



Reclamation of Galamsey Land is Not Land Restoration: The Land Beyond Agriculture

Gilbert Danyo 

Council for Scientific and Industrial Research (CSIR), Oil Palm Research Institute (OPRI), Coconut Research Programme, P. O. Box 245, Sekondi, Ghana-W/A. E-mail: bertdanyo@gmail.com; Orcid ID:0000 0003 3387 0607

Abstract: Agriculture is not the only imperative for land reclamation. In Ghana, conflation of disapproval, and clarion call for compulsory reclamation of ‘galamey’-degraded arable lands, by the moral society and eco-conscious minority in order to sustain biodiversity, agricultural productivity, environmental safety, and public health is muffled by the oratory artifice of utilitarians (both utilitarian narrowness and indifference) and the financial might of political financiers fronting for international gold merchants. The coup de grace is delivered by unpatriotic, unethical, and compromised environmental scientists and scholars whose acquiescence legitimized the false scientific narrative of synonymy of land reclamation to land ecosystem restoration. The error builds complacency that weakens collective revulsion for the insensate destruction of nature by illegal small-scale gold mining; believing that, remedy lies in merely covering up dugouts or levelling up degraded areas and re-vegetating them. Neither ignorance nor conceptual oversight is an alibi; the interchangeable use of land reclamation and land restoration is a veneer by insincere political actors to shirk responsibility for a national course, and sophism by opportunistic scientists and scholars to plunder national resources in a course which does not fully address a national tragedy!. Yes, degraded lands must be reclaimed at all cost but, further efforts must be expended to attain land ecosystem restoration in the end. Land reclamation is only the important first step in the long journey to land ecosystem restoration; it is not an end in itself. This is the thesis of this scientific master piece.

Keywords: Galamsey, Soil profile, Land reclamation, Agricultural productivity, Ecosystem restoration

INTRODUCTION

The Land

Land is a prime natural resource in agriculture, forestry, mining and quarrying, industrialisation, real estate, recreation, nature conservation, and more! The soil is the most important part of land (Krishnakumar *et al.*, 2013). Technically, soil is the unconsolidated mineral or organic substance on the earth’s surface that provides a natural medium for the growth of land plants. More commonly, the upper layer of the earth’s crust that supports plant and animal growth. The soil is formed from the combined action of the physical and chemical weathering of parent rock material (that provides the mineral substrate), the incorporation and decay of organic matter (mainly as plant remains that soil microbes decompose) and the movement of soluble or suspended materials in percolating water (colloidal matter of humic substances) (Jackson and Raw, 1973).

Primary functions of soil in agriculture, forestry and ecosystems are sustaining biological productivity, regulating water flow, storing and cycling nutrients, filtering,

buffering, and transforming organic and inorganic materials (Krishnakumar *et al.*, 2013). Plant nutrients are the essential components of soil health, at least with respect to sustaining biological productivity. Soil health is the capacity of a soil to function within ecosystem and land use boundaries; to sustain biological productivity, and maintain environmental quality.

Soil Profile

A soil profile is a vertical cross-section of soil, showcasing its different layers. These layers, also known as soil horizons, are distinct physically, chemically, and biologically due to variations in their composition, structure, and appearance (soil colour, texture, structure, consistency, biotic populations and pH) (Figure 1). The soil profile is very important in agricultural, forestry, and geological sciences

(<https://agropublishers.com/2024/10/05/mcqs-soil-science/>).

In agriculture, the soil profile influences the availability of nutrients, water holding capacity, and root growth, all crucial for plant growth. In forestry, the soil profile is essential for understanding forest ecosystems and the suitability of different forest types to specific soil conditions. In constructions, geotechnical engineers rely on soil profile analysis to assess the suitability of a site for building foundations and to predict potential geological disaster.

Soil horizontal development is a product of subsisting ecosystem properties as well as land history. Agriculturally, the most important and studied soil horizons are the O, A, and B (Figure 1).

O Horizon (Organic Layer): This is the uppermost layer, rich in organic matter and often containing partially decomposed plant and animal remains (or humus).

