Agricultural Production, Land-use/cover Change and the Desertification Debate in the West African Savannah: An Adapted Political Ecology Approach

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ABSTRACT

In the semi-arid tropics of West Africa where farming is the major livelihood source, it is claimed that African farmers are degrading their land: first because of shifting cultivation, later because population growth brought about "over-cultivation" or farm expansion and the scattering of more farms on the landscape. In response to these issues, West African governments have emphasised the need and rolled out programmes for modernisation of smallholder agriculture through promotion of capital-intensive and market-driven strategies. Implicit in this modernisation policy orientation is the idea that the way production is organised by peasants in the semi-arid environments have to change; meaning poor peasants, regarded as perpetuators of land degradation, who may not produce for the market need to be modernised in line with the state's vision of agricultural development and environmental management. However, new perspectives being generated from several local level studies of agricultural production and land-use/cover change in the semi-arid savannah regions of West Africa offer departure points from those dominant narratives of increasing degradation and desertification. This paper discusses this emerging paradigmatic revolution by reviewing the literature on 3 highly polarised issues around land-use/cover change in the West African savannah – (a) discourses of environmental degradation; (b) human-environment interactions and agricultural production; and (c) mapping of land cover changes in drylands. Within these reviews, the paper highlights ways it move beyond currently contrasting views, before advancing an adapted political ecology framework deemed suited for exploring the complex relationships between agricultural production and land-use/cover change.

1.0 BACKGROUND

Since the infamous Sahel Drought of 1968 – 73, recent recurrences of drought and hunger in parts of (semi) arid areas of West Africa, the Horn of Africa and northern Kenya have revived international concern about desertification in Africa. In the 1990s, the UNEP Atlas of Desertification (1997) drew on data from the GLASOD project[2] to show that almost 30% of the West African Sahel is affected by human-induced soil degradation. An International Food Policy Research Institute (IFPRI) discussion paper used the GLASOD data to assert that as much as 65% of Africa's agricultural land was degraded (Scherr, 1999). Subsequent reports by a number of international organisations have repeatedly reinforced this scenario of environmental disaster for West Africa and the African Sahel, predicting greater constraints on availability of biodiversity, farmlands and water by 2050 (UNEP GEO-4, 2007). One widely held view is that dryland degradation or desertification is due to population growth and poverty which contribute to increased pressure on natural resources through overgrazing, over-cultivation, and over-harvesting of woodlands. These activities, in turn, lead to deforestation, soil erosion and poor land management which result in further environmental degradation and desertification (Mortimore, 1998). The implication of this simplistic cause-effect relationship between population growth, poverty and desertification is that most policy interventions regard indigenous management practices as destructive and in need of transformation by 'market-driven' poverty reduction strategies (ibid).

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[2] Global Assessment of Human-Induced Soil Degradation ; an expert based assessment on worldwide soil degradation

The Ghana National Action Plan to Combat Drought and Desertification (*Ghana NAP hereafter*) for example reports that desertification is creeping southwards from the north of the country at an estimated 20,000 hectares per year, with the attendant destruction of farmlands and livelihoods. It identifies socio-economic (human-induced) factors such as "population pressure, unsustainable cultivation practices, deforestation, overgrazing, bushfires, improper use of agro-chemicals, mining, soil nutrient depletion without replenishment, lack of security in land tenure, migration and poverty" as the major causes of land degradation and desertification in the semi-arid regions of northeast Ghana (EPA, 2003:16). While this is a very comprehensive list of causal factors, the Action Plan does not indicate how these have interacted to intensify desertification in this region.

In contrast to the dominant narratives of increasing desertification which are reflected in the Ghana NAP, several local level studies of land-use/cover change and agricultural productivity in the semi-arid savannah regions of West Africa run counter to dominant narratives of the increasing extent and severity of desertification (see e.g. Mazzucato and Niemeijer 2000; Mortimore and Tiffen 2004, Mortimore et al. 2009). The researchers point out that conventional perspectives on dryland management assume a fragile, yet stable, environment where resource flows can be controlled and in which nature can be restored to equilibrium when human 'stressors' are removed. However, the reality is that dryland landscapes in West Africa are complex and dynamic and that there is no equilibrium or ideal steady state to which they can be restored. Instead, they propose a Dryland Development Paradigm (see Reynolds, et al. 2007 and Mortimore et. al 2009) that focuses on agro-ecosystem resilience (see Resilience Alliance 2010) in the context of dynamic biophysical and socio-economic constraints. When viewed from this paradigm perspective, the complex landscapes in the semi-arid regions of West Africa are not degrading but changing in different ways, ranging from 'greening' and afforestation in some areas to land-use transformation in others as a response to climatic shifts, changes in market demand, or reorientation of government policies.

