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Review

Environmental degradation and assessment: A survey of the literature

Isaac Agyemang

University for Development Studies, Ghana. E-mail: issacagyemang@yahoo.com.

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This article examines the theoretical positions and conceptual frameworks of environmental degradation and assessment as reviewed extensively in literature. It focuses on the complexities associated with global environmental problems and the numerous assessment frameworks put in place to address the sensitivity and resilience of environmental degradation worldwide. The article concludes with a case study of environmental degradation assessment in northern Ghana using the Driving force-Pressure-State-Impact-Response (DPSIR) framework, developed by the European Environmental Agency, within the legal basis of the European Union Environmental Policy Acts 95, 174, 175 and 176 of the consolidated version of the treaty on European Union.

Key words: Environmental degradation, environmental assessment, environmental sustainability, DPSIR assessment framework, Northern Ghana.

INTRODUCTION

Environmental degradation is the deterioration of the natural environment through human activities and natural disasters (United Nations, 1997). According to the International Strategy for Disaster Reduction (ISDR) (2004), environmental degradation is the reduction in value of the environment to meet its ecological and socio-economic needs. It includes issues such as land degradation, deforestation, desertification, loss of biodiversity, land, water and air pollution, climate change, sea level rise and ozone depletion. There is now a widespread recognition that human development is a holistic concept that involves not only on economic and social aspects but also through the wise use of the natural capital stock (Essam and Manzur, 1987). In view of this, the landmark report of the World Commission on Environment and Development (WCED) warned that unless mankind changes many of its present lifestyle, the world would face unprecedented environmental degradation that would affect the present and future generation (WCED, 1987). The growing realisation of the importance of environmental degradation has emerged repeatedly in many international conferences on human and his environment. The United Nations Conference on Human Environment convened in Stockholm in 1972 and the first of its kind on the issue of the environment brought into focus the realisation that the environment has limited assimilative and carrying capacity and that control measures should be instituted to safeguard the environment for quality of human life. The Earth Summit in 1992 (20 years after the Stockholm 1972 conference) had environmental degradation as one of its major themes. One of the main functions assigned to the Governing Council of the United Nations Environmental Programme is to keep under review the world environmental situation in order to ensure that emerging environmental problems receive appropriate and adequate attention by government of member states (Essam and Manzur, 1987). The World Summit in 2004 that took place in Johannesburg, South Africa, was purposed to assess the outcome of the declarations of the Earth Summit and the possible implementation of the Agenda 21 by member states. Despite these efforts to safeguard the natural environment and prevent further environmental degradation and the depletion of natural resources, there is still unprecedented global increase in environmental and related problems evident in most recent scholarly literature such as Zhao et al. (2006), Muttil and Chau (2007) and Cheng et al. (2008) (The report of WCED, 1987). In Ghana, for instance, there is great concern among various stakeholders, state government, civil societies, non-governmental organisations and other related environmental agencies

as to the current threat of environmental degradation (EPA, 2003). It is estimated that in Ghana, the annual cost of environmental degradation is $1.2 billion and representing 10% of the total Gross Domestic Product (GDP) (EPA, 2007).

Assessment of environmental degradation has therefore become a global issue for the long-term management of the earth bountiful natural resources and the sustenance of livelihood that depend on them (William, 1998). As proposed by Reed et al. (2007) and Stringer and Reed (2007), key steps should be taken in the assessment of human driven environmental problems through research into the scientific and social determinants and the adoption of an appropriate environmental assessment procedure. It is upon this assumption that this article is situated.

ENVIRONMENTAL DEGRADATION AND ASSESSMENT FRAMEWORKS

Studies on environmental degradation assessment have shown that assessing the cause-effects relationship of environmental degradation requires a multi-dimensional approach (Stafford-Smith and Reynolds, 2002; Ostrom et al., 2002). In line with this, several conceptual frameworks for environmental degradation assessment have, over the years, been formulated by various scholars and research agencies to address the issue of human-environment interaction and the corresponding physical and social impacts (Luzadis et al., 2002). This article addresses the achievements, difficulties and challenges associated with each conceptual framework and methodologies suggest an alternative framework that can be used to assess holistically global environmental problems. The assessment framework so suggested is tested in northern Ghana for its robustness.

