"Critical Ecosystems" as a concept in political ecology – developing a comprehensive analytical framework

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Abstract

Political ecology is supposed to be a field of two parts of equal importance – "politics" and "ecology." However, critics have pointed to the fact that it dwells on the politics, while rendering ecology secondary in its focus. Political ecologists have hardly used the structure that the concept of ecosystem services brought to the field of ecology, and this lends credence to this critique. In this article, I introduce the concept of "critical ecosystems" that reinforces understanding of the science of "ecology", as an important dimension of political ecology. I use components of the framework of ecosystem services in context of unequal power relations. Some local people who have symbiotic relationships with their environment owe their existence – both their livelihoods and culture – to specific natural resources whose decline has proximate and tangible consequences for them. However, they often lose these "critical ecosystems" in times of natural resource exploitation due to their relative powerlessness. I argue that it is important that political ecologists utilize the framework of ecosystem services in our inquiries, to prioritize those ecosystems that are intricately connected to the survival of the local population. Based on this, I introduce the "critical ecosystems" model, and how it can be modified to fit specific cases and can reconcile the sociological and political dimensions of political ecology, with biophysical understanding of ecological processes. This holistic inquiry, I argue, will make political ecology worthy of its name.

Keywords: Political ecology; ecosystem services; unequal power relations; Millennium Ecosystems Assessment; Ghana

Résumé

L'écologie politique est censée être un domaine de deux parties d'égale importance – «politique» et «écologie». Cependant, les critiques ont souligné le fait qu'il s'attarde sur la politique, tout en rendant l'écologie secondaire dans son objectif. Les écologistes politiques n'ont guère utilisé la structure que le concept de services écosystémiques a apportée au domaine de l'écologie, ce qui donne du crédit à cette critique. Dans cet article, j'introduis le concept d '«écosystèmes critiques» qui renforce la compréhension de la science de «l'écologie», en tant que dimension importante de l'écologie politique. J'utilise des éléments du cadre des services écosystémiques dans un contexte de relations de pouvoir inégales. Certaines populations locales qui ont des relations symbiotiques avec leur environnement doivent leur existence – à la fois leurs moyens de subsistance et leur culture – à des ressources naturelles spécifiques dont le déclin a des conséquences immédiates et tangibles pour elles. Cependant, ils perdent souvent ces «écosystèmes critiques» en période d'exploitation des ressources naturelles en raison de leur relative impuissance. Je soutiens qu'il est important que les écologistes politiques utilisent le cadre des services écosystémiques dans nos enquêtes, pour prioriser les écosystèmes qui sont étroitement liés à la survie de la population locale. Sur cette base, j'introduis le modèle des «écosystèmes critiques», et comment il peut être modifié pour s'adapter à des cas spécifiques et peut concilier les dimensions sociologiques et politiques de l'écologie politique, avec une compréhension biophysique des processus écologiques. Cette enquête holistique, selon moi, rendra l'écologie politique digne de son nom.

Mots-clés: écologie politique; service d'écosystème; relations de pouvoir inégales; Millennium Ecosystems Assessment; Ghana

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Resumen

Supuestamente, la ecología política es un campo de dos partes de igual importancia -"lo político" y "la ecología". Sin embargo, los críticos han apuntado a que se da preferencia a lo político, mientras que el enfoque ecológico, queda relegado en segundo plano. Quienes estudian ecología política, apenas han usado la estructura que el concepto de servicios de los ecosistemas ha traído al campo de la ecología, hecho que abona a la credibilidad de esta crítica. En este artículo introduzco el concepto de "ecosistemas críticos", el cual refuerza la comprensión de la ciencia de la "ecología" como una importante dimensión de la ecología política. Utilizo los componentes del marco del concepto de servicios de ecosistemas en el contexto de relaciones de poder desiguales. Algunos habitantes locales que tienen relaciones simbióticas con su medio ambiente, deben su existencia -tanto su subsistencia, como cultura- a recursos naturales específicos cuyo declive tiene consecuencias cercanas y tangibles para ellos. Sin embargo, ellos suelen perder estos "ecosistemas críticos" durante los periodos de explotación de recursos naturales debido a su indefensión. Sostengo que es importante que quienes estudian ecología política utilicen el marco de los servicios de ecosistemas para indagar, para priorizar estos ecosistemas que están íntimamente conectados con la supervivencia de las poblaciones locales. Con esta base introduzco el modelo de "ecosistemas críticos", y planteo cómo este puede ser modificado para ajustarse a casos específicos y así reconciliarse con las dimensiones sociológicas y políticas de la ecología política, con una interpretación biofísica de los procesos ecológicos. Esta investigación holística, sostengo, puede hacer a la ecología política merecedora de su nombre.

Palabras clave: ecología política, servicios de los ecosistemas, relaciones desiguales de poder, Evaluación de Ecosistemas del Milenio, Ghana

1. Introduction

Emerging from the Marxist tradition, political ecology as a field has grown into a formidable one. Over nearly five decades, it has become a dominant framework for understanding the geography of nature-society/human-environmental interactions (Khan 2013; Walker 2005; Wolf 1972). Primarily, political ecology politicizes environmental issues and takes into consideration how the global and local power structure, and the unequal exchanges therein, result in differential outcomes for different actors in case of environmental change. One of its greatest appeals is also the source of its most common criticism – its eclecticism and fluidity (Robbins 2011). Lacking a grounded theory (Khan 2013), political ecology has been used as a framework of analysis for a myriad of issues. However, critics argue that it focuses on the "political" more than the "ecological" (Vayda and Walters 1999) or it has generally become a field of politics without ecology (Bassett and Zimmerer 2004).

Walker (2005) said this critique was premature, and adduced evidence to support his argument that the "ecology" in political ecology is alive and well. He inquired, though, whether political ecology will "retain a claim to its identity as political 'ecology' rather than a primarily social science/humanities study of environmental politics." (p. 73) The evidence in the current literature point to the latter (Bebbington 2009; Christopher Brown and Purcell 2005; Muradian *et al.* 2012). This is because even though it has been almost two decades since the Millennium Ecosystems Assessment (MA 2005), political ecologists have hardly utilized the structure that it brought to the field of ecology and to the understanding of environmental services through the categorization of ecosystems.

The Millennium Ecosystems Assessment has not been without its own criticisms. **First**, along with its offshoot components such as payments for ecosystem services, the ecosystem services framework has been rightly criticized for its neoliberal worldview (McAfee and Shapiro 2010; Dempsey and Robertson 2012; Gómez-Baggethun and Ruiz-Pérez 2011; Kosoy and Corbera 2010). **Secondly**, the MA focused on aggregate analyses of human wellbeing, and was insensitive to differential impacts on different subgroups in a society even though it acknowledged that there are steep inequities between different social groups. To mitigate this shortcoming, Daw *et al.* (2011) have suggested several baselines from which disaggregation can be carried out, one of which is the difference between social groups based on how immediate and tangible the utility of certain resources is to their survival. It is important to note that even across a very small landscape, there can be many ecosystem services and underlying processes with multiple feedback loops that complement or antagonize one another (Fazey *et al.* 2016). In fact, Agren *et al*. have supported this argument by stating that "ecology is a subject with many facets. From any particular viewpoint, we cannot see the whole system" (1998: 7). They continued: "by picking a fixed position from which to study the system, we lose information but hopefully

what we see becomes more intelligible." This means that perspective is crucial in the field of ecology, and when assessing the impact of a certain activity or initiative on ecosystem services, there is a need to precede that inquiry with – *which* or *whose* ecosystems?

The disaggregation that Daw *et al.* (2011) suggest to mitigate the shortcomings of the MA approach lends insight into how we answer "which or whose ecosystems?" by drawing on an understanding of power relations between winners and losers from environmental outcomes. Ecologists are finding it useful to adopt some of the core tenets of political ecology in addressing ecosystem services, albeit not explicitly alluding to them. In light of this, the question is, *why are political ecologists not using the ecosystem services framework to reinforce the 'ecology' side of their research*? The simple answer, it would seem, despite Walker's argument otherwise (2005), is that as a field that emerged largely from cultural and human ecology and the social sciences, the science of ecology remains tangential. This is a great disservice because utilizing ecosystem services concepts in political ecology can help improve our inquiry as political ecologists, especially when examining the intricate connections between environmental degradation, loss of livelihoods, and social degradation under natural resource exploitation activities: pursuing holistic research that is both biophysically and socio-politically robust. With this said, as the field of political ecology can be quite eclectic, I centralize my arguments around the socio-ecological consequences of natural resource exploitation. This is because there is a close association between exploitation of natural resources and ecosystems degradation in many regions, especially in resource-rich communities in the developing world (Adger 2000).