Across many jurisdictions in the West African savannah, many land –use/cover change studies (e.g. Dickson &Benneh 1970; Korem 1985; Nsiah-Gyabaah 1994; Ministry of Lands and Forestry, 2001) are premised on the assumption that there has been a historically simple, linear, and uniform degradation due to progressive and irreversible losses in woody vegetation across all landscapes (Pabi, 2007). They claim that the savannah is expanding and subsuming forest land and, at the same time, the quality of the savannah in terms of providing environmental services is falling because of land degradation due to population pressure and poor land management practices of rural communities. However, these studies, including the Ghana NAP, do not show how changes in social (e.g. influence of market conditions, organisation of agricultural production) and ecological (e.g. climate) conditions have interacted over time to influence patterns of land-use/cover change.

This gap in the knowledge may necessitate the need for coherent analytical framework that is useful for *investigating the patterns of socio-economic and ecological interactions influencing land use and land cover changes in the West African savannah region*. In the paragraphs that follow, this paper advances an adapted political ecology framework deemed suited for exploring the complex the complex relationships between agricultural production, land-use/cover change, and the desertification debate in the West African savannah. But first, the state of the literature around agrarian, social, and environmental change in the West African savannah will be reviewed.

2.0 REVIEW OF THE LITERATURE

Knowledge regarding environmental, agrarian, and social change in the West African semi-arid savannah, and northeast Ghana in particular is highly polarised around a) discourses of environmental degradation; (b) human-environment interactions and agricultural development, and (c) measurement and mapping of environmental change. I will discuss the literature under each of these sub-headings, and highlight how this paper will move beyond the existing polarised views in each of these areas.

2.1 Discourses of Environmental Degradation and Desertification

According to Peet and Watts (1996), issues such as deforestation, drought, and desertification become a dominant part of national and global environmental discourses about particular regions or parts of the world. These can be theorized as a "regional discursive formations", or;

"certain modes of thought, logics, themes, styles of expression, and typical metaphors [which] run through the discursive history of a region, appearing in a variety of forms, disappearing occasionally, only to reappear with even greater intensity in new guises" (pp.15 – 16).

Historically, European explorers/scientists, notably the French, in West Africa during 1930s concluded that the drylands of West Africa were undergoing progressive desiccation and the Sahara was moving southwards (Adams, 2009). The savannah was seen as a form of open deciduous forest, progressively degraded by burning and shifting cultivation, grazing, browsing and pollarding by livestock and crop farmers, culminating in desertification or the degradation of productive land in dry regions. The extent and severity of desertification were seen to be increasing in every arid region in the developing world (Kull, 2004).

This view of dessication in West Africa was originally introduced in the early twentieth century by the French colonial forester Auguste Aubreville and became so influential that it subsequently was accepted as unquestioned fact (Fairhead and Leach, 1996). Aubreville described the conversion of forested areas as the process of "savannization" resulting from a combination of shifting cultivation and fires. The activities of shifting cultivators reduced fallow periods and created conditions for invasion by grassy species that were prone to annual fires, prevented forest vegetation succession, and thus produced areas that were 'derived savannahs'.

Other European colonial writers on the North and West African environment repeated Aubreville's explanation of forest regression and desiccation caused by the indigenous populations of who had created a 'zone pseudo-desertique' (Davis, 2004: 241). A common observation was that the forests of West Africa were "in miserable condition," due to the expansion of agricultural areas, fires, grazing, and chopping down of trees for fuel. The use of grass fires for managing pastures was called a "barbarian practice".

Discussions about 'savannazation' processes in semi-arid parts of Ghana repeated these explanations. Adu (1969) claimed that the original vegetation of the northern savannah was characterised by short deciduous trees often widely spaced and a ground flora made up of different species of grasses of varying height. But the growth of settlements, population, and bush fires contributed to rapid de-vegetation and degradation of the original tree-savannah. Dickson &Benneh (1970) also made the same argument, claiming that the original vegetation in the savannah was much richer and included numerous tree species found in forest remnants and sacred groves. These studies were important in reinforcing the savannization discourse in Ghana, and many other researchers reiterated these explanations in their work during the 1980s and 1990s. (Korem, 1985; Durning, 1989; Brown & Hal, 1994).

Benjaminsen and Berge (2005) link the "regional discursive formation" of the desertification narrative in West Africa with that of the Dust Bowl experience in the 1930s in USA. They point out that the drought between 1930 and 1932 in West Africa coincided with the concerns about soil erosion in the USA, and this was the time the desertification discourse became dominant in West Africa. There was less interest in of desertification during the 1950s when there were unusual amounts of precipitation in the Sahel and increase in areas under forest vegetation. But the desertification discourse revived in West Africa when the amount of rainfall started to decline from the 1960s onwards, and became a global discourse following the major Sahelian droughts in 1973 and 1984.

In 1977, following the United Nations Conference on Desertification (UNCOD) held in Nairobi, the UNEP was made responsible for coordinating a Plan of Action to Combat Desertification. The UNEP established an Interagency Working Group and a Consultative Group on Desertification Control, and began publishing a bulletin on the activities carried out (Thomas and Middleton, 1994). This institutional interest along with the persistence of droughts and famine in the Sahel during the 1970s and 1980s kept the desertification discourse high on the international development agenda. There was a broad consensus that the Sahara was moving south and more data needed to be gathered to track the speed of the process.