Stress-Response framework

The United Nations Statistical Office in the mid 1970s developed a general framework of environmental statistics through a joint initiative with Canada that led to the development of the Stress-Response. The framework considers the stress on the natural environment beyond its carrying capacity and its effects on human beings. The focus of the stress-response framework is on the effects of human activities on the natural environment. The stress-response approach has had a major impact on environmental reporting around the world (Hodge, 1991). This is seen in the current approach of the Department of Education and Child Development (DECD) towards environmental policy analysis (Comolet, 1992). The exclusion of the major causes of the stress on the natural environment is, but, one of several serious limitations to current expressions of the stress-response concept, one that reduces significantly its usefulness for assessing environmental degradation holistically, especially in northern Ghana.

Pressure-State-Response framework

The Pressure-State-Response (PSR) assessment framework of Organisation for Economic Cooperation and Development (OECD) (1994) was a step further of the stress-response framework. The assessment framework takes into consideration, the “pressures” which describe the intensity and extent of human activities acting directly on the environment beyond its carrying capacity. The “state” refers to the baseline state of the environment as judged from areas relatively unaffected by direct human activities. Examples include air pollution, water contamination, land degradation, depletion of renewable and non-renewable natural resources, and expansion of human settlement (Pinter et al., 1999). The “responses” deal with the impacts of stresses on the environment and assess human actions, such as legislation, new technology, economic instrument, economic expenditures, changing consumer preferences and international conventions, undertaken to protect the environment (Gallopin, 1997). The PSR framework is the most widely accepted of the many frameworks advocated, having been adopted by the OECD for its analysis of the degradation and pollution of the natural environment. The European Environmental Agency of the European Commission also used the PSR approach in assessing various environmental problems within member states (Jesinghaus, 1998). The PSR is also used in the methodology of the World Bank’s Land Quality Indicator programmes (World Bank, 2002). In most developing countries, one cannot examine critically environmental degradation without considering the indirect causes of degradation, hence the limitation of PSR in this study.

Driving force-State-Response Framework

The Driving force-State-Response (DSR) framework was first initiated by United Nations Commission for Sustainable Development (UNCSD) (1997) to consider the shortcomings of both the stress-response and the PSR framework. The framework, instead, considered the driving forces of environmental problems that did not feature in both the stress-response and PSR frameworks. The replacement of the term “pressure” in the PSR framework by the term “driving force” was motivated by the desire to include economic, social and institutional aspects of environmental problems (UNCSD, 1997; European Environmental Agency (EEA), 1999). The World Bank adopted the DSR framework in its work on indicators of environmentally sustainable development (World Bank, 1995a), even though in 1997 it published World Development Indicators (World Bank, 1997) which used the PSR framework. A major advantage of the DSR framework is that it organizes information on sustainable

development systematically in a way that guides the user of the framework through all aspects of sustainability. In distinguishing between the social, economic and environmental aspects of sustainable development, the framework ensures that no aspects of sustainability indicators are automatically excluded. The inclusion of the economic and social aspects is particularly important for developing countries with economies in transition, for which an equal balance between the developmental and environmental aspects of sustainability is important in order to ensure future sustainable growth patterns (UNCSD, 1997). The DSR works perfectly when an environmental stress has been identified and linked to a causative set of human activities as perceived in most developing countries.

Driving force-Pressure-State-Impact-Response Framework

The European Environmental Agency (EEA), within the legal basis of the European Union Environmental Policy Acts 95, 174, 175 and 176 of the consolidated version of the Treaty on European Union and under the auspices of the European Commission, in their effort to introduce environmental issues in their developmental agenda, further improved the existing assessment frameworks into a five indicator framework (which includes PSR and DSR as special cases) dubbed as the "DPSIR assessment framework" (Jesinghaus, 1998; Pierce, 1998; EEA, 1999). Each indicator conveys its own distinctive meaning and application. "Driving forces" are social processes that cause either the increase or mitigation of pressures on the environment. Examples of such social processes are population growth, migration, poverty, level of production, human behaviours and attitudes and consumption pattern (Rigby et al. 2000). "Pressures" are represented by direct human activities on the environment, such as exploitation and excessive consumption of natural resources, beyond its carrying capacity, carbon dioxide emission into the environment, the use of fluorocarbons, use of mercury, lead, arsenic and cyanide in the purification and smelting of gold ores and the use of lead as an ingredient of gasoline (Rigby et al., 2000). The "state" relates to the spatio-temporal changes to the environment that include rising global temperatures, ozone layer depletion, environmental degradation, soil erosion, soil compaction, desertification, deforestation, global warming, acidification and eutrophication. The "impacts" are the consequences of observed changes on the environment that include fall in agricultural production, percentage of children suffering from lead induced problems, food insecurity, malnutrition, mortality due to noise-induced heart attacks and number of people starving due to climate-change induced crop losses. The "responses" are what the society perceives to be done to realise a better environment and that include introduction of energy taxes, polluter pays principles, environmental conservation, environmental movement, environmental awareness programmes, environmental capacity building and mitigation measures (Pierce, 1998). The DPSIR assessment framework considers all the important indicators of environmental degradation assessment, hence its adoption in this study.