Local people in extractive regions disproportionately bear the harmful effects on productive agricultural land for farming, forest resources, or productive marine environments (Arhem 2005; Daw *et al.* 2011; Hartel *et al.* 2014; Jike 2004; Liu *et al.* 2007; MA 2005; McMichael 2010). Ecosystem degradation produces "winners" and "losers", in which local people are frequently the losers. In restricting our scope of inquiry into priority ecosystem services, we will also be simplifying our mode of inquiry into the complex biophysical pathways through which a stressor impacts crucial ecosystem services. Even though prominent political ecology scholars have emphasized *critical* ecosystem services, the concept is rarely found in the political ecology literature (Blaikie 1985; Forsyth 2003).

Any loss of ecosystem services can be through direct and indirect biophysical processes, and Blaikie (1985) and Forsyth (2003), have argued that there is the need to understand the biophysical processes through which such impacts occur. This is because biophysical processes and signatures, however latent and imperceptible, often precede the manifestation of devastating social outcomes (Kates and Clark 1996). For political ecology to be truly ecological, it is crucial that it captures both relevant ecological and human variables, and the complex interaction that exist between them through the lens of prevailing power dynamics of human components. Building such a comprehensive conceptual framework requires an interdisciplinary understanding that interfaces political economy, human ecology, and biophysical sciences, among others. Through such expansive knowledge, the underlying mechanisms responsible for the direct antagonism between exploitation of natural resources and local livelihoods become luminescent from varying perspectives (Crane 2010; Goldman and Schurman 2000; Jike 2004; Kick *et al.* 2011; Liu *et al.* 2007; McMichael 2010).

My aim in this article is to introduce the concept of "critical ecosystems" and introduce a framework of inquiry that combines knowledge of categories of ecosystem services and power dynamics inherent in society. To achieve this, I review and draw from the main themes from the aforementioned disciplines and fields of knowledge, and demonstrate the flexibility of the "critical ecosystems" model by presenting a modified version, using the relatively nascent oil industry in Ghana as a case study. Secondly, I emphasize the centrality of understanding biophysical mechanisms through which extraction industries impact "critical ecosystems." The article is organized as follows. The next section discusses some of the different perspectives from which adverse social and environmental outcomes of natural resource exploitation in developing countries have been analyzed. Following that, I provide a background to political ecology and explain the concept of unequal power relations, using world-systems theory. In the subsequent section, I introduce the "critical ecosystems" model, which illustrates how the knowledge of trade-offs and differential power relations can incorporate ecosystem services into political ecological inquiry. Following that, I provide a brief background to the Ghanaian oil industry and the inherent power dynamics between different actors as a case study, and identifying the "critical ecosystems" that demand attention of political ecologists. Next, I adapt the "critical ecosystems" model to the

Ghanaian oil and gas case study, showing and explaining comprehensive conceptual and methodological frameworks that incorporate themes that are emphasized throughout the article to capture both the human and ecological variables, before concluding.

2. Resource exploitation and adverse socio-environmental outcomes in the Global South – same problem, different perspectives

Researchers have documented the trail of degradation left as a result of resource exploitation, in many countries. This includes land degradation, air and water pollution, and loss of biodiversity. In many countries, competition between extraction industries and local people for resources and space has devolved into full-blown conflicts (Adusah-Karikari 2015; Chambers 1987; Cuba *et al.* 2014; Odukoya 2006; Plänitz 2014; Plänitz and Kuzu 2015). The tendency for the discovery of natural resources to result in negative repercussions in various countries in Africa is an issue that has been explored through many frameworks, including but not limited to resource curse theory, and various development and dependency theories (Akiwumi 2006; Manu 2011; Omoweh 2005; Rosser 2006).

The arguments of resource curse proponents conceptualize a chain of causality between resource abundance and poor development outcomes in developing countries (Adusah-Karikari 2015; Obi 2010; Plänitz and Kuzu 2015; Ross 1999). Proponents of the resource curse theory argue that countries endowed with natural resources are more likely to experience poor economic, political and social outcomes. Some of these outcomes are abject poverty signifying poor economic performance; high levels of illiteracy; low levels of democracy; and in the worst cases, civil war with countries such as Libya, Algeria, Angola, Egypt, Equatorial Guinea, and Democratic Republic of Congo among others presented as evidence (Humphreys, Sachs and Stiglitz 2007; Karl 2005; Ross 2001; Rosser 2006). Some of the factors leading to these outcomes, they argue, are privileging natural resource extraction at the expense of other sectors, and the potential for corruption offered by lucrative resources (Adusah-Karikari 2015; Karl 2005; Karl 1997; Obi 2010; Malaquias 2007; Manu 2011; Shepherd 2013).

Some critics of resource curse theory, however, argue that while it may be valid on the surface level, it is reductionist and ahistorical, focusing mainly on economic factors and internal policies responsible for negative development outcomes. It largely ignores very important historical and global dynamics of resource exploitation and trade (Ayelazuno 2014). As Adusah-Karikari (2015) asserts, the circumstances and conditions that engender the resource curse are deeper and more complexly interrelated, needing to be carefully unraveled and understood. The critics argue for a more sophisticated understanding of underlying causes and dynamics that may lead to more accurate explanation for the reasons accounting for the stress under which resource-rich countries live, especially through the lens of historical and global dynamics (Ayelazuno 2014; Obi 2013; Omoweh 2005).

Dependency and world-systems theorists, as well as political ecologists explore and probe the underpinnings of the resource curse paradox through the understanding of political economy (Murshed and Altaf 2008; Ross 1999; Rosser 2006). Many of these researchers point out how the paramount role of unequal power relations inherent in the global economy lays out the conditions that characterize the resource curse. They also situate dynamics at the national level within the global context, arguing that the development of countries in the global North is directly linked to underdevelopment of the global South and overexploitation of its resources (Ahiakpor 1985; Babones 2015; Bornschier and Chase-Dunn 1985; Burns *et al.* 2003; Kick *et al.* 2011; McMichael 2010; Wallerstein 2003; Wallerstein 1979; Wallerstein 1974).

3. Political ecology – exploring its meaning and foundation

The underlying rationale behind political ecology is that unequal power relations play a decisive role in struggles over the environment, emphasizing how the poor are increasingly marginalized and vulnerable in such conflicts (Bryant 1998). Blaikie (1985) observed that social issues are the major underlying constraint to environmental conservation and protection, rather than physical and technical concerns. There is a growing realization that issues of environmental conservation and degradation are as much about social processes as physical ones. In many cases, social processes are dictated by the political structures in a given locality and the

distribution of power, making politics an indispensable element of environmental discourse. In this light, the field of political ecology has emerged and grown over the past decades to focus on these underlying and widespread political explanations for the change in, and deterioration of, the environment (Forsyth 2003). In this sense, according to Bryant (1992), political ecology inquires into political forces and their consequences for changes in the environment and its outcomes.

The term political ecology was used briefly by Wolf (1972) to explore environmental issues through the lens of neo-Marxist understanding of dependency and world-systems theory. As readers of this *Journal* will know, "political ecology" combines two popular concepts; a broadly defined political economy and concerns in ecology (Blaikie and Brookfield 1987; Escobar 1996). For this reason, there is a consensus among scholars of political ecology that it is not an entirely new approach but rather, a new dimension of ecological study predicated on the extension of ideas and assumptions from political economy (Bryant and Bailey 1997). According to Forsyth (2003), a combination of the two concepts captures the constantly shifting discussion about society and land-based resources, as well as how these dynamics play out among classes and groups within society.

