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Research Article

Land degradation is indicative: proxies of forest land degradation in Ghana

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Abstract: How is land degradation measured? The aim of the paper is to address this research question. At the premise, the paper states that land degradation as one of the truth claims of environmental science, is not directly monitored and detectable. Observers rely on indicators to know land degradation. The issues are illuminated by theoretical reference based on the notion of critical political ecology which tries to combine realist biophysical predictions and socio-political constructions. A methodology which mixes literature review, group discussion and field work produces a set of indicators of land degradation. Indigenous farmers used the indicators to spot land degradation in the forest ecosystem of Ghana. The results reveal physical indicators of iron pan formation in farms, uphill and downhill respective lost and gain of soil fertility, roots and building foundations exposed by soil erosion and river channels that do not carry running water even in the raining season. There are biological indicators of invasive species and termite infestations as well as socioeconomic indicators of poverty implicitly taken as indicators of land degradation. The paper concludes that land degradation includes multifaceted set of processes measured by variable and error-filled indicators operating at various spatial, temporal, economic and cultural scales.

Keyword: *land degradation, indicator, concept, operationalization, Ghana*

Introduction

Diagnosis of land degradation is as necessary now as it was in the 1970s, particularly, as it was useful during the 1977 World Conference on Desertification, to correct misapprehensions (Dregne, 1986); and, to help improve knowledge of land users, planners and scientists (Warren and Agnew, 1988); and, to integrate scientific and indigenous knowledge bases through the use of iterative process (Stringer and Reed, 2007). As explanation, land degradation means reduction or loss of the biological or economic productivity of land (Millennium Ecosystem Assessment, 2005) caused by human occupancy and use (UNCCD, 2012) leading to reduction in ecosystem functions (that is, reduction in the provision of ecosystem goods and services) for the present and future beneficiaries (LADA, 2011) in which the land cannot recover unaided (Bai et al., 2008). In this context, degraded land becomes less useful to human beings (Wasson, 1987) because 'good' land has changed for the worse (Stocking and Murnaghan, 2001); and, the worsen change has happened to the intrinsic or natural quality of the land (Gyasi et al., 2006). In this regard, land refers to aggregate of soil, water, vegetation, rocks, air, climate and relief (Stocking and Murnaghan, 2001); or terrestrial ecosystem (Safriel, 2007). The special emphasis of the various explanations of land degradation is that land resources are useful to human sustainability on earth; therefore, land degradation reduces human well-being and by so doing, poses a threat to sustainable human life.

A critical question is how do we know land degradation or how is land degradation measured? At a start of the solution to the problem posed by the question, land degradation is viewed as a concept and as a measurement of concept (Viswanathan, 2005). The concept, in fact, is a sub-concept of the broader natural environmental degradation concept, and is derived from a combination of spatial, temporal, economic and cultural materials as well as systems, processes and consequences. The measurement of the concept uses a methodology which assesses land degradation indirectly through the larger natural environmental degradation by selecting and monitoring of indicators that are symptomatic of land degradation. Hence, land degradation is indicative. This methodology is fundamental to the understanding of land degradation as well as other truth claims in the realm of environmental science and assessment.

Theoretical reference

The theoretical basis of this paper is drawn from the relationship between society and land degradation – regional political ecology (Blaikie and Brookfield, 1987) and social justice for environmental explanation and development – critical political ecology (Forsyth, 2013). Land degradation and society share two-way (*reflexive*) or bi-directional relationship. In which case, land degradation impacts on society's economic development positively in a win-win scenario whereby land degradation is remedied by sustainable land management practices which at the same time increases incomes. The opposite is equally true in a downward spiral of land degradation resulting in income reduction as in the 'desperate ecocide'.

The relationship plays out through *time* whereby rapidity of exploitation of land resources produces feedbacks effect through time in terms of future options. In the industrialised society, there is industrial provision of substitutes to offset land degradation impacts in the future. In the non-industrialised society, there is out-migration, environmental refugee and tillage of degraded land. As regarding *scale* of operation, there is the large-scale for instance at the national level in the form of cost-benefit relationship. The cost relates to degradation-afflicted areas or uphill position on a slope and benefits refers to accumulation or downhill position. The small-scale relates to river basin analysis whereby soil fertility and dissolved minerals are the critical issues. Obvious problems include requirement of great volume of *data* for analysis. Often, there is scanty data on farming and pastoral practices to address land degradation analysis.