LITERATURE ON THE STATE OF THE ENVIRONMENT WITHIN THE DPSIR FRAMEWORK

Statistical evidence of the state of the environment by the United Nations have estimated that, of the 8.7 billion hectares of arable land, pastures and forests worldwide, nearly 2 billion of them have been degraded over the past 50 years, of which 18% are of forest land, 21% are of pasture land and 37% are of arable land (Haaften et al., 2004). The third assessment of the world status of desertification undertaken by the United Nations Environment Programme (UNEP) in 1990-1991 (UNEP, 1991) estimated that about 43 million hectares of irrigated lands or 30% of the total area in the world's dry lands (145 million hectares) are affected by various processes of environmental degradation. Nearly 216 million hectares of rain-fed croplands or about 47% of their total area in the world's dry lands (457 million hectares) are affected by various processes of environmental degradation and about 3.3 million hectares of rangeland or nearly 73% of its total area in the world's dry lands (4.5 million hectares) are affected by degradation of vegetation. Each year, 6 million hectares of productive dry lands turn into worthless desert (WCED, 1987). Environmental degradation is leading to more severe natural disasters which have already cost the world over $608 billion in the last decade, killed and displaced over 8 million people, mainly poor people in most developing countries in 1998-1999 alone (Worldwatch, 2001). The Food and Agriculture Organisation/United Nations Education, Scientific and Cultural Organisation/World Meteorological Organisation (FAO/UNESCO/WMO) (1977) also gave an estimation that the annual loss of productive land due to environmental degradation amounted to US$26 billion with annual cost of reclamation measures estimated at US$388 million. Other statistical evidence have established that the highest rate of savannah forest loss in Africa has occurred in the West African sub-regions between 1.3 and 1.5% per annum (FAO, 1997; World Resource Institute (WRI), 1994). Theories concerning the agents of these global vegetative losses are placed within the natural and human context. Berry and Kim (1988) attributed the loss to global socio-economic transformation, cultural, political and technological changes. The Tragedy of the Commons, that involves a conflict over finite natural resources between individual interests and the common good (Hardin, 1968) has also been used to illustrate the intense influence of human actions on the recent observed global environmental

changes (Haaften et al., 2004).

Driving forces of environmental degradation within the DPSIR framework

Driving forces of environmental degradation have been proposed to include the poverty-environmental degradation nexus (Durraippah, 1996), the population growth-environmental degradation nexus (Ehrlich and Ehrlich, 1990), the migration-environmental degradation nexus (Bilsborrow and Delargy, 1991), the urbanisation-environmental degradation nexus (Nsiah-Gyabaah, 2004), the culture-environmental degradation nexus (White, 1976; Tuan, 1986), the common property institutions-environmental degradation nexus (McCay and Jentoft, 1998), and the economic policies-degradation nexus (O'Connor, 1988). However, the IPAT formulation (Impact, Population, Affluence, Technology) was an initial attempt to acknowledge the multiple-complex interrelationships of driving forces and their effect on the environment. The IPAT formulation explained that the causes of environmental degradation stemmed from multiplicative rather than individual additive forces and that an increase in one driver is often mitigated by either the changes in the direction or the scope of other observed drivers to bring about significant changes on the environment (Dietz and Rosa, 1994). Various researchers have tried to differentiate driving forces into biophysical forces of environmental degradation and socio-economic forces of environmental degradation (Barbier, 2000; Briassoulis, 2000; Young, 2002) The bio-physical drivers include complex interplay of various characteristics and processes of the natural environment such as weather and climate variations, landform, topography, geomorphic processes, volcanic eruptions, plant succession, soil types and processes, drainage patterns and the availability of natural resources. The socio-economic drivers, on the other hand, comprise characteristics such as demographic, social, economic, political and institutional factors and processes of population change, industrial structure and change, technology and technological change, the family, the market, public sector bodies, economic policies, human attitudes and behavioural values, community organization and norms and property regimes all acting in a complex structure to affect the quality of the environment. It seems plausible to argue that complex interrelationships of human driving forces such as poverty, population growth, migration and urbanisation tend to increase pressure on scarce natural resources in most developing countries, leading to environmental degradation. However, there exists a large and growing literature which counters the above argument as other factors such as land tenure system, community level institutions, macro-economic policies and institutional structures are also found to be significant contributors to environmental degradation. This article examines the driving forces of environmental degradation perceived in northern Ghana.