Robbins (2012) minces no words in emphasizing that it is erroneous to think of political ecology as a framework, method, theory, or even a single perspective. He noted that while some definitions stress political economy, others point to more formal political institutions; some stress environmental change, while others emphasize narratives or stories about that change. Khan (2013) explained that even though political ecology is a broad concept utilized by different scholars in different ways without a concrete or universally accepted theoretical underpinning, it generally stresses how power relations and differentials around the globe structure relationships between humans, society, and nature. For this reason, the analytical approach of most political ecologists has been the examination of political economy, and its linkage to issues of environmental change and loss of ecosystem services in terms of exploitation based on geographical location, gender, class, and subaltern status (Khan 2013). Simply put, political ecology is a kind of argument or narrative that examines winners and losers in environmental outcomes around the framework of unequal power relations. Rather than finding a single body of theory, Robbins (2012) stresses the number of independent trains of thought colliding in the field. This supports the assertion of Bryant (1999) that political ecology is a field of "disciplinary transgressions", where researchers trace their personal and professional trajectories through disciplinary training and then, moving well beyond disciplines.

One of the areas that has had significant focus in political ecology is the role of multinational corporations (MNCs) in environmental degradation in developing countries. MNCs have been the principal driving force behind the global capitalist project that has wreaked environmental havoc in many nations, and in many cases they have found formidable partners in the state and local elites. According to Bryant and Bailey (1997), the debt crisis that engulfed the third world in the 1980s opened them to even worse forms of environmental degradation. Under the auspices of the World Bank and the IMF, many third world countries were compelled to compromise on environmental protection in order to encourage largely *laissez-faire* exploitation of natural resources, through Structural Adjustment Programs (SAPs). With a compromised rent-seeking state authority, which in most cases was looking to protect its interests, powerful actors successfully shaped "public transcripts" in order to portray activities as socially acceptable, fueling an agenda of market triumphalism (Peet and Watts 1993). The plight of grassroots and weak actors that are confined in the "hidden transcripts", is what often forms the basis of resistance, and it is only with such resistance that the legitimacy of public transcripts are questioned (Scott 1990).

A quarter century ago *The Ecologist* magazine highlighted that many MNCs often take advantage of their position as non-place-based actors to pursue their economic interests (1993). Since they are disembedded from any particular culture or environment, the only loyalty they have is to their stakeholders and therefore, they work to ensure maximum returns, even if it means desecrating the environments and livelihoods of many place-based actors, especially those at the grassroots. State authorities play an ambiguous role: often complicit in the activities of MNCs, but ill-equipped to enforce environmental regulations even if they wished to do so. They can be coerced by powerful MNCs, to give the "green light" for destructive activities, even when alternative clean technologies and modes of operation exist (Adeola 2001; Akiwumi 2006; Ayelazuno 2011; Bush 2009; Bryant and Bailey 1997; Ecologist 1993; Harvey 1998; Hilson and Garthforth 2012; Manu 2011;

Yaro 2013). The instances of environmental degradation perpetrated by extractive MNCs around the world are abundant. In countries like Nigeria, Ecuador, Malaysia, Ghana, Brazil and Papua New Guinea, "development" has been characterized by disruption of indigenous livelihoods and cultural genocide. The mining and agribusiness sectors alone have caused massive environmental degradation, cultural disintegration, and social disruption (Bryant and Bailey 1997; Bebbington 2012; Colchester 1993; Hecht and Cockburn 1989; Hilson and Garforth 2012). It is the reaction of local people to these outcomes that spark the conflicts that are all too common in resource-rich communities (Blaikie and Brookfield 1987; Bryant and Bailey 1997; Chambers 1987; Hornborg 2006; Kick *et al.* 2011; Yaro 2013).

Explaining unequal power relations, using World-Systems Theory

Dependency theory is a set of ideas originally developed in the 1960s to explain the dynamics of global development. Dependency theorists emphasize the need to understand the complexity of imperialism in shaping post-colonial states (Amin 1997; Chase-Dunn 1975). In understanding this complexity, world-systems theory emerged to elaborate on capitalist exploitation of underdeveloped countries by highly developed ones, although the models used are more nuanced than this binary suggests (Adeola 2001; Amin 1997; Chase-Dunn 1975).

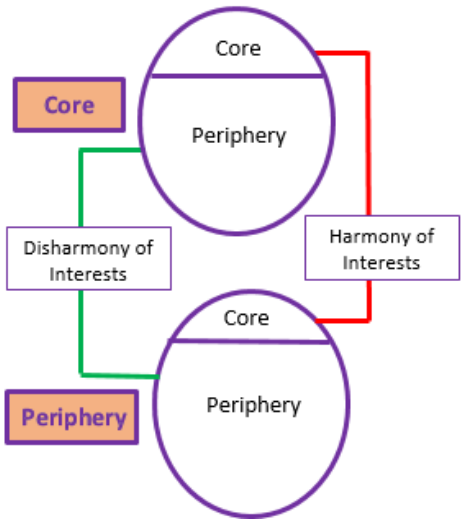
Fundamentally, adherents of world-systems theory explain how the current state of the modern world emerged (Kohl 1987). World-systems analysis as devised by Immanuel Wallerstein in the 1970s is deeply rooted in the grand theory of historical materialism of Marx (Adeola 2001; Akiwumi 2006; Bornschier and Chase-Dunn 1985; Chase-Dunn 1998; Kick et al 2011; Wallerstein 1979; Wallerstein 1974). Primarily, Wallerstein was concerned with understanding the global patterns of power and domination, and how uneven distribution of resources and power is shaped by the larger capitalist economic system (Adeola 2001; Akiwumi 2006; Wallerstein 1974; Yaro 2013). The framework is deployed to interpret the dynamics inherent in the market-driven social system of the modern world developed over the past 500 years (Babones 2015). It has therefore become one of the many lenses through which scholars of social sciences and economics can study how power differentials within the global system perpetuate exploitative capitalist processes and class relations (Babones 2015; Wallerstein 2012).

As in the case of other dependency theories, the world-systems framework divides the world into core, semi-peripheral, and peripheral zones (Akiwumi 2006; Babones 2015; Gregory 2004). The exploitation of natural resources serves to fuel massive development of the core while ravaging the periphery (Amin 2002; Ayelazuno 2011; Shivji 2009). The core countries attain their wealthy status through the exploitation of the peripheral zones essentially through past colonial relationships, neocolonialism, conquest, and economic imperialism that establishes economically and politically skewed exchange relationships (Adeola 2001; Akiwumi 2006; Bornschier and Chase-Dunn 1985; Burns *et al.* 2003; Chase-Dunn 1998; Kohl 1987; Wallerstein 1979). The semi-peripheral countries, according to Akiwumi (2006), play a two-sided role within world-systems dynamics. As they themselves are exploited by the core, they also play a key role in the exploitation of the true peripheral countries in a quest to move up the hierarchy – a process restricted and largely at the whim of core countries (Adeola 2001; Akiwumi 2006; Babones 2015; Bornschier and Chase-Dunn 1985).

Galtung (1971) and Babones (2015) show that nations have centers and peripheries. Even the USA has a periphery and semi-periphery, with a smaller number of people in the core (Ahiakpor 1985; Babones 2015). In poor peripheral countries, the gap between the core and peripheries at the local and national level is wide. The insertion of such countries into the global capitalist system successfully creates niches of tightly organized local elites and traditional leaders, who have a symbiotic relationship with foreign entities in terms of economic interests (Bryant and Bailey 1997). The conspicuous synergies of interests between the core of periphery nations and that of core nations is best described by Galtung (1971) in his center-periphery model to depict the functioning of imperialism (Figure 1).

Another nuance is the reproduction of world-systems structure on the local level. There are core-periphery microcosms that are produced locally, sustained through operations that emanate from core countries and aiding the smooth operation of the global system (Adeola 2001; Akiwumi 2006; Kick *et al.* 2011). Wallerstein indicated that the word "world" in his framework does not necessarily have to reflect the global

scale (2002). Chase-Dunn and Hall (2006) clarified that a world-system can depict the core-periphery interactions between two cultural groups in a given locale and the polities that exist between them, where one dominates or exploits the other.