Another problem is *definition*, *measurement* and *availability*. In these regards, the authors advocate for multiple definitions and measurements due to multiple realities of the various societies. Other problems involves establishment of physical changes in soil and vegetation and relating it to decreases in land productivity (e.g. crop yield or livestock production decline). In addition, there is the problem of differentiating between physical changes in soil and vegetation and socioeconomic changes in land managers. Furthermore, quantification of the flows of resources between people and regions present other problems. The authors concede that assessment of causes and rate of land degradation as well as reduction in capacity of land is error-filled. The authors admonished that:

> "There are competing social definitions of land degradation, therefore the challenge of moving away from a single 'scientific' definition and measurement must be taken up. This means we must put the land manager 'centre stage' in the explanation, and learn from the land managers' perceptions of their problems. Thus, the land becomes a 'resource-in-use', inextricably related to people and society that uses it. Therefore, reliable methods of measurement of land degradation is crucial" (Blaikie and Brookfield, 1987:16).

Stocking (1987) added that science is a fact and measurement is right and good to believe. However, scientists have preconceptions, misconceptions and ideologies. Hence, measurement is not value-free (never neutral, never a pure service for science or policy). In measuring land degradation, the author cautioned that capricious nature of environmental variables has made land degradation dynamic. "Measurement has to have a purpose and trying to use measurement originally designed for another purpose is like wearing somebody else's suit – it may cover the body but rarely does it fit" (Stocking, 1987:51).

The critical political ecology considers the intricate ways in which science and politics are mutually related in the discussion of environmental facts and knowledge in political debates. The ultimate goal is to integrate realist biophysical predictions with social and political construction. In so doing, there is the avoidance of inadequate science and social injustice of the reconstructed science. Instead, there is pursuance of biophysically accurate and socially relevant science in which the relationship between science and society are explored. "In this sense, a 'critical' political ecology may be seen to be the politics of ecology as a scientific legitimatization of environmental policy" (Forsyth, 2013).

The concept of land degradation

The concept of land degradation takes into accounts the spatial, temporal, economic and cultural contexts of land degradation (Warren, 2002). The spatial aspect deals with the biophysical nature of the land resources involved in the degradation process; the extent of land degradation, that is, the geographic spread or the area/land coverage of the degradation; as well as the degree of degradation as including intensity of the degradation, that is, low, moderate, severe or very severe degradation (GRID, 1991). In relation to time, there is "the full length of timescales over which land degradation occurs"; while, the future time sheds lights on reversibility of land degradation in the long-term (Baartman et al., 2007:23). In the economic context, land degradation devalues land as a property, that is, reduces the economic value of land as stated in the definition by the Millennium Ecosystem Assessment (2005). In addition, land degradation occurs in specific cultures, the lived experiences of the affected people, and have to be interpreted by the people (Blaikie, 1995). In this case, the concept of land degradation is taken from the actors (victims) points of view, which are relative to the various cultural backgrounds.

Again, land degradation as a concept is related to the systems theory, processes and consequences. "A system is a set of objects together with relationships between the objects and between their attributes" (Hall and Fagen, 1956:18). The degradation of land resources as a systemic concept entails the degradation of soil, water and vegetation as sub-systems of the overall land system. And, the sub-systems are made up of various physical, chemical and biological elements; for instance, soil sub-system contains soil properties; water sub-system consists of quantity and quality of water; and, the vegetation sub-system comprises of plant species, habitats and biomass of vegetation (Vargas et al., 2009).

The concept also involves physical, chemical and biological processes which may reduce or alter the inherent capacity of land. For example, physical process – running water may create gullies resulting in badland; chemical process – plants removing soil nutrients without adequate replacement; and, biological process – destruction of habitat or food niche of some organisms resulting in ecosystem dysfunction. These processes are either natural or human-induced.

