of these systems include the Rift valley kingdoms of southern Uganda, central and western Kenya and the Ethiopian Highlands.\textsuperscript{20} In these materially and socially complex societies energy was found in agricultural wealth which was derived from rich and abundant fertile soils. The proliferation of Iron Age technologies throughout these realms facilitated energy conversion which made permanent cultivation amidst dense human populations possible. Even today, these few and scattered highlands and riverine valleys support the densest populations on the continent.

\textbf{The Emergence of Modern Energy Systems}

The political structures that evolved in many traditional energy systems were indeed expansive and possessed complex social organizations and material power. Yet, all of these entities were bounded by the natural limits of climate, soil, water and local population. Although technological innovation served to overcome some of these limits by increasing efficiency and energy throughput, the spread of technologies and ideas remained limited. The thresholds of the traditional political economic expansion coincided with natural resource limits. These biotic thresholds were not crossed until the industrial revolution when technological innovation and institutional proliferation capable of producing and sustaining highly fungible and mobile energy sources were developed. This allowed societies to overcome the age old strictures of land and population (at least in the short term). This transformation marks the beginning of the modern energy system.

The modern state is the quintessential expression of the modern energy system. Its ability to accumulate and preside over a voluminous
flow of energy has made it the greatest expression of social power in human history. As Stephen Bunker states:

The modern state ... emerged out of energy intensive industrial production systems. In its promotion of social welfare, in its attempts to maintain order, and in its regulation of economic activities, the modern state's complexity and size have corresponded to the high degree of economic differentiation, specialization, and complexity of the articulated industrial economy. As it has grown, its increased size and complexity have directly absorbed higher levels of human and non-human energy.\(^{21}\)

Through the industrial revolution, vast amounts of energy were released through natural resource conversion. These massive increases in aggregate energy allowed the state to accumulate power and regulate social growth in ways that traditional bureaucracies were incapable of doing. As the power of the modern state expanded it became more fully integrated and interdependent with society and the market to create the modern energy system. Moreover, the growing demands of these modern political economies created a global energy system that began with colonialism and has managed to envelop, subvert or marginalize most traditional energy systems ever since. The end result is a global system of differential social complexity,\(^{22}\) in which developed political economies, which are capable of constant reproduction and material development due to their control over high yielding energy complexes, coexist with developing political economies which struggle to achieve similar development levels by relying on low yielding biotic energy complexes.

In Africa, like much of the non-European world, the modern political economy was introduced via colonialism. From its very inception this entity was rationally conceived to function as an outpost of an expanding global production-consumption system. As an extension of the European political economy, the colonial system helped foster production and consumption patterns which were conducive to the social reproduction of the modern industrial-energy complex. Economic development was oriented towards the rapid expropriation of energy
through mineral extraction and cash crop production. These modes of production, in combination with a constant stream of financial and technical supports from mother countries, helped sustain the expansion of the colonial political economy up until independence.

In the modern setting, the African political economy has changed little. Although political independence was achieved decades ago, the African political economy continues to function as an appendage to the modern industrial energy complex. The entire political economy of Africa is still highly dependent upon the constant infusion of foreign aid, loans and investments. By the early 1990s, Africa's external debt stood at $183.4 billion\(^{23}\) and annual international aid averaged over $10 billion per year.\(^{24}\) Economic development was still based almost exclusively on rapid resource conversion through the constant expansion of extractive economies. Foreign aid and the income earned from rapid resource extraction have been the bases and the principle means of support for most of Africa's material development. While these financial and technical efforts have succeeded in creating select urban and industrial areas which are integrated in the modern production-consumption matrix, this development does not extend far beyond the urban zone. Outside of these modern energy enclaves the majority of Africans still rely largely on traditional energy forms. To date, no African nation has been able to transform traditional energy systems into the modern energy system and thereby create the type of socio-economic development that has characterized the industrialized West.