Benjaminsen and Berge are critical of the methods used to track deforestation in the Sahel. They refer to Lamprey's 1975 study of vegetation change in the southern Sudan (Lamprey 1988), where he attempted to compare aerial photographs of the desert-semi-arid grassland/scrub boundary which he took flying in a light aircraft with the 1958 vegetation maps of the area. Based on these comparisons, Lamprey claimed that the desert boundary had spread 90 – 100 kilometres southwards, roughly at a rate of 5 to 6 kilometres per

year between 1958 and 1975. Benjaminsen and Berge argue that rather than tracking the expansion of the desert what Lamprey actually did was "compare the extent of the desert in the exceptionally wet 1950s with the conditions in the middle of the drought of the 1970s" (pp.45).

Several other studies also revealed the weakness of Lamprey's findings (Adams, 2009; Benjaminsen and Berge, 2005; Tucker and Nicholson, 1999, Hellden, 1991) by showing that short-term droughts and the back-and-forth movement of the desert edge during the 1960s and 70s were more due to annual rainfall variations than human activities in the area. There was neither systematic decline in crop production, nor major changes in vegetation cover. Thus as Lambinet. al. (2001:267) noted, popular narratives of human-initiated ecological degradation are "simplifications of cause-consequence relationships that are difficult to support empirically but have gained sufficient public support to influence environmental and development policies".

Fairhead and Leach (1996) also pioneered a famous hypothesis of successful environmental stewardship by smallholders in Kisidougou, Guinea, in the West African savannah. They studied oral histories and remotely sensed images to assess patterns of land-use/cover change over a 40 year period (from 1952 to 1992) and concluded that there has been no significant recession of forests due to human mismanagement as often cited in the literature. They proposed that the patterns and processes of land cover changes have been due to complex interactions across nested scales, with forest cover expanding and/or reducing during certain periods but always being produced and reshaped through the agency of local communities. Instead of criticising small-scale farmers, they emphasise the ingenuity of local communities to create land-use/management conditions which encourage forest regeneration – for example by "creating the fire-protection and soil structure, fertility and water conditions which favour forest regeneration in savannah, as well as by planting pioneer tree species to initiate forest successions" (pp.218). However, their findings have also been criticised by Nyerges and Green (2000) for relying too much on the "simple inspection of remotely sensed images (without benefit of GIS), uncritical acceptance of villagers'/indigenes' statements, and an (as yet) insufficient ecological assessment" (pp. 273).

Other recent studies have also challenged those dominant narratives of human-induced desertification in the West African savannah generally, of which detailed findings have been reported and synthesized at country level (e.g. Drylands Research Working Papers, 1 – 41, available at www.drylandsresearch.org.uk; Mazzucato and Niemeijer, 2000; Mortimore and Tiffen, 2004). Mortimore (2005) summarises the results of these studies, noting that in some West African semi-arid areas classified as 'desertified' or very prone to 'desertification;

- population growth led to the development of new land, and urbanization created new markets, partly compensating for the loss of export markets
- primary production was maintained over the long term , despite variability from year to year, in terms of the output of food commodities per capita, or in a shift to higher-value crops;
- agricultural intensification, including increased attention to soil fertility management, was evident over the long term despite the moisture constraint;
- new technologies were selected, adapted, experimented and adopted within the limits imposed by climate, soil and capital constraints;
- a farmer capability for investment in natural resources was present, and incentives to invest, provided by good policy, produced a robust response; and
- changes in the nature of the rural family and its financial management responded to new needs and opportunities.

While the desertification discourse may seem simplistic and thus open to criticism for producing stereotyped narratives of ecological degradation based on inadequate evidence, this does not mean the opposite – i.e. there is no land-use or land cover change happening. The studies showing successful re-greening in the Sahel indicate the complex relationships between population growth, environmental change, technology, and social organisation (Mortimore, 2009). There is a complex array of processes structuring human-environment relations in semi-arid areas which are reflected in the land-use/cover changes. It is therefore important to focus on changes in agrarian structure, agricultural development and techniques in order to assess associated land use/land cover changes.

2.2 Human-Environment Interactions and Agricultural Development

In order to contextually understand complex processes of agrarian and (anthropogenic) land-use/cover changes, there is a need to move the debate beyond Malthusian versus Boserupian perspectives in the man-

environment debate in dryland dynamics (Batterbury, 2007). This suggests we need to factor the trajectory of political and socio-economic forces that in turn influence (a) agricultural creativity and capabilities; (b) land use decisions made over time, and (c) their manifestations on land cover changes.