The natural and anthropogenic processes operate simultaneously making it very difficult to delimit where one starts and leave off for the other to continue (SEDAC, 2012). However, it is possible to distinguish between: ultimate process e.g. drought/flood and proximate process e.g. aridification/water-logging; slow process e.g. changes in soil fertility and fast process e.g. changes in crop yield; as well as, independent process e.g. soil fertility flux and dependent process e.g. crop yield variability (SEDAC, 2012). Inherent in the concept of land degradation is the consequence experienced by affected people. The adverse impacts of land degradation (consequences) could also serve as proxies (indicators) of land degradation. With respect to the discussion of concept of land degradation, consequences are categorized into physical, chemical, biological and social. Physical consequences include destruction of soil surface structure, loss of top and sub-soils, burial of seeds and seedlings by deposited sediments, siltation of reservoirs, dams, dugouts and river channels, river bank erosion/caving-in and destruction of coastal reef (Wall et al., 2003; Peters and Meybeck, 2000). Chemical consequences involve accumulation of pesticides in the soil and crops as well as noxious and toxic pollutant (Wall et al., 2003; Peters and Meybeck, 2000). Examples of biological consequence are water borne pathogens, destruction of marine ecosystems, spread of insects and pathogens, loss of ecosystem services, loss of biodiversity, reduction in agricultural productivity particularly yields and destruction of herbage for livestock feeding (Peters and Meybeck, 2000; UNEP, 2011; Asiamah, 2008). The social consequences include declining quality of life and migration (Asiamah, 2008).

Operationalization of land degradation

According to Viswanathan (2005), operational definition simply means measurement of the concept, in this case, the measurement of land degradation, in terms of nature, extent and degree/intensity. As stated earlier, operationalization of land degradation provides answers to the methodological question 'how is land degradation measured'? During operationalization of land degradation, indicators are measured. Indicators are "processes and phenomena which provide important information for land degradation assessment" (Mari et al., 2009:241).

A critical question to be asked is why is land degradation not measured directly? The answer lies in the fact that land degradation is derived from the broader environmental degradation concept. Therefore, it is measured through the very processes which represent natural environmental resource depletion. In the words of Wasson (1987) land degradation is not directly detectable and monitored. Another important question to consider is what processes and/or phenomena are indicative or proxies of land degradation? In attempting an answer to this question, the advice by Symeonakis and Drake (2004:575) is that "there is a clear distinction between the indicators that are useful to have and those which are practical to obtain". According to

Mari et al. (2009:241), "the emphasis in this case is instead on how to choose the appropriate indicators and to combine their values so to obtain an overall result, interpreted as the value of a property, i.e., the measurand, for the system under analysis". To Warren (2002), neither the case of biophysical indicators or socio-economic indicators is conclusive. Hence, a synthesis is necessary but requires field test and verification to address the question – has land degradation occurred (Hoffman and Todd, 2000).

Land degradation is detected through the use of combination of indicators, as involving, measurable proxies of land degradation. A visit to any landscape which is reportedly degraded will show physical, chemical and biological indicators of the degradation. Also, a critical examination of the lives of the affected people will result in the identification of some socio-economic indicators of land degradation. Where the vegetation cover of the land is sparse, physical indicators of degradation are the most observable signs; created by wind and water action as well as industrial and natural activities. Physical indicators may include continuous incision of rills and gullies, dry river beds, soil compaction or hardening as well as waterlogging and flooding (Stocking and Murnaghan, 2001; Rubio and Bochet, 1998). However, if the land contains some appreciable vegetation cover, then biological indicators of land degradation are the visible signs. The biological degradation comes out through diagnosis of the ecosystem. The diagnostic check list include reduction in native species, abundance of invasive species, alteration in habitat of fauna, extinction of species and out-migration of animals.

Other biological indicators of degradation are detected through comparison of the performance of crops between the present and past. The comparable indicators include germination, growth and development, yield and perishability of crops. Common biological indicators cited in the literature include diminishing size of maize cobs and potato, stunted growth of crops, yield gaps in addition to the presence and absence of some soil organisms (Stringer and Reed, 2007; Kessler and Stroosnijder, 2006; Dumanski, 1997). Furthermore, a collection of soil specimen from the degraded land for laboratory test produces chemical indicators such as organic carbon, macro and micro nutrients levels (Rubio and Bochet, 1998). Besides, physical, chemical and biological indicators, the dependents of degraded lands portray certain socio-economic signs symptomatic of land degradation. The literature reveals desertion of degraded land, abandonment of soil and water conservation practices, relatively large household sizes in addition to increases in unemployment and poverty (Rubio and Bochet, 1998; Hoffman and Todd, 2000;, Peprah, 2014d).

As observed by Thiam (2003), indicators of land degradation assessment could be human pressure (grazing, forest resource depletion and agricultural activities), rainfall deficit (below-normal rainfall) as well as decreasing potential primary biological production by measuring normalized difference vegetation index (NDVI). A study by Chorkor and Odemerho (1994:148-149) revealed early warning indicators of land degradation as including loss of soil litter, change of soil colour, changes in green vegetation, appearance of beetles on farms, appearance of weeds on farms, increase in crop diseases and appearance of worms on farm.