Ecology and the Limits of State and Market Development in Africa

The endurance of traditional energy systems, despite decades of modernization, reveal some of the limits of development based on political and economic criteria. More importantly, the recognition of these limits brings the analysis of African development back to a more fundamental level, one which defines these limits not simply in terms of the internal limits of political and economic capacity, but within the broader parameters of ecology and demography. When African development is contextualized within these contours, the correlations between demography, resource limits and social problems becomes more evident. This provides better insights into the chronic problems of state collapse, market failure and poverty.
In the African Sahel, the correlation between ecology and failed modern development is most striking. Throughout this vast arid region, a vicious cycle of social and environmental degradation has been unfolding for several decades, one which has had serious consequences for development and social stability. The combination of natural climatic changes, population increases and sedentarization due to government and international pressures have created conditions which have led to massive depletion of soil and forest resources. The social consequences of this ecological transformation have been chronic poverty, famine, out migration and social conflict. The connection between the exhaustion of the underlying socio-ecological systems and the rampant social strife in the region is striking. Some of Africa's most serious military conflicts have occurred in an area where the struggle for resources has been most acute. Somalia, Sudan, Chad and Ethiopia are all examples of countries which have endured social conflicts that are rooted in the inability of the underlying social ecology to sustain local or national social development. The imposition of complex and expansive political and economic structures upon fragile and simple agrarian subsistence economies seems to defy the laws of ecology and common sense. These contradictions point to an interesting connection between the underlying social ecology of the African Sahel and the persistence of political and economic collapse.

In the tropical forest zones of West and Central Africa, ecological factors have influenced political and economic development in other ways, but with similar social consequences. In these eco-zones conversion of virgin forest to plantation agriculture, mineral extraction and timber felling has been synonymous with development for over a century, yet the local material benefits have been minimal. While these processes of mass energy conversion often create rapid rises in regional and national incomes, they are also followed by equally rapid collapses when resources (especially timber and mineral stocks) become depleted. Furthermore, since the energy extracted from these processes does not flow back into the social systems (it is exported and the value added is captured abroad), these economies do not foster the development of long term human productivity and social complexity, and therefore are unable to support the costly and complex organizational structures of the modern political economy. The expansion of extractive economies also marginalizes the traditional biotic system with which it coexists. Since the
best tropical lands are generally procured for plantation agriculture or timber extraction, local populations are expropriated from these lands and often relegated to marginal lands in which population densities are higher. This creates conditions which only exacerbate environmental degradation and human misery.

Perhaps the greatest socio-ecological dilemma in Africa is emerging in the areas of high soil fertility and a history of permanent agriculture. Throughout west and east Africa, the alluvial river basins and the rich upland volcanic soils are witnessing dramatic increases in population. Some of Africa's highest population densities occur in these rich agricultural areas—namely the Niger River basin, the East African Highlands and the temperate zones of South Africa. While these energy systems have been able to sustain large populations for centuries, there are indications that many of these areas are beginning to reach the point of exhaustion, a process which may have dramatic social and political consequences. The Ethiopian Highlands, Rwanda, Burundi and Uganda are saddled with increasing populations amidst dwindling resources. These are areas which have also recently been embroiled in constant internal strife and social instability. In all of these cases there exists a strong correlation between chronic socio-ecological instability and the disintegration of formal political and economic structures.

Modernization theories hold that the state and market will harness energy to facilitate development. This will initiate a cycle of constant material growth through which higher levels of social differentiation and energy throughput can be sustained. This process also assumes that resource and population dynamics are neutral with respect to the processes of state and market formation, and that social and ecological obstacles can be overcome through the constant infusion of aid, investment and technology. However, an examination of historical and contemporary Africa reveals that social structure and process are deeply embedded in ecological conditions which makes the wholesale integration of these subsistence economies into modern energy systems exceedingly difficult, if not unlikely. From the arid Sahel and fragile tropical forests to the ancient highland kingdoms, the disparity between development and underdevelopment continues to persist, yielding chronic social disintegration that modern ideologies and institutions have been unable to overcome. Thus, as biotic systems are beginning to reach their physical limits in many parts of the continent, the question of development has
begun to revolve less around the prospects for material growth and technical achievement, but rather around more modest goals of sustainability and stability.