Several theoretical perspectives have attempted to respond to this call. Contemporary Marxian concepts and issues such as "Ecological Marxism" (O'Brien, 1995), "Ecological Agrarian Question" (Akram-Lodhi and Kay, 2010) and Jason Moore's (2008) "Ecological Crises and Agrarian Question a World-Historical Perspective" have been propounded and focused on the contradiction between the forces and relations of production, on one hand, and the ecological conditions of production, on the other. The classical Marxian theorist Karl Kautsky highlighted this contradiction in his treatise, The Agrarian Question (1899 [1988]) where he argued that "the constantly mounting loss of nutrients" pouring out of the countryside "does not signify an exploitation of agriculture in terms of the law of the value, it does nevertheless lead to...material exploitation, to the impoverishment of the land" (pp.214). Kautsky noted that, "technical progress in agriculture, far from making up this loss, is, in essence, a method for improving the techniques of wringing the goodness out of the soil." The classical and neo-Marxist theories thus emphasise the ecological contradiction of capitalist development – i.e. its tendency to destroy its own ecological conditions on which its maintained production depends – thereby creating economic and social crisis in the long run. External factors are seen as the most crucial as they alter production systems that in turn induce environmental decline.

In contrast to the political economy perspectives, neoliberal views as reflected in the programmes of the World Bank for poverty reduction, attribute environmental degradation in the tropics to faulty incentive systems affecting economic and demographic behaviours centred on the use of common property resources and to "irrational traditional" (that is stagnant and using 'primitive technology') land use decisions of small producers (Yaro, 2008). This view posits that the market is a perfect instrument that can allocate resources optimally. It argues that a competitive market is required for proper management of resources, and the elimination of market anomalies is a prerequisite for environmental redemption (Aubynn, 1997). Hence, from a neoliberal perspective, under-development and environmental degradation can be addressed by reducing the role of governments in influencing the market, liberalising trade and through privatisation schemes.

These neo-liberal views have historically informed the main policy proposals for agricultural development and desertification management in Ghana's northeast savannah, which are oriented to 'modernisation' of subsistence smallholder agriculture. 'Modernisation' has been driven by input provision/support and limiting the expansion of subsistence farming into what they call 'marginal', 'fragile' or forested areas. Implicit in this modernisation policy orientation (in colonial and post-colonial Ghana) is the idea that the way things are done by peasant producers in the semi-arid environments have to change; meaning poor peasants who produce for subsistence and who are regarded as perpetrators of land degradation, need to be modernised in line with the state's vision of agricultural development. It is assumed that a lean but efficient farming sector will boost productivity while limiting the proportion of people who rely on inefficient and unsustainable farming practices for mere subsistence. However, such views have been problematic in producing policies and plans that do not take into account the historical experiences of people who live within and work those landscapes (Diaw, 1998), and how their activities shape land-use/cover changes.

Neo-liberal views have also been criticised on several other grounds. The perfect competitive markets intended to ensure optimal resource allocation may tend to misallocate resources to the advantage of a few profit oriented 'rational' (and sometimes well-connected and powerful) individuals. In response to prices of products on the markets, influential farmers and agri-business companies may go into the cultivation of crops that earn them more money and may use potentially destructive inputs such as herbicides, excessive inorganic fertilizer, and other heavy machinery, etc. and potentially destructive cropping systems such as mono-cropping (Yaro, 2008). All of these actions, which are part of modernised agriculture that responds to market forces, are more likely to intensify land degradation than the activities of subsistence farmers.

Both pure political economic and neo-liberal views overstress the role of external factors in a structuralist determinist fashion that fails to recognise 'factors of agency' of local land users (Awanyo 2001). Peasant livelihood dynamics are the anthropogenic drivers of land-use/cover change and reflect the outcomes of complex ecological, socio-economic and political interactions (Yaro, 2008). Thus, what is needed is a historical understanding of the social and ecological interactions associated with land use and land cover

changes in the semi-arid savannah region so that these can inform the mapping of land-use/cover changes in the region.

2.3 Mapping of Land Cover Changes in Drylands

There are very few studies that measure 'desertification' based on actual observations of vegetation change in places over time. Most studies use Geographical Information Systems (GIS) and remote sensing to track the expansion of areas of moving sand, the deterioration of rangelands, the degradation of rain-fed croplands, waterlogging and salinization of irrigated areas, deforestation and declining ground or surface water supplies (Adams, 2009). Scoping of the literature reveals that methods used to map desertification in the past and presently can be conveniently grouped into four main categories – visual analysis, biophysical parameter method, vegetation index differencing, and the integrated GIS and remote sensing method.

Visual analysis involves the visual interpretation of different aerial images of the same study area and on-screen digitizing to assess change (Lu, et. al. 2004). An example is Hugh Lamprey's 1975 study of vegetation change in the southern Sudan where he attempted to compare aerial photographs of the desert-semi-arid grassland/scrub boundary which he took flying in a light aircraft with the 1958 vegetation maps of the area. Lamprey used these comparisons to claim that the desert boundary had spread 90 – 100 kilometres southwards, roughly at a rate of 5 to 6 kilometres per year between 1958 and 1975. As discussed in the previous sections, Lamprey's method and calculations have come under criticism, notably by Benjaminsen and Berge (2005) on grounds such as incomparability of datasets due to differences in time of year that they were taken.