Pressures on the environment within the DPSIR framework

Pressures on the environment, according to Geist and Lambin (2002) are human activities or actions, usually at the spatial level, that originate from intended land-use and directly impact negatively on the natural environment. Just like the driving forces reviewed above, the pressures of environmental degradation are usually multivariate but for the purpose of this article, four selected pressures perceived to have contributed to environmental degradation in northern Ghana are examined.

Impacts on the environment within the DPSIR framework

Wathern (1988) described environmental impacts as the change in environmental parameters, over a specific period of time and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initialised. Touching on its significance, Kate et al. (1990) and Briassoulis (2000) noted that it is usually the negative impacts that stimulate scientific researchers and policy makers to take keen interest in environmental degradation. Environmental impacts, according to Briassoulis (2000), are broadly categorized into physical and social impacts with the argument that the physical impacts are more pronounced than the social impacts. She also observed that the physical and social impacts are closely interrelated with each other with the former causing the latter which then feeds back to the former again, potentially causing successive rounds of spatio-temporal land-cover changes. Fons-Esteve (2003) also argued on the same line and observed that the physical and social impacts of environmental degradation are closely related to each other. The direct impacts, according to them, are usually manifested in changes in physical environment, including vegetative loss, and the indirect impact is the effect of physical impacts on the human population. Another hypothesis to describe environmental impacts was that of the working group on erosion of the European Union (2003). They made a distinction of "on-site" and "off-site" impacts of environmental degradation. Whilst the on-site impacts are associated with land-cover changes on the environment, off-site impacts are those transmitted through other media of the environment such as sedimentation in downstream water resulting from soil erosion. Impacts of environmental degradation are also distinguished according to spatial levels through which they are manifested. Global environmental impacts have been referred to as "systemic" forms of environmental change as the impact at one point on the global scale can affect

other areas of the global ecological system (Turner and Meyer, 1990). Ozone depletion, global climate change, desertification and sea-level rise are examples of systemic forms of observed global environmental problems (Kates et al., 1990). Sub-global scale impacts, broadly referred to as “regional level” impacts are specific to a particular locality where impacts are not transported to other areas. Eutrophication of water bodies, acidification of aquatic and terrestrial ecosystems, floods, soil nitrate pollution, land degradation, groundwater pollution are environmental alterations that follow either directly or indirectly from land-cover-changes of a specific area (Briassoulis, 1994).

One would therefore infer that environmental impacts usually manifest themselves in both the physical and social impacts that cumulatively affect the well being and development of those victims of degradation. This article is based on this argument.

The DPSIR assessment framework, as reviewed above, allows for the integration of various factors of environmental related problems. It failed in its formulation to provide an appropriate methodological framework to measure the inclusive five indicators. Subsequently, various assessment methodologies that seek to take into consideration the DPSIR assessment framework and justify the adoption of methodological triangulation as an appropriate method for assessing environmental degradation are reviewed.

Classic approach

This assumes technical, scientific and deductive solutions to environmental degradation and emphasise on quantitative techniques and expert opinions (Stringer and Reed, 2007). Under this approach, greater emphasis has been placed on quantitative, modelled scientific indicators that are developed within the confinement of constricted scientific space. However, the sole adoption of the classic approach has its own shortcomings as it cannot provide accurate solutions to complex environmental problems using the DPSIR assessment framework.

Populist approach

This approach adopts stakeholder participation and local ecological knowledge in environmental assessment (1991). The approach is based on Principle 10 of the Rio Declaration that stipulates grass-root participation. Ironically, as stated in the scientific article by Reed et al. (2007), the populist approach cannot be used to measure the five indicators of the DPSIR framework, hence its limitations.