Advanced indicators involves sandy or coarse top soil texture, decreased crop yield, deceptive black earth, dominance of palm bush, waterlogging and soil crusting or hardened top soil. To Lindskog and Tengberg (1994), land users often monitor and detect land degradation with indicators such as extinction of tree species, emergence of new invasive grass and siltation of depressions and water channels. With specific reference to soil degradation indicators, Kertesz (2009) catalogs acidification, salinization, loss of organic matter, nutrient depletion, structural deterioration, loss of topsoil, soil erosion and chemical contamination; whereas, Botchie et al. (2007) record sheet and gully erosion, soil compaction, soil surface crusting and loss of soil stability, and Ghana's Environmental Protection Agency (2002) lists formation of iron pan, poor growth of plants and low crop yields. According to Vargas et al. (2009), indicators of water degradation include progressive aridity and/or adverse change in water quantity and quality; whilst, vegetation degradation refers to loss of biomass, biodiversity and soil life, specifically, loss of certain species, habitats and biomass, spread of invasive species and uncontrollable pest and disease outbreak.

A contextual criterion for indicator selection for assessment and control of land degradation is recommended by Rubio and Bochet (1998). The authors argue that global assessments are necessary; however, indicators adopted in such studies may not be relevant to some areas due to differences in socio-economic characteristics and cultures. For instance, indicators relied upon for rangeland research may not be appropriate for arable land conditions which exhibit different biophysical, socio-economic and cultural features. In the specific context of Europe, Rubio and Bochet (1998) suggested the use of five parameters, namely, soil (water erosion, wind erosion, physical, chemical and biological degradation with specific indicators for each parameter), climate, vegetation, topography and socio-economics.

Materials and Methods

Study area and methodology

The study area is the watershed of two major rivers in Ghana, Rivers Tano and Bia of the forest dissected plateau, administratively designated as Asunafo North Municipal and Asunafo South Districts. A case study approach was adopted in which the basic techniques of data collection were literature search, participatory appraisals (community meetings, interviews, group discussions and farm visits), personal observation (photography, transect walk and transect drive), questionnaire survey and pot experiment. The details of study materials, methods and area have already been discussed in (Peprah et al., 2014:490; Peprah, 2014b:221; Peprah, 2014c:477; Peprah, 2014a:714; Peprah, 2014d:484).

Selection of indicator criteria

During a field work in Ghana, four indicator criteria was use to select specific indicators for the diagnosis and monitoring of forest land degradation.

Biological Indicator Criteria

- Ecological zone
  - Forest
- Ecosystem diagnosis
  - Reduction in native species
  - Abundance of new species
  - Alterations in habitat of fauna
  - Extinction/permanent migration of fauna
  - Pest and disease
- Performance of crops
  - Germination
  - Growth and development
  - Yield
  - Perishability of produce
- Reduction in ecosystem benefits
  - Extinction of species /food/crabs
  - Drying up of stream

Physical Indicator Criteria

- Creation of physical signs on the land
  - Water action
  - Farming practices
  - Industrial activities
  - Natural processes

Chemical Indicator Criteria

- Changes in nutrient levels
  - Reduction in organic carbon/ matter
  - Reduction in macro-nutrients
  - Reduction in micro-nutrients

Socio-economic Indicator Criteria

- Alteration in victim's life style and livelihood
  - Poverty directly attributed to land degradation
  - Poverty indirectly linked to land degradation

Results

The study came up with 67 indicators drawn from a literature review, group discussions and community meetings at Asunafo, Ghana (2010-2011). The relevant literature was sourced from FAO (2004:40-42), Rubio and Bochet (1998:118), Stringer and Reed (2007:106-107), Kessler and Stroosnijder (2006:238-239), Dumanski and Pieri (2000:96-101), Stocking and Murnaghan (2001:28-80), and Asiamah (2008:225-226).