The biophysical parameter category involves a biophysical parameter estimation model using field measurements to estimate the desertification status of a study area (Lu et. al. 2004). The method was promoted by the FAO and UNEP to monitor desertification. The UNEP method involved field visits to individual sites that were perceived to be degraded and required determination of their desertification status. Biophysical variables such as plant cover, water erosion, wind erosion, and salinization (using a range of qualitative and quantitative indicators) were recorded and incorporated into a 16x4 matrix (UNEP, 1992). Each of the 16 variables had their own set of qualitative and quantitative indicators for assessment against 4 classes of degree of desertification (i.e. slight, medium, severe, very severe). Quantitative assessments were made based on a range of values reflecting the degree of desertification status. Qualitative assessments were based on verbal descriptions. These were then compiled to indicate the overall desertification status of the places surveyed.

Veron et al. (2006) critiqued this FAO/UNEP method on logical and practical grounds. They pointed out that the main problem of the method was the number of implicit assumptions underlying the matrix:

> *"it assumes that 40% of perennial plant cover is equivalent to a 75% decline in plant production. In a similar way, a system with 10% of the area with exposed subsoil (slight desertification) and 25 cm of soil thickness (severe desertification) is made equivalent to a system with 15% of the area with exposed subsoil and 70 cm of soil thickness (moderate desertification)"* (pp. 756).

These assumptions informing how the approach estimates and map the desertification status of a place are unclear. Veron*et. al*(2006, pp.757)claimed that the FAO/UNEP method, which relied heavily on soil variables, was "more an autopsy than a preventive diagnostic" for assessing the processes of desertification. Agnew and Warren (1993, cited in Veron et. al. 2006) also criticised the subjective nature of the assessment as most variables were not really measured but estimated on the basis of "informed opinion".

Veronet. al. (2006) also discusses the labour-intensive nature of the method, pointing out the practical difficulties of carrying out such assessments at regular intervals to track desertification. They note that despite the enormous investment of resources in this approach during the 1980s and early 1990s, it yielded not significant insights regarding complex land-use/cover change processes. The UNCED acknowledged this when it noted that these global assessments served to reveal knowledge insufficiencies regarding the desertification process (United Nations Conference on Environment and Development, 1992).

More recent assessments such as those of Herrmann and Hutchinson (2005) and Mortimoreet. al (2009) use the Normalised Difference Vegetation Index (NDVI)[3] through satellite imagery to estimate biological productivity or 'greenness' in the West African Sahel. These assessments have produced counter evidence to the conventional view of progressive desertification. They indicate significant 'greening' in this zone between 1982 and 2006, confirming earlier findings on oscillations of the desert edge having a positive relationship with rainfall. There were some localised exceptions to the general trend, and the strength of the association with rainfall was variable (Mortimore et al. 2009). They note that other drivers such as management may have positive or negative effects on the extent of vegetation, and that the NDVI data need to be supported by contextual studies of land use change on the ground.

Mortimore (2009) observes that assessments solely based on satellite images merely show vegetation borders and provide no information about diversity or the quality of the vegetation cover. They also do not provide any understanding of what local people are doing, why, and with what effect on the vegetation. Satellite image analysis of 'greenery' or 'greening' fails to capture the different values of vegetation in dryland landscapes. It offers little indication of whether 'greening' is the result of increase in socio-economically and ecologically important vegetation, or due to increase in invasive species as a result of abandonment of land, or due to temporal increases in rainfall. For instance the expansion of plant communities such as *Prosopisjuliflora*, *P. chilensis*, *Calotropisprocera* in semi-arid regions may produce a positive effect on the 'greenness index' but may in fact indicate poor quality grazing land or abandoned agricultural fields (Mortimore, 2009).

The Land Degradation Assessment in Drylands (LADA) is another methodological framework promoted by the UNCCD for assessing land degradation at different scales, from local to global. It integrates GIS and remote sensing techniques to examine the relationship between human activity and dryland ecology. It incorporates expert assessments, field measurements, remote sensing, geographic information systems (GIS), modelling and other modern means of data generation and dissemination for analysing and sharing information at national and international level (UNCCD, 2005). However, as with some of the previously discussed mapping techniques, LADA concentrates largely on measurement of the physical dimensions of land-use/cover change mapping, usually interpreting visible data. The scale at which they are mapped does not provide any way of interpreting land-use/change outcomes of what people are doing, why, and how their activities affect vegetation quality at different scales.

Another short-coming of all the aforementioned methods is that they are limited to mapping current vegetation forms and land cover change within short periods (e.g. 10 – 20 years) but are used to deduce long-term processes of land-use/cover dynamics. That understanding complex long-term processes that structure land-use/change dynamics is critical requires systematic analysis and interpretation of historical datasets. Such historical datasets to aid mapping of long-term land-use/cover processes include archival maps, early aerial photographs, historical descriptions of the landscape, and carefully sourced recollections of elderly people of the study area (see e.g. Fairhead and Leach, 1996). These are valuable sources of information to build a general picture of changing land uses and its effects on landscape transformations, at least for the periods before the advent of sophisticated mapping tools. These can then be complemented with modern mapping methods where satellite imagery and topographic data of the same study area and time period that they were taken will be processed with appropriate GIS approaches to map land-use/cover change over comparatively recent times. Thus, this process enables a long-term mapping (e.g. over a century) of complex land-use/cover dynamics through an integration of historical mapping methods (using historical datasets) and relatively modern mapping methods using GIS. As Petit and Lambin (2001) explain, integration of multiple data sources (e.g. historical datasets, previous thematic maps, aerial photographs) is very critical for land-use/cover change mapping, especially when the period of change detection is long.