Methodological triangulation

This resultant hybrid knowledge stemmed from the shortcomings of both the populist and the classic approaches. It allows scientific and local ecological knowledge to interact to produce useful ideas on matters relating to the environment. Borrowing from the classic reductionist approach, this approach takes the idea that natural resources need to be assessed qualitatively and quantitatively thus it is able to cater for the five indicators of the DPSIR assessment framework.

ENVIRONMENTAL DEGRADATION AND ASSESSMENT IN NORTHERN GHANA

This study made use of the methodological triangulation to facilitate the accommodation and adjustments of two discrete but complementary quantitative and qualitative techniques to measure the five indicators of the DPSIR framework. The first phase made use of geographical information system and remote sensing to study the nature and extent of environmental degradation in the study area. This took care of the state indicator of the DPSIR framework. The second phase is the participatory approach that seeks to examine, in more qualitative forms, the societal attributes of the driving forces, pressures, impacts and responses of the state of the environment as computed in the first phase. Figure 1 shows the graphical presentation of the proposed assessment methodology tested for its robustness in northern Ghana.

Figure 2 demonstrates how human actions interact in a complex way to bring about environmental degradation at Bolgatanga Municipality of northern Ghana. Using the DPSIR (Driving force-Pressure-State-Impact-Response) framework of the European Environmental Agency as an assessment framework, conventional GIS techniques were integrated with participatory research tools to assess the state of the environment, evaluate the driving forces, assess the impact, evaluate community coping strategies and their responses towards a better environment. While most of the study area was a healthy environment in 1990, by 2004 about 600 km² of the land area was degraded to the point where it could not be used for any commercial purposes. It was observed that the problem of environmental degradation in the area is aggravated by socio-economic and cultural processes including economic policy transformation, demographic factors, changing tenure systems, poverty and attitudinal changes that motivate individuals to engage in activities that exert many pressures on the environment. Impacts were evaluated to include threats of desertification, food shortages, cross-cultural tensions, health risk and reduction in living standards. Driving force reduction, effective environmental management practices, environmental awareness programmes and compensation to affected communities were responses participants perceived would help realise a better future environment.