Center-Center	Elites (political, social and economic), MNCs
Center-Periphery	Rural inhabitants, small-scale farmers
Periphery-Center	Predominantly city dwellers: Elites (political, social and economic), MNCs
Periphery-Periphery	Rural inhabitants, small-scale farmers

Figure 1. Galtung's Center-Periphery model. (Adapted from Galtung 1971)

In all of these scaled and unequal relations, reckless appropriation and destruction of resources under 'development' tend to affect local groups as they are incorporated into national and international webs of economic activities, destroying their livelihoods and particularly, indigenous cultures (Adeola 2001; Amin 1997; Harvey 1998; Omoweh 2005; Yaro 2013). These conditions in resource-rich countries are engendered by the unequal power relations within the world-system (Adeola 2001; Adusah-Karikari 2015; Amin 1997; Renner 1996). Since capital accumulation is dependent on ecological assets such as forests and minerals, Hornborg (2006) argues for "ecologizing" world-systems theory. By this, he means conceptualizing an interface between the world-system and ecosystems. This requires substituting or supplementing the Marxist labor-oriented concept of exploitation with one that is resource-oriented.

4. A place for political ecology in ecosystem services

Understanding ecosystems services

Daily (1997) defined an ecosystem as a set of organisms living in a given area, the physical environment in which they thrive, and the interactions that ensue between them. Ecosystem services are also defined as the conditions and processes through which natural ecosystems, and the species of which they consist, fulfill and sustain human lives. From ecosystems, humans obtain tangible goods – like forage, natural fibers, pharmaceuticals, timber, seafood, and many industrial products and their precursors. Ecosystems provide life-support systems through regulation of weather patterns, control of erosion, prevention of floods and droughts, etc. (Daily 1997; Daw *et al.* 2011; EC *et al.* 2012; MA 2005; Noss *et al.* 1995). While the phrase "ecosystem services" is a fairly new one, the idea that ecosystems provide services has been around a long time (Lele *et al.* 2013). It has overtaken "environmental services" as used by Wilson and Matthews (1970, see also Lele *et al.* 2013; Norgaard 2010).

The myriad of services that ecosystems provide are classified under four main categories; provisioning, regulating, cultural and supporting services (Figure 2) (Daw *et al.* 2011; EC *et al.* 2012; MA 2005; TEEB 2010). Considered under provisioning services is the production of tangible goods such as food, water, fiber, fuel and other resources. Regulation of air quality, carbon sequestration and climate regulation, and regulation of the water cycle are examples of regulating services. Cultural services include non-material benefits such as

recreation, tourism, inspiration, educational values, aesthetic values, and cultural heritage and identity. Support services include provision of habitat for species, and the maintenance of genetic diversity (Daw *et al.* 2011; EC *et al.* 2012; MA 2005).

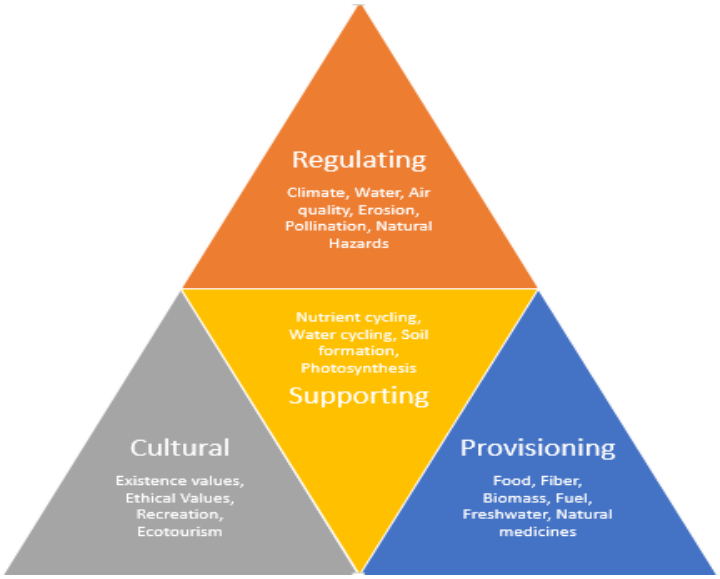


Figure 2: The four main categories of ecosystem services. (MA 2005)

Decline of ecosystems and the possible repercussions have been at the forefront of the environmental movement because human activities have drastically degraded them over the years. Concerns associated with degradation and the scientific uncertainties associated with ecosystem processes led to the Millennium Ecosystems Assessment (MA), called for by UNEP and the UN. Between 2001 and 2005, the MA was carried out to assess the linkages between ecosystem services and human well-being, especially in illuminating the repercussions associated with changes in ecosystems and their implications for human societies (Carpenter *et al.* 2009; Daily *et al.* 2009; Dugan *et al.* 2010; Maes *et al.* 2012; MA 2005**)**.

While traditional economic analyses have attempted to quantify ecosystem services, they grossly underestimate the values associated with them. For instance, while tangible goods such as fish in the ocean and forest products may readily be quantified, the third aspect, the cultural value for traditional cultures that are intrinsically dependent upon such natural systems, may not be easily quantifiable. Most human religious beliefs are essentially attached to the natural world and the integrity of natural ecosystems (Daily 1997; EC *et al.* 2012; Kosoy and Corbera 2010; TEEB 2010). Ingalls and Stedman (2017) have exhaustively addressed the roots of human identity in socio-ecological systems – an important component of ecosystem services that does not lend itself to quantification. Owing to this, there has been some explicit legal acknowledgement of the right of many native groups to productive and healthy natural ecosystems, for instance, enshrined in Australian legislation concerning Aboriginal and Torres Strait Islander peoples (Trigger *et al.* 2014).

Even with provisioning services that can relatively be easily quantified, the MA found that those needed by the rural poor are typically overlooked in national statistics and poverty assessments. According to MA (2005), a study conducted in 17 countries found that national statistics did not capture about 22 percent of household income for rural communities in forested regions from activities such as harvesting of wild foods, fuelwood, medicinal plants, and fodder among others.

In assessing changes in ecosystems and their impacts on human well-being, the conceptual framework of the MA posited that humans are only an essential component of ecosystems and that there is a dynamic cyclical interaction that exist between them and the other components (Figure 3). In the framework, as the human condition changes, this both directly and indirectly causes alterations in the other elements. This in turn

can sometimes drastically impact human well-being (MA 2005). Meanwhile, there are other direct and indirect drivers of change. Anthropogenic factors such as overexploitation, pollution, and physical modification of ecosystems, and biological factors such as invasive alien species are classified under direct drivers while population change, sociopolitical and cultural factors, and technological change are classified under indirect drivers (Chapin III *et al.* 2000; MA 2005).

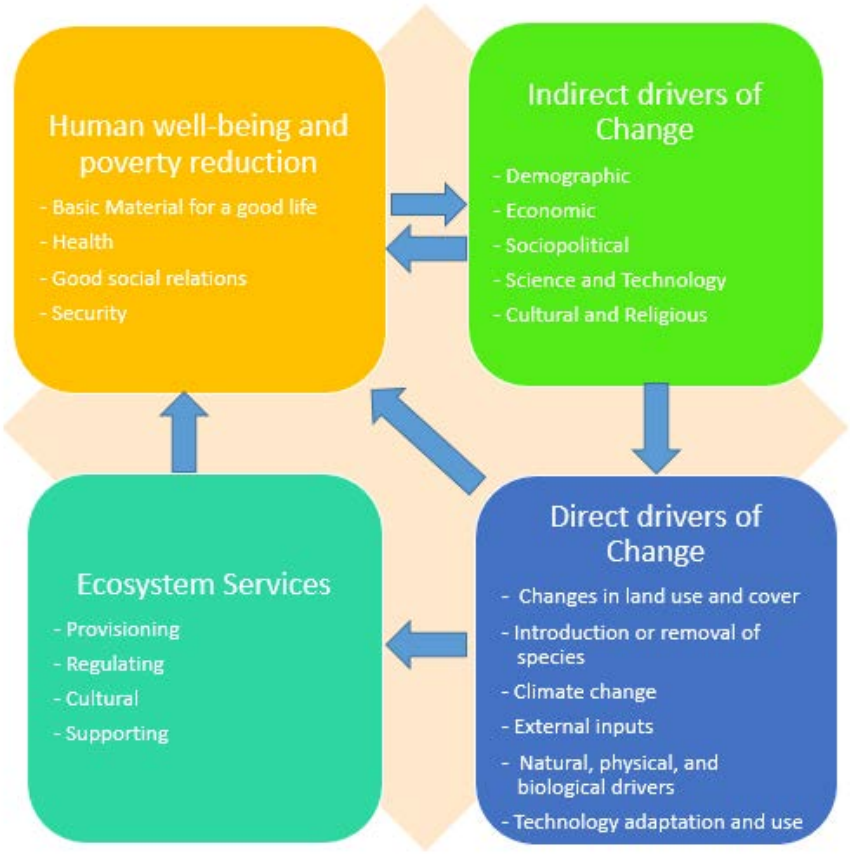


Figure 3: Millennium Ecosystem Assessment framework of interactions between ecosystem services, human-wellbeing, and drivers of change. (Adopted from MA 2005)