Aside early aerial photographs and archival maps, the usability of other historical datasets to map land-use/cover changes require careful inferences. For instance, detailed descriptions about changing uses of

[3] An index calculated from reflectance measured in the visible and near infrared channels. It is related to the fraction of photo synthetically active radiation. Equation: NDVI = (NIR-R) / (NIR+R) where NIR is the reflectance in the near-infrared band, and R is the reflectance in the red visible band. The chlorophyll (green pigment) absorbs incoming radiation in the visible band, while the leaf structure and water content are responsible for a very high reflectance in the near-infrared region of the spectrum. NDVI has been correlated to a variety of vegetation parameters, including quantity, productivity, biomass, etc. (http://www.ccrs.nrcan.gc.ca/glossary)

land and species composition can reveal much about the landscape conditions. Changes in animal ecology are also useful sources for inference. Other examples include descriptions of the distribution and feeding requirements of certain animals, farming systems, plant materials for roofing houses, distribution patterns of raw materials for certain crafts (e.g. certain grass species for making hats, mats, roofs, etc.), population distributions, among others.

However, use of historical datasets to aid mapping of long-term land-use/cover changes are not without their methodological problems. Fairhead and Leach (1996) document a number of difficulties in using such historical datasets. They raise issues such as ambiguity of the scale and spatial extent of the land-use/cover maps generated; difficulties in comparing sets of aerial photographs because of possible varying resolutions and differences in time of year at which they were taken; periods taken; possible seasonal biases in historical descriptions due to differences times of year at which they were observed and described; possible intellectual biases in historical descriptions as the way the landscape is described may partially reflect descriptors' experiences of other environments with which they make their comparisons. Fairhead and Leach point out that one way to deal with these methodological difficulties is to analyse them solely on information provided about landscape descriptions at the time of observation, not in terms of their interpretive contexts. Despite these methodological issues however, the use of historical datasets provides an important first-step to assemble information with which to build a long-term picture of past and present land-use/cover patterns.

Use of the aforementioned long-term approach to map land-use/cover changes in the study areas (i.e. the districts) offers several benefits. Not only does it map biophysical patterns of land-use/cover change over a longer term, it also incorporates relevant socio-economic variables to contextually interpret biophysical land-use/change outcomes of what people are doing, why, and how their activities affect vegetation quality at different timescales. Thus, it provides the opportunity for assessment of land-use/cover changes at scales which allow for detailed investigation of the effects of land users' livelihood activities on landscape formations/configurations and with richer historical depths (see e.g. Kull, 2012)

Table 1 below summarises the various techniques used to map/assess land cover changes in drylands as discussed in this section.

Table 1: Dryland Cover Change Detection Techniques

Mapping Method	Characteristics	Advantages	Disadvantages
Visual Analysis (e.g. Lamprey's method)	Involves the visual interpretation of different aerial images of the same study area to assess change	Quick to use in detecting land cover change when comparable aerial photographs are available	Visual analysis alone cannot provide detailed land cover change information. Problematic when incomparable image are used. Requires a lot of skill from the analyst in image interpretation
Biophysical parameter method (e.g. UNEP method)	Involves a biophysical parameter estimation model using field measurements to estimate the desertification status of a study area	Can be used to estimate desertification status of a place based on biophysical properties	Excessive use of subjective and unclear assumptions for estimation. Labour-intensive nature of the method, culminating in many practical difficulties in carrying out such assessments at regular intervals. Usable in estimating land cover change only over short-terms.

Vegetation Index Differencing (e.g. Normalised Difference Vegetation Index [NDVI])	Captures photosynthetic radiation released by green plants, then produces vegetion index differencing by subtracting the secon-date vegetation index from the first-date vegetation index	Ability to map land cover change across large geographical areas	Does not provide much information to show the different use-value of vegetation change. Usable in mapping land cover change only over short-terms (e.g. 10 – 20 years)
Integrated GIS and Remote Sensing (e.g. LADA method)	Incorporates remote sensing and GIS techniques to examine relationship between human activity and dryland ecology by overlaying GIS image layers on ancillary socio-economic data of study area	Use of socio-economic data of study area aids interpretation and analysis of change	Incorporation of different data of differing quality from different sources may affect the quality of detecting land-use/cover change. This method alone is only usable in mapping land cover change over short-terms (e.g. 10 – 20 years). It is also very complex and requires a lot of skill and experience to use
My technique (Long-term mapping method)	Integrates historical and modern GIS-based methods to map land-use/cover changes to help understand complex long-term processes that structure change	Provides opportunity to map land-use/cover over a longer time, and integrates appropriate contextual biophysical and socio-economic variables in mapping change	Possible ambiguity when mapping spatial extent of land-use/cover change patterns, especially using historical datasets. Also, availability and accessibility of comparable aerial photographs may be a challenge