CONCLUSION

This article has surveyed the literature on global

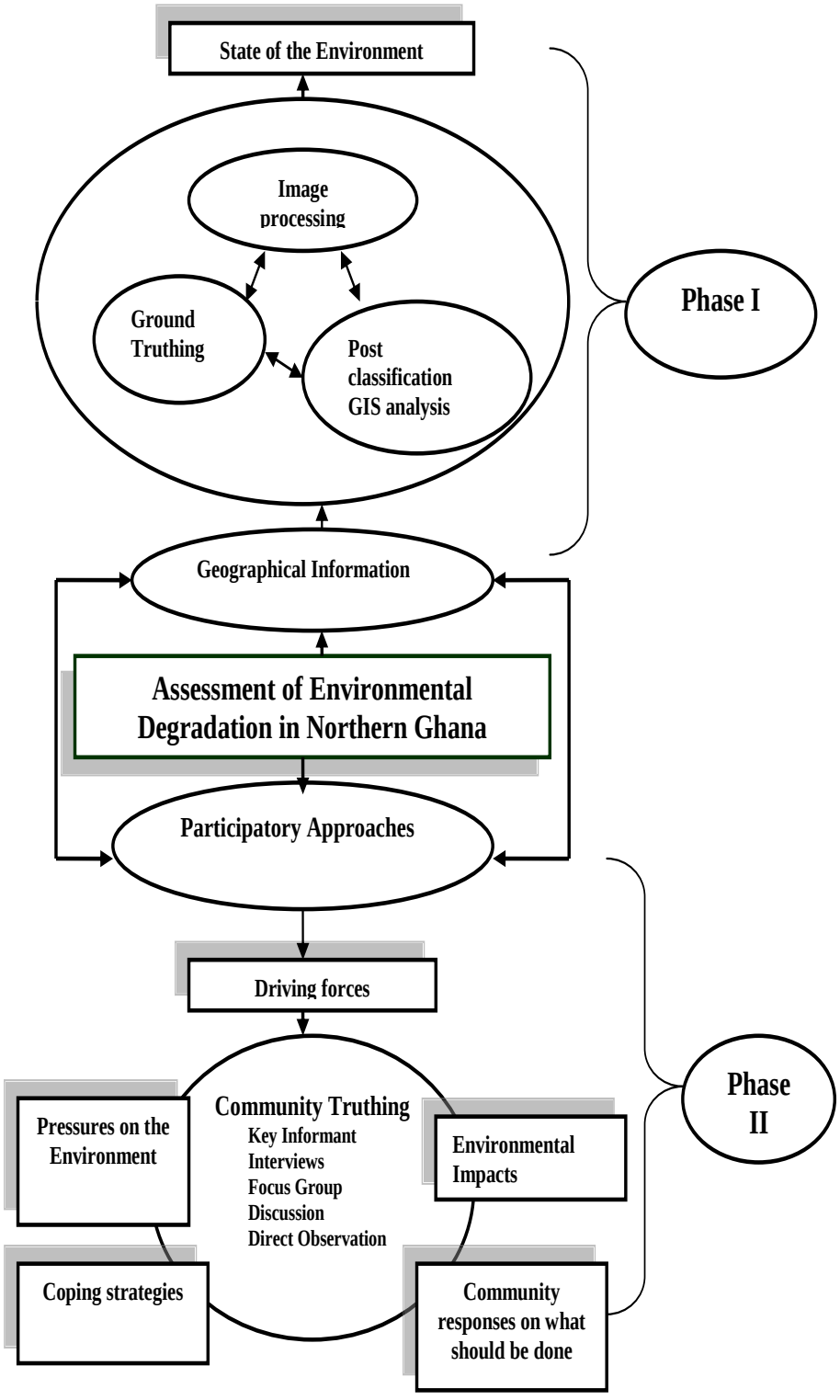

Figure 1. Assessment methodology.

environmental problems and assessment frameworks as referenced to northern Ghana. The literature included in this survey has been grouped under two main issues: Environmental degradation, conceptual issues and environmental degradation assessment frameworks. While a good deal is known about the global state of the

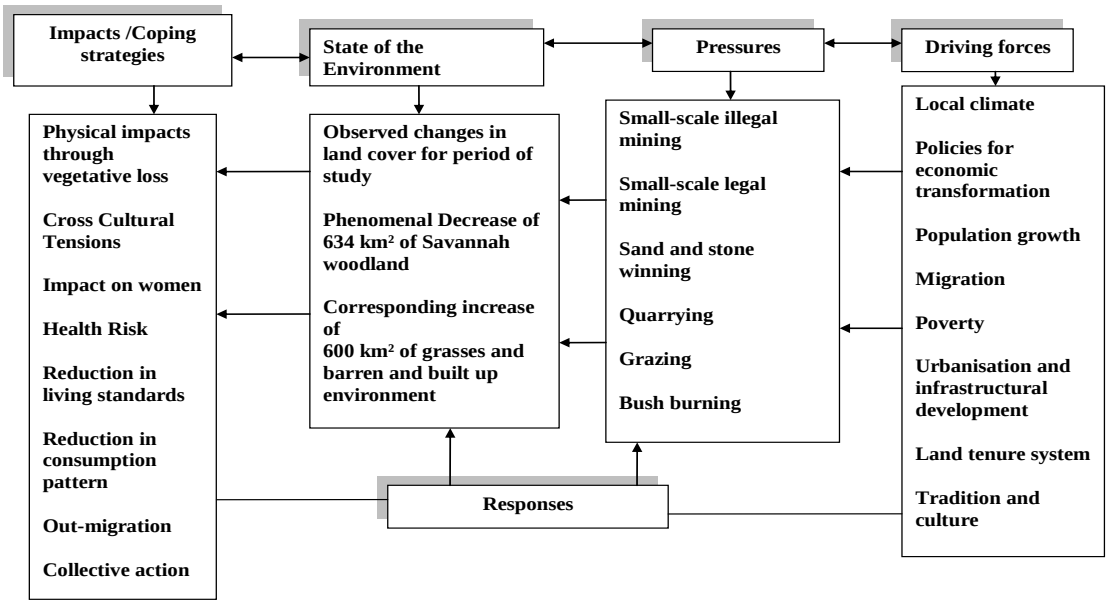

Figure 2. Results of the Methodological Assessment Framework at Bolgatanga Municipality of northern Ghana.

environment and assessment framework, there remains an open issue, particularly the generic methodological frameworks suitable enough to assess environmental degradation. A good example of such methodology is provided in this article where participatory GIS methodological triangulation is used to assess environmental problems at Bolgatanga Municipality of northern Ghana within the DPSIR assessment framework.

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