Biological indicator for detecting land degradation

- Diminishing size of farm produce
- Absence of some wildlife/elephant, buffalo
- Absence of non-timber forest products
- Presence of grass
- Crops used to grow faster than weeds but now the opposite is true
- Presence of termites
- Reduced tree cover/adverse changes in vegetation
- Failure of seed germination e.g. cocoyam
- Increased growth years (planting to maturity)
- Absence of some birds
- Stunted growth of crops
- Rotten farm produce
- Increased occasions for weeding in-between crops >3
- Presence of Diplopoda - Millipede
- Leaves of cocoa tree turning yellow
- Presence of Camponotus
- Absence of earthworms
- Death of plantain crops
- *Euphorbia heterophylla* - spurge weed
- Plantain leaves become red/yellow
- Presence of weeds
- Presence of very tiny black ants [ntetia]
- Death of *Pycnanthus angolensis*

- Presence of fungus in the farm
- Yield rate
- Presence of pest and disease

Physical indicator for detecting land degradation

- Erosion rills and gullies
- Dry river beds
- Hardened soil/compaction
- Loading camp of timber vehicles
- Waterlogging
- Soil depth
- Flooding frequency and intensities
- Presence of stones
- Presence of wet sand
- Exposed roots
- Presence of Iron pan/plinthite
- Burnt logs and soil
- Build-up of soil against barriers
- Burrow pits
- Rate of soil loss
- Crusting
- Bulk density
- Porosity

Chemical indicators for detecting land degradation

- Contamination by heavy metals
- Acid deposition
- Electrical conductivity
- Salt crust
- Nutrient pool
- Presence of nitrogenous fixing weeds

Socio-economic indicator for detecting land degradation

- Food for the farmer's family
- Quality of farmer clothing/appearance
- Loan/borrowing of money
- Welfare of school going children
- Quality of housing
- Number of cocoa bags harvested
- National Health Insurance Scheme registration
- Farm size
- Number of farm labourers
- Availability of supplementary jobs
- Abandonment of land
- Soil and water conservation practices
- Risks of forest fire
- Unsustainable agricultural practices
- Land use
- Human density
- Rate of unemployment

Figure 1 shows specific indigenous farmers' indicators of forest land degradation.

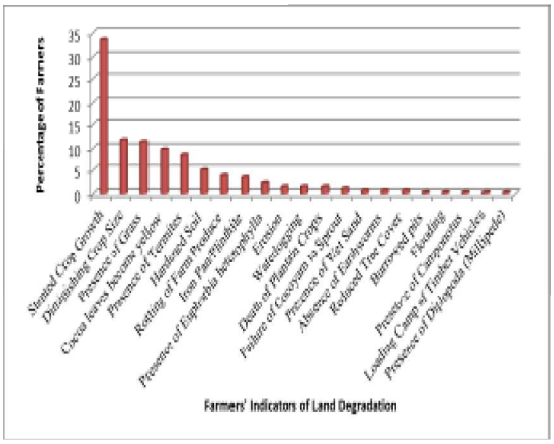

Figure 1. Indigenous farmers' indicators of land degradation.

Figure 2 displays indicators that serve dual purposes: first as indicators of poverty and secondly as indicators suggestive of land degradation.

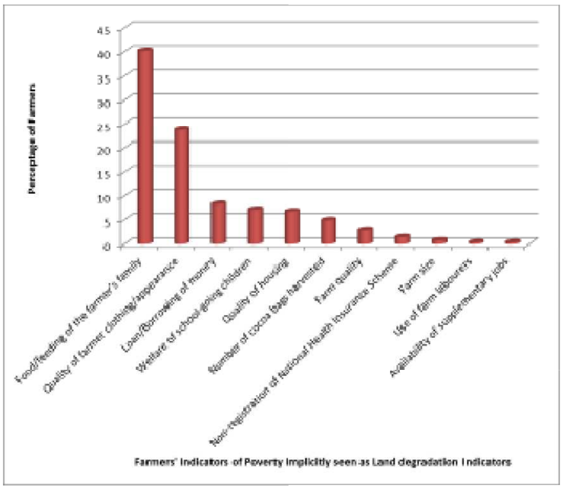

Figure 2. Farmers' indicators of poverty and land degradation

Field validation of indicators

Plate 1 shows presence of ironpans in a farm at Dantano as well as stunted growth of crops mainly plantain and cocoyam.

Plate 1. Surrogate of physical indicator of land degradation - stunted growth of plantain (*Musa ABB*) and cocoyam (*Colocassia esculenta*) in the presence of ironpans at Dantano study community 26th June, 2010.

Plate 2 shows roots and stones exposed by soil erosion.

Plate 2. Proxy of physical indicator of land degradation (soil erosion) – exposed ironpans and tree roots at Dantano 26th June, 2010.