3.0 HOLISM IN THE ANALYSIS OF THE COMPLEXITY: AN ADAPTED POLITICAL ECOLOGY APPROACH

Having explored the state of the literature and emerging issues around the complexity of environmental, agrarian, and social change in the West African savannah, this section will present and discuss a suited framework to assess these relationships holistically – the Adapted Political Ecological Framework. This framework seeks to understand environmental or ecological conditions (i.e. land-use/cover change conditions) as the product of socio-economic and political processes, linked at a number of nested scales from the local to the national (Adams, 2009). Two key themes running through the political ecology literature are identified to guide analytical discussions expounded by this framework. The first is an integrated analysis of the human-environment relationships through the amalgamation of both ecological studies and political economy in *critical* considerations of how local actors' agency shape landscape changes over time (Blaikie& Brookfield, 1987; Robbins, 2004). The second emphasises that nature is understood differently by different actors, and the way it is understood is highly political. As Escobar (1999) reiterates, conceptualisations about nature are formed and shared and applied in ways that are essentially political and socially mediated. Applying this theme for instance allows analysis of how the dialectic of material environmental conditions in given contexts is formulated, articulated, and legitimized. In other words, the way power relations are reflected in differing discourses and knowledge claims about the environment.

The political ecology approach adapted here, among others, offers a reappraisal of the history of land use and land cover *change* in the West African savannah, as opposed to severe *degradation*. This historical reappraisal is grounded in the conviction in the literature that 'resource use histories' help explain contemporary and past landscapes (Batterbury and Bebbington, 1999). It can allow us to understand the varied socio-economic, political and ecological processes (at a number of nested scales) that have shaped decisions about land users' livelihoods and their manifestations on land cover dynamics. After all, the

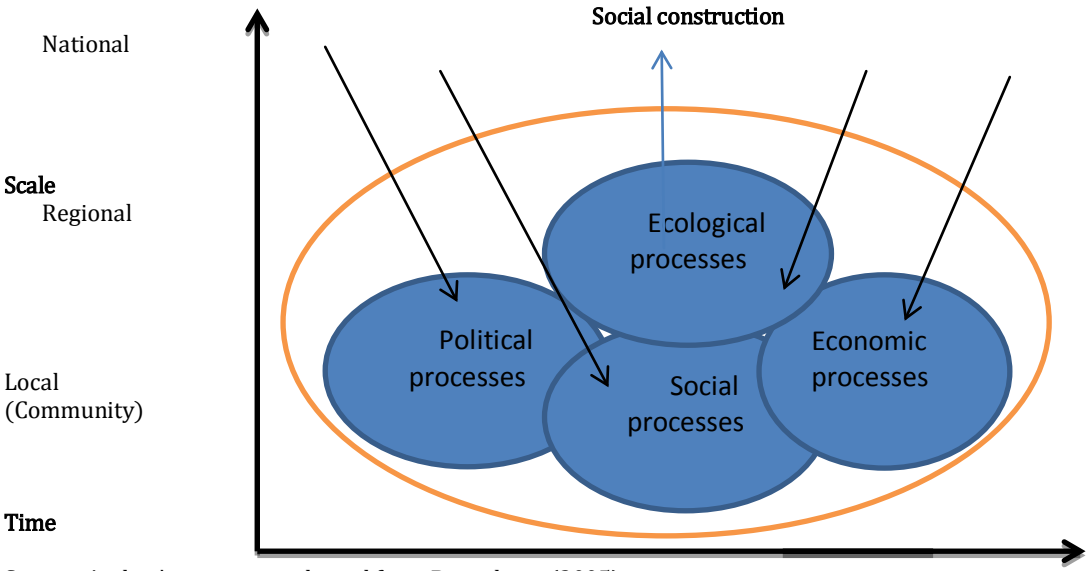
decline or otherwise in biological productivity of an ecosystem, which is at the heart of desertification, is situated within this broader context. This is so, as decisions/strategies about individual livelihoods (in response to climatic shifts, changes in market demand, or reorientation of government policies, etc.) over time affects land use change, and land use change is expressed in land cover changes (Mortimore and Turner, 2005). Thus, this framework emphasizes;

i. Land users' differing power to negotiate for access to and use of resources (such as land, labour and other technologies) for production – i.e. the cultural and political structures that define the social relations of production;
ii. Livelihood adaptation and coping processes to economic, environmental, social, and political changes or stresses – e.g. through income diversification and migration;
iii. How such social relations (*i.e. item i*) and adaptation measures (*i.e. item ii*) affect and are affected by the ecological settings in which production takes place;
iv. Implications of these social and ecological relations on agricultural productivity.