Considerable economic development around the globe over the past 50 years, has created rapid ecosystem change in order to meet the constantly growing demand for timber, fuel, fiber and so on in the world system. The MA assessed and evaluated 24 ecosystem services worldwide. Of this number, 60 percent were found to be degraded or used unsustainably through various means such as harvesting or pollution (MA 2005). The full costs associated with the degradation of ecosystems are now becoming apparent. While the lack of constant monitoring makes it daunting to estimate the full impact on ecosystems and societies, there is evidence to indicate adverse socio-economic outcomes. The MA found that regions that struggled to meet the Millennium Development Goals targets (MDGs) were those facing the most problems with ecosystems degradation, particularly where the rural poor are most reliant on ecosystem services for their livelihoods (EC *et al.* 2012; MA 2005). Poor communities disproportionately bear the burden, negating some of the strides made in meeting human development needs in recent decades.

Making a case for disaggregation – when ecosystem service debates turn "political-ecological."

While there has been a recent explosion of interest in ecosystem services over the past decade in academia and in policymaking, assessments of ecosystem services tend to be made on an aggregate basis (Carpenter *et al.* 2006; Daw *et al.* 2011; MA 2005). Daw *et al*. describe aggregate ecosystems analysis as analogous to national aggregate indices of wealth such as gross domestic product per capita, masking very important and wide variations in the wealth of individual members of the poorest segment of societies. Daw *et al*. emphasize the need to identify the "winners" and "losers" from ecosystem changes. The MA findings supported this view, also observing that the impact of ecosystem changes on the most vulnerable segment of the population are not adequately taken into account during management decisions. Trade-offs exist between different ecosystem services. Many authors have shown how increasing one ecosystem service may result in the decline of another (Bennett *et al.* 2009; Daw *et al.* 2011). For instance, while offshore drilling for hydrocarbons from the ocean ecosystem may increase energy supply, the processes involved may lead to the release of substantial artificial pollutants such polycyclic aromatic hydrocarbons (PAHs) which pollute and destroy ocean habitat for organisms. In this same scenario, considering the social dimension of the trade-offs, the extraction of hydrocarbons may lead to the expansion of wealth for 'biosphere people'[2], while local peasants whose livelihoods are bound to flourishing ocean ecosystems ('ecosystem people') lose out. It is also worth noting that while the latter suffer the proximate decline in essential system services, they may also likely face restrictions to accessing the revenues from hydrocarbons due to their social and politically marginal position (Figure 4).

For a more robust analysis of ecosystem services, different authors suggest disaggregated or multiscale assessments that are sensitive to needs of different segments of societies, especially distinguishing the different elements of the poor and the peasantry. Disaggregation is necessary to distinguish between different groups of poorer people based on their functional relationship to provisioning ecosystem services in terms of whether they are immediate users, sellers, or non-participants (Daw *et al.* 2011; MA 2005). Daw *et al.* (2011) further suggest that depending on context, an appropriate level of disaggregation may be within the scales of wealth, gender, ethnicity, or groupings based on livelihood as well as class, in terms of opportunities for income generation and access criteria. I suggest building on this work on disaggregation based on the functional relationship of local people to certain provisioning ecosystem services. For this reason, I define "critical ecosystems" as those that form the foundation upon which livelihoods and culture of local people primarily depend, while "critical ecosystem services" refer to services produced thereof.

Explaining the ecosystems and biosphere people dichotomy: how to disaggregate human society based on the relationship to provisioning ecosystem services

Dasmann (1988) developed the idea that certain populations of 'ecosystems people' are wholly or at least primarily dependent on ecosystem services, while the livelihood of 'biosphere people' are far removed from them. Ecosystems people are the world's peasant farmers, fishers, and forest dwellers among others. They have a prime dependence on biological resources that are found within their local ecosystems for the entirety of their lives, and in many ways have become part of the ecosystems they inhabit. 'Biosphere people' are urban dwellers and inhabitants of industrialized societies, as well as individuals engaged in commercial or high-input agricultural production and fishing. Most citizens of First World countries as well as the elites in third world societies can be classified as biosphere people. The suggestion is that ecosystems people are the most vulnerable as they are equipped with few skills to exchange for livelihood, in order to cope with major changes in the ecosystem. Meanwhile, biosphere people are better cushioned against shocks that ecosystems changes may present, as their livelihood base essentially encompasses the entire biosphere (Daily 1997; MA 2005).

[2] Not dependent on ecosystems for their daily needs, including urban dwellers, unlike 'ecosystem people'. Described below and in Gadgil (1995) and Bawa and Gadgil (1997).

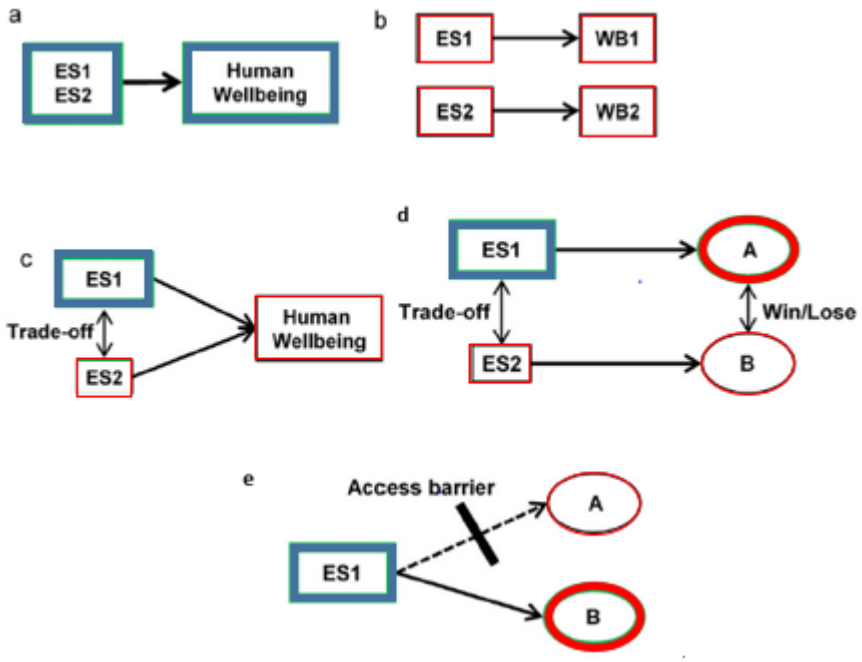


Figure 4. Conceptualizations of ecosystem services (ES) and human well-being (WB) as adapted from Daw *et al.* (2011). (a) through (c) indicate concepts that do not disaggregate human well-being (i.e. the beneficiaries). Hypothetical increases in ES and well-being are indicated by bold boxes. (a) Simplistic aggregated view of well-being and ES, which leads to assumptions that increases in ES will lead to increases in well-being. (b) Elements of human well-being are disaggregated, recognizing that different ES may contribute to different elements of well-being. (c) ES are disaggregated to explore trade-offs between them. (d) and (e) illustrate aspects of ES and human well-being that disaggregate the human beneficiaries of ES. Each scenario shows an increase in the flow of an ES (highlighted boxes) and the differential impacts on two potential beneficiaries (A and B). (d) Trade-offs between different ES lead to winners and losers depending on who is placed to benefit from which ES. (e) Access mechanisms determine the well-being impacts of changes in ES. Increases in ES1 are captured by B but are not available to A.