Plate 3 shows soil erosion as exhibited by exposed building foundations at Dantano.

Plate 3. Surrogate of physical indicator of land degradation – soil erosion exposed building foundations at Dantano 26th June, 2010

Plate 4 shows a river channel in a cocoa farm that no longer carries running water even in the raining season

Plate 4. Proxy of physical indicator of land degradation – dry river bed during the raining season at Dantano 21st September, 2010

Plate 5 shows invasion of *Mimosa pudica* and the prevention of the growth of other plants at the spot.

Plate 5. Proxy of biological and chemical indicator of land degradation – invasion of *Mimosa pudica* at Asunafo 21st September, 2012.

Plate 6 displays invasion of *Centrosema pubescens* and its ability to overshadow and out-compete robust weed such as grass. Figure 3 shows remote sensing image of a section of Bonkoni Forest Reserve in 1986 while Figure 4 shows the same portion of the Bonkoni Forest Reserve in 2003. Figure 5 and Figure 6 display post classification analysis of Landsat images of 1986 and 2003 of a portion of Aboniyere Forest Reserve.

Plate 6. Proxy of biological and chemical indicator of land degradation – invasion of *Centrosema pubescens* at Asunafo 21st September 2012.

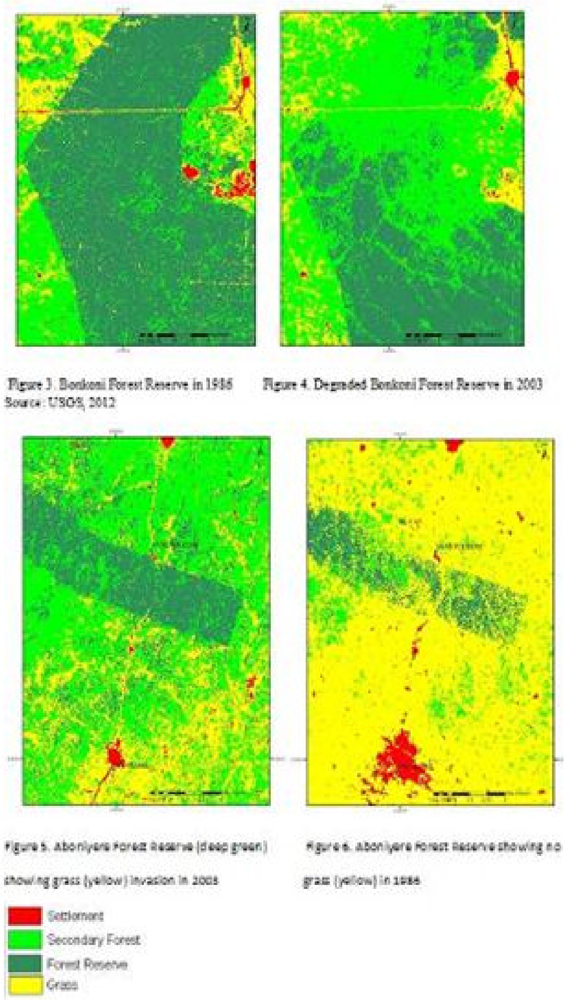

Plate 7 shows grass succession instead of forest fallow after abandoning of the farm land. Plate 8 shows occurrence of *Euphorbia heterophylla* (spurge weed) found in food crop farms. Plate 9 shows termite hill, a biological indicator used by local farmers to detect land degradation.

Plate 7. Surrogate of biological indicator of land degradation – *Panicum maximum* succession to the forest instead of forest fallow at Asunafo 21st September, 2012.

Plate 8. Proxy of biological indicator of land degradation – invasion of *Euphorbia heterophylla* (spurge weed) in a farm at Asunafo out-competing cassava and cocoyam 21st September, 2012.

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Plate 9. Surrogate of biological indicator of land degradation – anthill representing presence of termites in the soil at Kokofu 21st February, 2011 and Dantano 21st September, 2012.

Plate 10 and Plate 11 show different portions of the same farm (an example of uphill and downhill respective cost and benefit relationship resulting from soil erosion). The maize was sown on the same day. The variability in the growth and development of the maize is as result of differences in soil nutrients of the same farm.

Plate 10. Proxy indicator of fertile soil exhibited by well-developed maize crops on the lower slope of the farm (not degraded = downhill) at Goaso 20th June, 2010.

Plate 11. Proxy of biological indicator of land degradation – stunted maize crops on the hill summit of the farm (degraded = uphill) 20th June, 2010.