**Conclusion**

The current African political economy is situated between two energy systems, which entail vastly different and often competing socio-economic and cultural dynamics. It is this convergence and its contradictions that reveal the limits of conventional political economic development in Africa, limits which raise many questions about the efficacy of modern material progress, and what the industrial model based on high energy conversion portends for Africa's future. Understanding the significance of these factors in African underdevelopment may serve to shift the focus of development policy to alternative strategies which rely less on material growth, but rather on social change which is suitable to the culturally fragmented and economically marginal societies which inhabit increasing fragile ecosystems throughout the continent.

An examination of African development and underdevelopment in the context of social ecology is important not only for its practical implications, but also from an intellectual perspective. Understanding the impact of population, resources and energy flows in social change helps to bring a new focus to the entire discourse over development theory and international relations. Defining social change in terms of demography and ecology reflects the growing empirical reality that environmental factors are highly relevant to conflict, cooperation and development in the global system. This recognition may also foster greater understanding of the significance of ecological sustainability and stability as measures of internal development and international security, a conceptualization which provides meaningful alternatives to the conventional interpretation of politics and economics, a discourse which remains fixated on questions of power and material growth.

The question of alternative energy systems looms large in contemporary discussions of ecology and development. Historically, when energy conversion could no longer fulfill societal needs, the energy threshold had been reached and crisis occurred. Crisis may prompt innovation and positive social change, in which the conversion to new energy systems occurs, or it may lead to social entropy if the individual
and social collectivities do not respond in kind. If this threshold is being reached in Africa and much of the developing world, what will it portend for the global system? More importantly are mass industrial societies reaching similar energy thresholds? The disparity between these two energy systems and the processes of transformation and reconciliation may become the critical issues in the immediate future of the global system.
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Endnotes

1. This includes the study of non-state and non-market actors such as international organizations. While these actors are new entities and forces in the international system, they are still conceived and analyzed within the institutional logic of the political economy paradigm.


7. While this construction can readily lead to a purely materialist interpretation of history and social change, the fact that energy systems are embedded in varying cultural and social circumstances, leaves this conceptualization of society and development equally open to idealist interpretations.


9. Here development is defined in quantitative terms, as that which signifies material growth, complexity and differentiation. It does not carry any normative qualitative meaning.
10. In agrarian societies based on subsistence agriculture, political actors extract value through tax and tribute rather than direct controls over energy flows, as is the case in all modern industrial societies. This relationship between peasant and state has been the norm throughout most of Africa.

11. Traditional energy systems in which political bodies managed to integrate deeply into agrarian life were in hydraulic societies. Yet, even here, the influence of formal political controls could not extend far beyond the biotic source, namely the river.

12. The industrialized world has been very successful in securing a constant flow of energy. It accounts for less than a fifth of the world's population but consumes over three quarters of the world's non-biotic energy. The United States alone consumes one quarter of global non-biotic energy, enough to support approximately ten billion African peasants!

13. This relationship of inequality is the essence of the core-periphery model used by many Marxist scholars. While this model captures the structural relationship of inequality correctly, it attributes these disparities solely to political and economic causes without taking into account underlying disparities in energy development.


16. As Karl Wittfogel points out in *Oriental Despotism: A Comparative Study of Total Power*. (New Haven: Yale University Press, 1957), the hydraulic character of Chinese society was the essence of its political and economic development. This historical structure was ultimately usurped by modern day communism and its legacy continues into the present.
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18. In the west Africa coast, this trade was primarily with Europe and in the east, with Arab and Asian merchants.

19. Collapse was especially evident after European colonial expansion. Inland trading routes withered as the flow of energy and resources was redirected towards the African coasts. Yet, coastal trading societies also suffered as Europeans managed to usurp their traditional positions of economic and political power.


22. From a Marxian perspective global differentiation is viewed as a consequence of the uneven nature of capitalist development. However, these socio-economic disparities must also be viewed within the parameters of ecology and energy structures, which strongly influence the course and pattern of material development.


26. See Bunker, pp. 51-53 for a further explication of the relationship between extractive tropical development and the failure of modern political economic development.