Gadgil (1995; Baka and Gadgil 1997) has been most receptive to Dasmann's categorization of people into ecosystem people and biosphere people. He makes the distinction even more tangible by ascribing a 50km^2 radius to the space within which ecosystem people are likely to source the entirety of their livelihood. He also noted local resource use is intergenerational, and symbiotic with their environments. Maintenance of rights to access ecosystems is key for people dependent on them, a key agreement with the early work in political ecology which also stresses satisfactory access as a key requirement of rural livelihoods (Blaikie 1985). Biosphere people are spatially unrestrained, with access to additional resources that are sourced far beyond their immediate catchment, such as fossil fuels and hydroelectricity. Gadgil shows how wider access gives them the ability to transport and transform large quantities of material resources from around the globe for their own use. When studying the potential impacts of activities on ecosystems, with a firm knowledge of biosphere and ecosystem people within a vicinity by these guidelines, ecosystem services that form the foundation of livelihoods of the ecosystem people should be categorized as "critical ecosystem services", and prioritized.

5. The "critical ecosystems" model: merging political, sociological, and physiographic inquiries in political ecology

One of the significant driving forces behind political ecology as a field has been the critique of "apolitical" ecology. Ecology must account for the dynamic role of human actions, in addition to purely physiographic variables. Blaikie (1985) emphasized the need for balanced inquiry to ensure that technical and physical aspects of environmental issues are not neglected, but are researched and understood in the context of social and economic factors as they occur in the local situation. In his work explaining soil erosion in developing countries, Blaikie (1985) stated that:

> Essentially, in an explanation of a case of soil erosion, there are two sets of specificity to be tackled - that of the physical system and that of the social/economic system, and they both have to be brought together and analytically integrated. An omission of the first would lead to a failure to specify the physical processes of soil erosion… The omission of the second (the social/economic system) leads to a purely technocratic and physical study of the processes of soil erosion and perhaps the immediate land-uses leading to it, without any analysis of other political economic relationships at the local, regional and international scales which determine the actions of the land-user in the affected area. (Blaikie 1985: 88-89)

However, many scholars of political ecology have done less to develop this balanced agenda, as the field has expanded out to consider different aspects of justice and injustice, environmental movements, and denial of access to natural resources. Forsyth (2003) noted that the separation of science and politics in political ecology can be attributed to the fact that many political ecologists viewed biophysical explanation as unnecessary to arguments and research based more strongly in social science.

In an integrated approach, the philosophy and the sociology of science would provide new insights into the biophysical causes and impacts of environmental problems. Additionally, a balanced inquiry has the potential of shedding light on social and political factors that frame the tenets of environmental science, and how science can contribute in shaping politics (Forsyth 2003, 2015). Forsyth's discussion of '*critical*' political ecology indicated the need to integrate realist biophysical prediction with social and political constructions, remaining attentive to the power dynamics of both (2003). Politics should not be separated from the laws and principles of science of the environment. This was expressed as follows:

> First, the adoption of environmental science without acknowledging how it is affected by social and political factors undermines its ability to address the underlying biophysical causes of perceived environmental problems. Second, the adoption of policies based on such unreconstructed science frequently produces environmental policies that unfairly penalize many land users— especially in developing countries—and may even increase environmental degradation and poverty by threatening livelihoods. This book seeks to address these two problems by exploring the links between science and society in order to avoid the replication of inadequate science, and to enable the production of more biophysically accurate, and socially relevant, science. (Forsyth 2003: 2)

One of the key ambitions of Forsyth's *critical* political ecology framework was to offer explanations related to the environment that are more sensitive to political contexts within which changes occur. Socially relevant science does not offer universalist statements that are blind to class categories, and fail to incorporate understandings of local livelihoods. Adopting critical political ecology is essential to make science relevant to all social groups, and to increase the understanding of how complex biophysical changes may affect different groups (Forsyth 2003).

My "critical ecosystems" framework incorporates political-ecological thought into the science of ecology – specifically the concept of ecosystem services – in a manner that is socially and politically relevant (Figure 5). Social groups are disaggregated based on their functional relationship to certain aspects of

provisioning ecosystem services, and the trade-offs that exist. On the left side of the "critical ecosystems" framework, provisioning ecosystems are divided into commercial and critical (small-scale) provisioning ecosystem services (see section 4). Commercial services including mining, energy (oil extraction), and commercial agriculture, among others have a direct impact on the "critical ecosystems" services upon which local livelihoods depend. These impacts occur through the disruption of complex ecological and physiographic processes (P.D) which adversely affect regulating and supporting services. The disruption of these crucial services in turn interfere in the complex processes (P.I) that decrease the productivity of critical ecosystems. To illustrate this point, commercial timber extraction disrupts soil structure and the water cycle, which in turn affect local soil fertility and water availability, resulting in declining productivity on farmland.

There are trade-offs that also occur on the right-hand side of the model. Capital accumulation resultant from large-scale and commercial activities accrue to the biosphere people, while ecosystem people are denied access to it. Meanwhile changes in "critical ecosystems" have a detrimental effect on ecosystem people due to the decreased productivity, accessibility, and availability of these services.

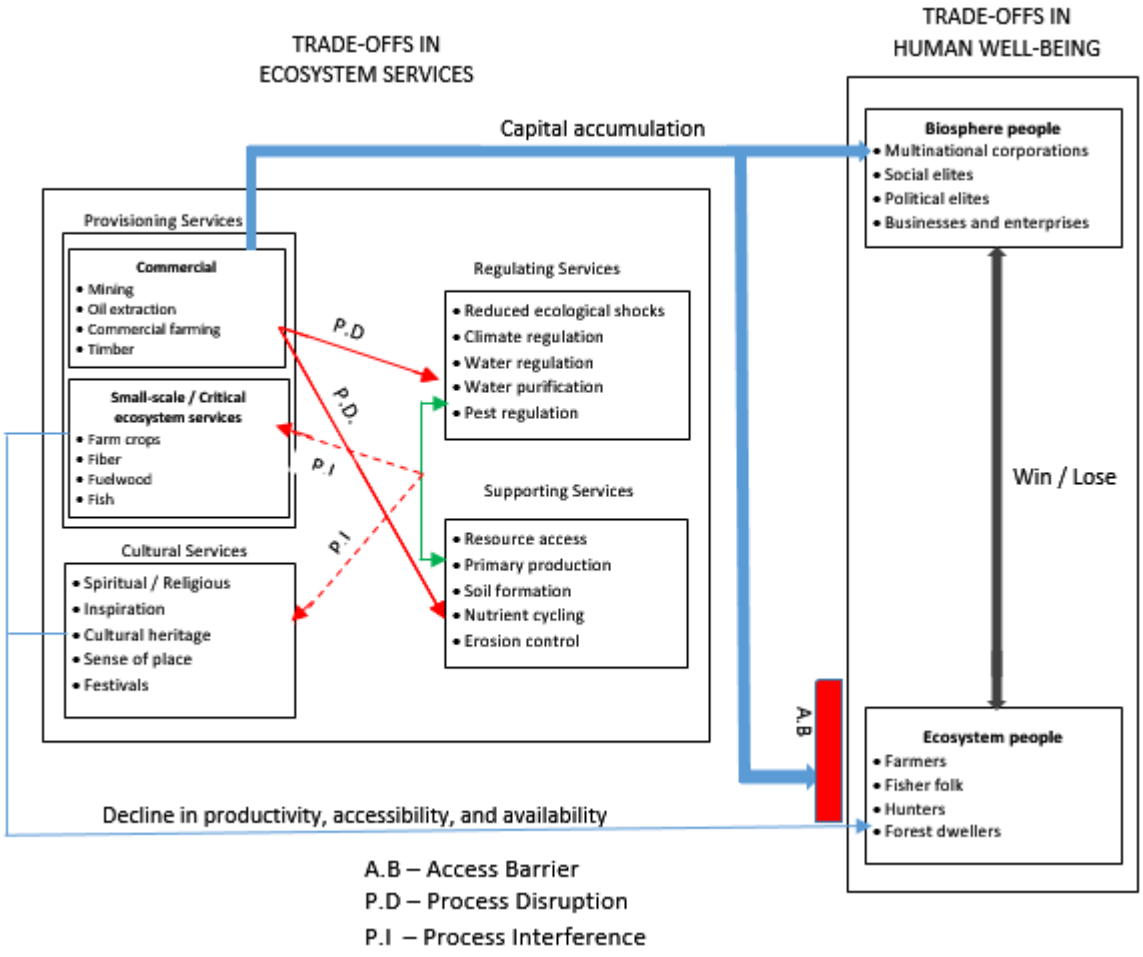


Figure 5: Conceptual framework for "critical ecosystem" services.