Plate 12 shows diminished and poor colour of mature tomato fruits in a farm at Kokofu near Goaso. Plate 13 indicates the death of crops (cocoa 'I' and plantain 'II') on the same piece of farmland at Kokofu near Goaso. The two male farmers suspected that the topsoil was underlined by plinthite or petroplinthite. A hole was dug close to the withered cocoa tree; and, ironpan was found a little below 12 cm of the topsoil. The leaves of the cocoa and the plantain changed from green to brown.

Plate 12. Farmers indicating land degradation with underdeveloped size and poor colour of mature tomato fruits at Kokofu 21st February, 2011

Plate 13. Proxy of physical and biological indicators of land degradation – withered or death of crops (cocoa 'I' and plantain 'II') as a result of ironpan underlying the topsoil 'III' at Kokofu 21st February, 2011

Plate 14 shows a piece of farmland with cracks and the growth of few weeds representing physical (cracks) and biological (weeds) indicators of land degradation.

Plate 14. Surrogate of physical and biological indicators of land degradation – soil compaction and cracks (physical) and weeds (biological) at Kokofu 21st February, 2011

Discussion

The vintage point of the paper is that land degradation is indicative, that is, it is not directly measurable hence observers use indicators. Examples of indicators used to detect and monitor forest land degradation in Ghana's Asunafo forest are discussed in line with major points of the theoretical reference.

Reflexivity

The bi-direction relationship between land degradation and society implies that land degradation consists of biophysical predictions and socio-political constructions. The biophysical aspects call in experts' knowledge of land resources derived from certain 'scientific' instrumentation. The social component dwells on land managers' accounts. While the political debates involve many stakeholders such as policy people, interest groups such as fertilizer companies, UN agencies, social commentators and the media. The indicators agreed upon by all major stakeholders are used to measure and communicate land degradation during research. However, the research is conducted by individuals or groups possessing various conceptions and ideologies (Stocking, 1987). There is also the issue of insider or outsider features of the researcher(s). The main issue for critical political ecology is how to combined 'objective reality out there' (realist biophysical predictions (Forsyth, 2013)) and inseparability of researcher and research object (social and political constructions (Forsyth, 2013)).

Time

Variability of the indicators of land degradation takes place over time. In turn, the land degradation indicators are affected by variable environmental factors (Stocking, 1987). Hence, indicators of land degradation and the influencing environmental factors are in the situation of constant flux. The assessment of land degradation indicator is also time bound, that is, snap shot of data either by field work data collection or even remote sensing of the land surface cover. However, caution needs to be taken to consider historical or archival records as well as fathom future changes and conditions. For instance, biological and physical indicator from the field work may not look the same in different seasons. Therefore, the indicators could be improved by comparing plates of the two major seasons in Ghana (dry and raining season). Of course, cracks in the land surface are not possible in the raining season and dry river channels in the dry season are also problematic due to the case of seasonal rivers that carry running water only in the raining season. Therefore, dry river channel becomes an indicator of land degradation when a river which used to carry running water throughout the year (perennial river), carries no water at all for some years now. The prospects of the dry river channel carrying some running water in the future is also important for consideration.

Scale

The scale of land degradation analysis is important for the uses of the research outcome. Research cannot be carried out for the whole region. Even though research often uses designs that are representative of respondent and study area selection, there is always a limit to extrapolating of the research results to cover other areas. Collecting data from 21 communities as happened in the present case and using the outcome to represent administrate district with a surface areas of 2.187.5 km^2 may be problematic. However, the study results serve some usefulness in supporting policy decisions which direct human use of the forest on sustainable lines. Another problem with scale is the use of district or national boundaries as biophysical land resources do not follow district or national boundaries. The problem is further compounded when one society is split by administrative boundaries.

Data

Extensive data is required for land degradation assessment. However, there is scanty data for land degradation assessment (Blaikie and Brookfield, 1987). Many land managers of the non-industrialised countries live in oral tradition society where quantitative records are not kept. Many land user experiments are mainly carried out on try and error basis. Results are orally shared among land users of that particular society. Often, very successful results travel to other societies. In the case of African state institutions, data collection and maintenance for state administration do not conform to research needs and often to international best practices. Also, political instability of the African political history has affected data collection of some state relevant institutions of environmental science. Often, historical data of the pre-colonial era is non-existence. Where colonial data are available, the present maintenance of such data makes it difficult to access. For the purposes of the present study, 30 years (1979-2009) of climate data was required. The Ghana Meteorological Agency data contained some gaps or no data for certain periods. The Ministry of Food and Agriculture could not provide staple food crop data for the 30 year period. Instead, data from 1995-2000 (10 years) was provided. Ghana Cocoa Board could only provide data from 2000-2008 while the farmers cocoa pass books contained data from 1994-2012.