The political ecology approach is a particularly novel and well-suited approach for examining the human-environment relationship in the desertification debate. It is not only useful for understanding the broader political economic dimensions of agrarian change, but also in terms of how it reinterprets both the agricultural development and desertification debates in the savannah agro-ecosystem region of northeast Ghana in particular and West Africa in general.

In this paper, I use the analytical approach of political ecology to develop a framework for examining the processes that have shaped land-use/cover changes. As Rangan (2000: 63) observes, political ecology provides the framework for understanding biogeographical outcomes of socio-economic relations within particular political configurations. The approach involves examining how socio-economic and political activities occurring at different geographical levels and hierarchies of socio-economic organisation (e.g. person, household, village, region, state, global) interact with ecological processes of change to produce varied ecological landscapes and social contradictions in regions (Agyeman, 2008). Figure 1 below provides a diagrammatic description of the adapted political ecology analytical approach.

Figure 1: An Adapted Political Ecology Approach



Source: Author's construct, adapted from Batterbury (2005)

Figure 1 reiterates that land-use/cover dynamics over the years are outcomes of complex socio-economic, political and ecological processes across spatio-temporal scales, and how people conceive of and respond to processes of land-use/cover change are "socially constructed" (Batterbury, 2005, p.151; Escobar, 1999). For convenience, the social, economic and political domains may be grouped together into a "social relations of agrarian economy" or the "social" domain for short. This domain encompasses issues such as institutions, norms, and policies of access to resources that influence the use of the natural environment; livelihood

diversification; livelihood adaptation and coping; inter-household differentiation in access to and use of farm and non-farm resources; land tenure systems; cultural influences; migration; market influences; political ideologies; among others. The ecological domain on the other hand constitutes the environmental variables of rainfall, soil, and vegetation structure. What is needed is a historical understanding of these social and ecological interactions associated with land use and land cover changes so that these can inform mapping of land-use/cover changes over a long term. From this insight, it can then be possible to unpack not only the array of internal causal factors of change such as local human agency and ecological conditions, but also factors that are external to the study area. These internal and external factors are discerned as the scale of analysis is 'nested' across the local, regional, and national levels.

The need to define the scales at which these social and ecological processes (i.e. the interactions between people, their cultures, their institutions, their ecological/biotic settings) that structure/determine patterns of land-use/cover changes are explained as key driving forces of change is important. This is important partly because of a longstanding notion in the geographical sciences that explanatory factors appear to change as the scale of analysis changes (e.g. from local to national or across different historical epochs) or as different scales of analysis are used to assess the same issue (Batterbury and Bebbington, 1999). In this regard, the analysis should transcend across local, regional, and national scales as a widened conception of environmental change is adopted by; engaging critically with environmental histories of communities; and assessing the mechanisms structuring the patterns of access and use of a range of resources which influence the use of the natural environment over space and time. For this to be possible, some of the data needs for this framework, such as obtaining and analysing first-hand perspectives from land users should normally be conducted at the local level. Other data needs such as remote sensing data may readily be available only at the regional level, whereas some resource access mechanisms and policies will be analysed from the global and national levels downwards.

This interconnection of 'nested' scales of analysis does not only allow for examination of the implications on land-use/land cover of the livelihood strategies/decisions of individual households and the local community institutions in which they embedded, but also the wider regional and national mechanisms that structure the use of the natural environment. It also helps to highlight, compare and contrast the relative spatio-temporal changes in the intensity and importance of causal forces of change, and patterns of land-use and land cover changes. Again, in the environmental history enquiry for example, the social-ecological history of the study area spanning different epochs of land-use/cover changes may be analysed. This allows reconstruction of the forces driving land use and land cover change both through secondary sources and the possibility of undertaking first-hand environmental histories that cover periods within the living memories of local land users (Thompson 1997, cited in Batterbury and Bebbington 1999).

4.0 CONCLUSION

This paper has discussed the narratological structure and basis of various theoretical perspectives surroundingland-use/cover change and the desertification debate in the West African savannah. Three issues stand out in the debate – a) discourses of environmental degradation; (b) human-environment interactions and agricultural development, and (c) measurement and mapping of environmental change. There are variants of Malthusian and Boserupian arguments within these issues. Generally the dominant Malthusian perspectives have assumed a fragile, yet stable, environment where resource flows can be controlled and in which nature can be restored to equilibrium when human 'stressors' are removed. On the other hand, Boserupian alternatives also suggests agro-ecosystem resilience in the context of dynamic biophysical and socio-economic constraints (e.g. see Reynolds, et al. 2007; Mortimore et. al 2009; Resilience Alliance 2010). However, the paper points out that there is a complex array of processes structuring agrarian, socio-economic and environmental change. Thus there is a need to move the debate beyond Malthusian versus Boserupian perspectives in the debate, factoring in the full trajectory of political and socio-economic forces that in turn influence (a) agricultural creativity and capabilities; (b) land use decisions made over time, and (c) their manifestations on land cover changes. In this light, this paper's adapted political ecology approach is presented as suited to examining the totality and complexity of varied socio-economic and political activities that interact with ecological processes of change to produce varied ecological landscapes and social contradictions in regions.

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