It is crucial that political ecologists isolate "critical ecosystem services" and subject to scientific inquiry the specific underlying processes that affect their productivity, quantifying any decline through the perspectives of local dependents, rather than outside neoliberal actors. This model is flexible and must be adapted based on the idiosyncrasies of any particular activity and the ecosystems under study, as different ecosystems are

characterized by vastly different and complex ecological processes that must be understood in context. As a demonstration of this flexibility, the subsequent section applies a modified version of the model to the oil and gas industry in Ghana, showing how it can guide research questions in a sensitive manner.

6. "Critical ecosystems" in the Ghana oil industry and local livelihoods

In 2007, Komos Energy announced the discovery of oil in commercial quantities in Ghana's offshore territory in the Gulf of Guinea. After several years of oil prospecting, the assessment of the offshore deposits along the coast of the Western Region meant Ghana could become an oil producing nation. In December of 2010, oil production formally started in Ghana and it was officially ushered into the league of oil-producing nations (Adusah-Karikari 2015; Amoasah 2010; Kumar *et al.* 2013; Planitz and Kuzu 2015). Ghana's poor track record in exploitation of other natural resources, and the experiences of other oil producing countries like Nigeria and Gabon meant optimism was tempered with caution (Obeng-Odoom 2013; Planitz 2014).

Formerly known as the Gold Coast, the country's importance in the trade of precious minerals, especially gold, can be traced to the pre-colonial era (Ayelazuno 2011; Dumett 1998; Hilson 2002). In spite of its endowments, there remains a sense of palpable despondency at the community level in resource extraction regions (Ayelazuno 2011; Hilson and Garforth 2012). Instead of enjoying the windfall from resource wealth, the general picture in these communities is one of degraded livelihoods and deterioration of economic and social well-being (Ayelazuno 2011; Hilson 2005).

There is a plethora of literature on the environmental, social, and cultural impacts of the new oil and gas industry in the Western Region of Ghana (Adusah-Karikari 2015; Amoasah 2010; Kumar *et al.* 2013; Manu 2011; Obeng-Odoom 2013; Planitz and Kuzu 2015; Planitz 2014). These studies draw on a variety of theoretical frameworks such as the ecosystems services approach (Amoasah 2010); sustainable livelihoods framework (Manu 2011; Planitz and Kuzu 2015; Planitz 2014); feminist political ecology (Adusah-Karikari 2015); and the resource curse thesis (Obeng-Odoom 2013). Only a few acknowledge the differential impacts of the industry on different segments and subgroups of society (Adusah-Karikari 2015; Ayelazuno 2014; Boahene and Peprah 2011; Obeng-Odoom 2013; Obeng-Odoom 2009). Only Adusah-Karikari singled out women in her study, taking into consideration gender-based power relations and differentiated rights at the local level and how their primary livelihood activities are affected by oil exploitation (2015).

Having already established that the livelihoods of local communities succumb to accumulation by the core (Adeola 2001; Bornschier and Chase-Dunn 1985; Bush 2009; Cuba *et al.* 2008; Odukoya 2006), it is expedient to illustrate how such processes may play out in the Western Region of Ghana with regard to the presence of the oil industry. Obeng-Odoom (2013; 2009) has already alluded to the need for a disaggregated study to illuminate the impacts of the oil industry on different subgroups. In his research focused on urban areas of the Western Region, he rejected the categorical claims of the resource curse narrative, as the curse plays out for only a particular subset of the differentiated population. He argued that "the oil city is not monolithically blessed or cursed… curses and blessings co-exist and are distributed along class lines." Continuing, Obeng-Odoom (2013) noted the importance of applying additional analytical frameworks that will provide empirical findings in understanding the dynamics around which the oil industry will be a curse for a one group and a blessing for another. According to him, a broader framework for analysis should be more sensitive to class and differentiated rights (Obeng-Odoom 2013). Along these lines, Obeng-Odoom has also rightly identified local farmers and fisher folks as a subgroup whose functional relationship with agricultural and ocean ecosystems render them uniquely vulnerable (2014). This study identifies the differentiation of people based their functional relationship with these critical ecosystems. In this sense, the farmers and fishers are considered as one subgroup (ecosystem people), while all others are grouped into another (biosphere people). This categorization is used in the subsequent section to demonstrate how the "critical ecosystems" model can be modified based on local dynamics and circumstances.

7. Modifying the "Critical Ecosystems" model for the Ghanaian oil case study

The "critical ecosystems" services that were considered in this study are those that are identified as primary and direct support systems to the livelihoods of the study area – fishing and farming (Adusah-Karikari 2015; Daw *et al.* 2011; Daily 1997; Manu 2011; MA 2005; Plänitz and Kuzu 2015).

The models as presented in Figures 6 and 7 explain the various interlinkages. As already stated from the points listed above, this study prioritized the livelihoods of the relatively powerless ecosystem people (farmers and fisher folk) in the context of the study area, and the impacts of the oil and gas industry on the "critical ecosystems" on which their livelihoods depend. From a broader view of unequal power relations and differentiated impacts, the exploitation of oil and gas interferes with optimal functioning of ecosystems and the services they provide (Figure 6). The model in Figure 7 posits that the impacts of oil exploitation on ecosystems and livelihoods involves several parameters that interact directly and indirectly, to disturb ecosystem services, which has feedback implications on social cohesion and culture.

According to the model as presented in Figure 7, the development of the new oil industry (an externally generated core activity with special interests, both internal and external), directly and indirectly affect land use change in two different ways. **First**, there is direct effect of land use change due to the priority given to the installation of massive infrastructure to facilitate operations. **Secondly**, the windfall of wealth promised by the oil industry stimulates a new wave of migration into the catchment area. This indirectly sets off a shift in land use priorities from farmlands to residential and commercial land development to accommodate the influx of migrants. A larger population increases pressure on ecosystems but more importantly, smallholder farmers, usually with weak land tenure systems, lose their land through appropriation by local elites whose desire is to accumulate wealth.

Within the model, the oil industry, whose primary goal is to minimize operational costs and maximize profits, freely pollutes the ocean and coastal areas. In a vacuum of strict environmental regulations, the toxic pollutants released by the oil industry into the ocean reduces the fish population. This means that small scale fishers whose livelihoods depends on fishing become severely affected. This reduction in fish catch is exacerbated due to restrictions in fishing zones.

With small scale fishing and farming being the main economic mainstays of these local communities within the surrounding communities closer to exploitation activities, the model further postulates that the loss of livelihoods disturbs the social structure and its optimal function. In the western region of Ghana, not only is an activity such as fishing an economic mainstay, it is part of cultural identity. For this reason, when such activities are disturbed, a socio-cultural dysfunction ensues which ultimately could have very negative repercussions.

Having explained the interactions as theorized within the models, an appropriate research question is as follows:

> *What are the impacts of the oil industry on "critical ecosystem" services and local livelihoods that depend on them?*

To address this, we can break it down into the following sub-questions:

- What is the impact of the oil industry on agricultural ecosystems and livelihoods?
- What is the impact of the oil industry on fishery ecosystems and livelihoods?
- How do oil industry-induced changes in "critical ecosystem" and livelihoods affect the socio-cultural systems in local communities?

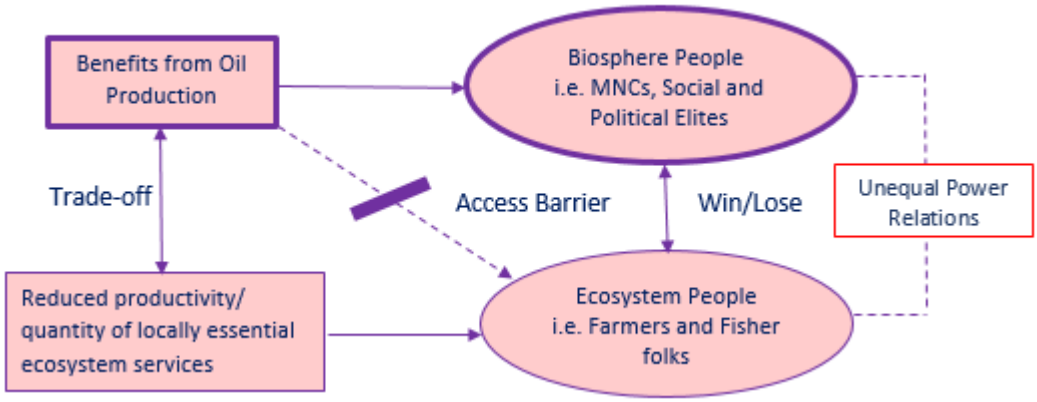


Figure 6: Conceptualization of aspects of ES and human well-being that disaggregates human beneficiaries with respect to the oil industry in the Western Region of Ghana, as adapted from Daw *et al.* (2011). This scenario depicts an increase in returns in the oil industry in the highlighted box, trade-offs with locally essential ecosystems, and the differential impacts on the two groups of people (ecosystem and biosphere people). Trade-offs exist between oil exploitation and locally essential ecosystems, leading to winners and losers depending on who is placed to benefit from the exploitation of oil resources. Access mechanisms determine the well-being impacts of changes that results from oil exploitation. Benefits accrued from increased returns of oil exploitation are captured by biosphere people but are not available to ecosystem people due to unequal power relations that exist between them.