Definition(s)

The theoretical reference of this paper advises the pursuit of the use of multiple realities in defining land degradation (Blaikie and Brookfield, 1987). Although, the concept of land degradation is the same, its expression or operationalization is influenced by different societies. In Ghana, savanna land degradation is very common. Forest land degradation appears to be a recent phenomenon of academic pursuit (land degradation not deforestation, the two are not synonyms). Hence differences in the biophysical resource-in-use (land resources) and savanna as well as forest societies influence the definition of land degradation. Although, land capacity or productivity may cut across the two areas, the resultant productivity is different in terms of crops and livestock. For the forest area, the definition of land degradation (conceptual and operational definition) depends on what is found on the land. Some definitions put up by farmers of land degradation include: when crops take unusually long time to mature, land that has lost its fat (fertility), land that progressively produces low crop yield and land that has been invaded by fire, weeds and pests. Obviously, the farmers' definitions are based on dominant indicators of land degradation.

Measurement

Measurement of land degradation has been discussed variously (Foster, 2006, Stocking and Murnaghan, 2001). The major concern is the biophysical, social and political mix through the use of quantitative and qualitative methods. The use of quantitative rigour allows for greater generalization of results. No matter the level of rigour, extrapolation of fine scale analysis (plot or farm level) for a large area is problematic (Stocking, 1987). Qualitative analysis may offer good explanation of land degradation but the result may not be very useful in characteristically different societies. However, the procedure used particularly as captured in the various plates could be used elsewhere in completely different societies to assess land degradation. Also, the use of photography in land degradation assessment is very useful. For instance, photography of invasive species such as *Mimosa pudica* (sensitive weed), *Centrosema pubescens* and *Mucuna sp* may on the surface indicate biological degradation. However, the realist biophysical prediction is that these plants are nitrogen fixing leguminous shrubby or creeping weeds, whose presence may be attributed on their ability to grow in nitrogen-poor soils, given their ability to fix atmospheric nitrogen for their use in the absence of soil N. Thus, they out-compete other plants which do not possess this characteristic. For such an interpretation *Mimosa pudica* (sensitive weed), *Centrosema pubescens* and *Mucuna sp* could be measured as chemical indicators.

Measurement of specific indicators is somehow problematic, for instance, the socioeconomic indicators of poverty and the implicit linkages to land degradation. The implicit relationship needs to be proven, but how? Also, what is the relationship between non-registration of NHIS and environmental science? Several factors which may not be related to land degradation may result in poverty. This however does not negate the relationship between land degradation and poverty. The problem may be a measurement problem as well as conceding to the fact that indicators are error-filled. Error is not a mistake, rather a deviation from the truth. Measuring land degradation with error-filled indicators implies that we may not know land degradation as it truly is.

Availability

Availability of land degradation is location specific as occurring at various plots where the variable and often error-filled indicators of land degradation are spotted. The situation where fertile lands alternate with degraded lands are possible. In this regard, the fertile lands do not exhibit same features or indicators as the degraded lands. Hence, land degradation is discontinuous (Gisladottir and Stocking, 2005). Furthermore, the available degraded lands do not show uniform degradation. There are several intensities or degrees of degradation such as low, moderate, severe or very severe degradation (GRID, 1991). The two key issues of availability of land degradation such as discontinuity and intensity categorisation place limit no generalisation of research results.

Conclusion

Land degradation is a multifaceted set of processes. It is not measured directly as such observers use indicators. Some indicators may be problematic or even error-filled. The indicators do not measure land degradation per se but the several aspects of land degradation operating at different spatial, temporal, economic and cultural scales. The indicators may be biological, physical, chemical and socioeconomic and are shaped by the political discourse in environmental science.

The use of indicators cut across various assessment or measurement pathways of biophysical or social and the critical political ecology pathway of making measurement right in environmental science by mixing realist biophysical predictions with social and political constructions. Irrespective of the research pathway, land degradation is indicative as it is observed by using proxies of land degradation referred to as indicators.

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