Designing a study that bridges the ecological and social science gap

Liu *et al.* (2007) have articulated the importance of bridging this disciplinary gap for a comprehensive inquiry. For this reason, to adequately explore these questions, it will be imperative to adopt a mixed method approach that can holistically capture relationships between the ecological and social variables of interest. For instance, the **first** question is a two-part one that will require biophysical inquiry into the first part and a sociological inquiry into the second. To answer that first part of the question, I would suggest a land use and land cover change (LULCC) assessment using Remote Sensing (RS) and Geographical Information Science (GIS) techniques to quantitatively estimate the impact of the oil industry on agricultural ecosystems, as in Acheampong *et al.* (2018). The second part of the question would require social research methods including surveys, interviews, and focus group discussions among others to reconcile the biophysical with the sociological, by focusing on the part of the population that are adversely impacted by the oil industry.

The **second** question may require a similar approach for its two parts. For the first part, I would suggest using a scientific technique such as Gas Chromatography and Mass Spectrometry (GC-MS) analysis to assess the levels of Polycyclic Aromatic Hydrocarbons (PAHs) to determine if they are at toxic levels that have the potential to threaten fish stocks. This is important because studies have shown that release of chemicals from the oil industry, through chronic effluent discharges and oil spills, have the potential to result in high level toxicity with acute and sublethal effects on aquatic organisms (Lee *et al.* 2013; Sojinu *et al.* 2012). As in the first question, the second part would require a sociological inquiry. The **third** question is also a wholly sociological one, which would require a sociological and ethnographic approach to understanding how changes in ecosystems and livelihoods may lead to change in society and culture. As in the second parts of the first two research questions, surveys, interviews, and focus group discussions would be used.

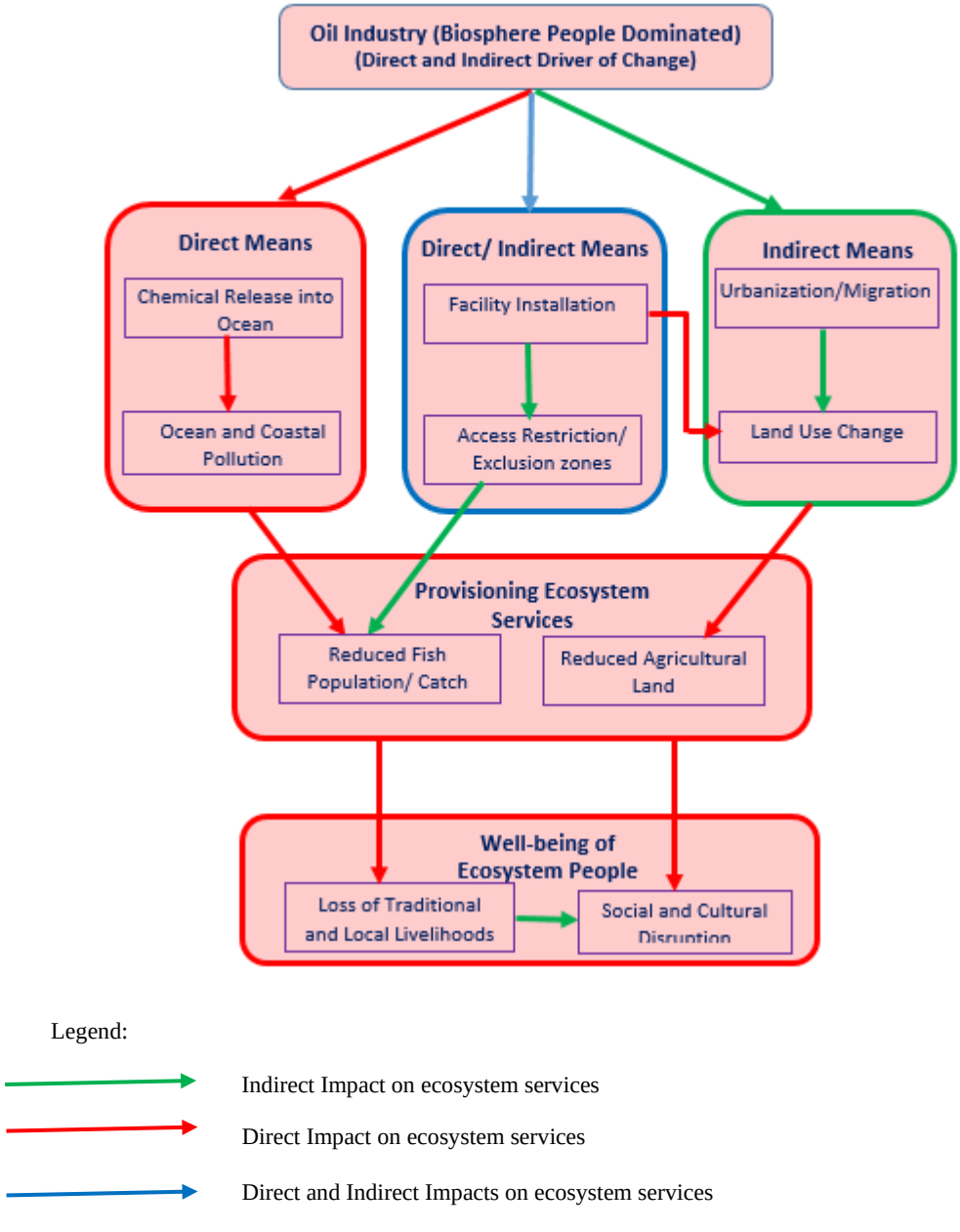


Figure 7. Modified "Critical Ecosystems" model showing the mechanisms of impacts of oil exploitation activities on the two locally essential ecosystem services (agriculture and fishery), and the livelihoods that depend on them.

8. Concluding remarks

In this article, I have furthered arguments about one of the unresolved and perhaps the most caustic criticisms of political ecology. Despite acknowledgement by prominent political ecologists that the field ought to span the political and the ecological, the focus of inquiry in the field has shifted farther to the "political" end of the spectrum, leaving the "ecology" behind. I argued that this is the case due to the deafening silence of

political ecologists (apart from their critiques of market-based instruments, in this *Journal* and eleswhere) on one of the most important inroads in ecology in almost two decades – the concept and framework of ecosystems services. The structure it provides could help deepen the political ecology spectrum.

I pursued this article with a two-sided objective. First, I refocused political ecology back to the ecology by introducing the concept of "critical ecosystems" that argues for prioritization of ecosystem services in the context of socio-environmental consequences of natural resource exploitation. To this end, the core argument is to look through the lens of unequal power relations to identify ecosystems that are of more proximate importance to the survival of local and indigenous people in cases of their decline. Since ecosystem services can be innumerable in any given landscape, this approach will simplify our scope of inquiry as political ecologists, by focusing on services that are most crucial for the survival of local people and underlying processes.

Secondly, I have presented a hypothetical analytical framework that will resolve one of the difficult aspects of holistically probing human-environment interactions – reconciling the sociological and biophysical. I presented the "critical ecosystems" model, and proceeded to demonstrate, with a case study of Ghana's oil and gas industry, how the model may be modified to pursue a comprehensive analysis that can capture both the human and ecological variables, and the various pathways through which they interact. Of course, in all of this, the centrality of power dynamics within human societies remain firm.

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