A Horizon (Topsoil): This is the layer immediately below the O horizon, characterized by accumulation of organic materials intimately associated with soil mineral matter. Better known as the surface or top soil, colloidal organic matter concentrations tend to be maximized in this portion of the mineral soil profile. Hence, this layer is also where most plant roots grow and where biological activity is highest.

B Horizon (Subsoil): Sub-soil, formed below an A or O horizon (where A is absent). Generally lighter in color and more clay-rich than the A horizon, it often has less biological activity but holds more moisture. Characteristically, the B horizon:

1. Are dominated by carbonates, gypsum, or silica, alone or in combination;
2. Show evidence of carbonate removal;
3. Exhibit sesquioxide concentrations;
4. Display alterations that form silica clay;
5. Manifest formation of granular, blocky, or prismatic structure, or combinations of these.

In soils without organic surface (leaf litter) accumulation, soil microbial activity tends to be maximized in the A horizon and declines precipitously in the B horizon (Tate, 1995).

C Horizon (Parent Material): This is the layer of partially weathered bedrock, the parent material from which the soil is derived.

R Horizon (Bedrock): This is the solid, non-weathered bedrock at the base of the soil profile.

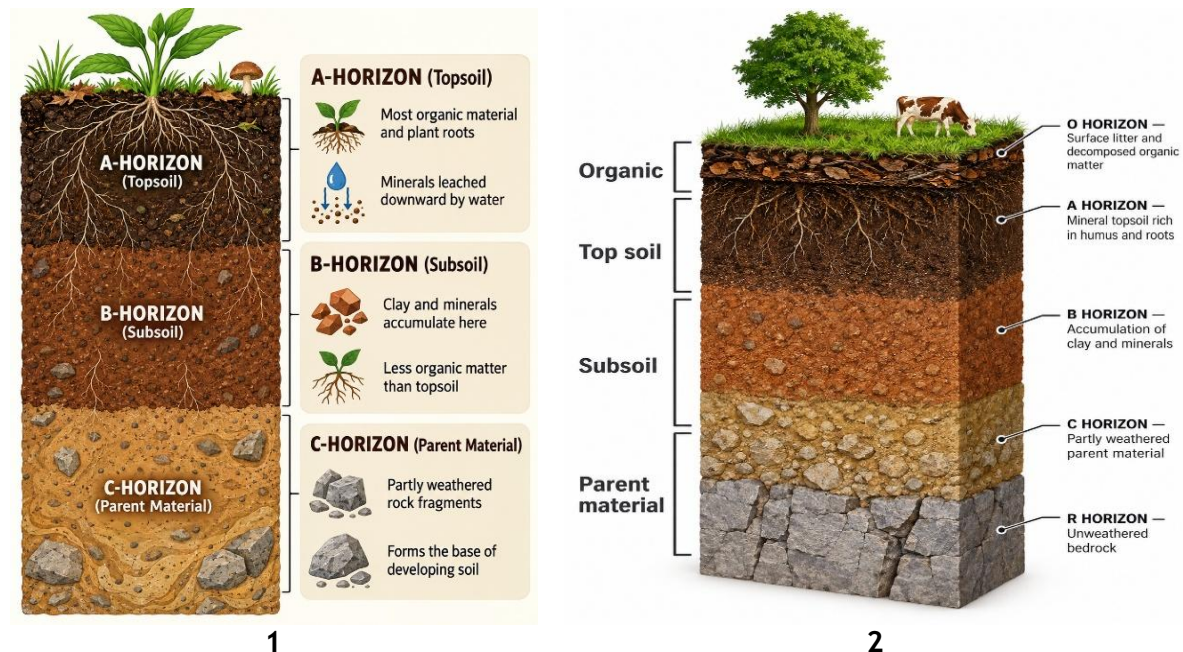


Figure 1: The Soil Profile (1: No Horizons O and R; 2: Horizons O and R are Present)

Credit: Adapted from (<https://agropublishers.com/2024/10/05/mcqs-soil-science/>)

Soil Health

Soil health is the capacity of a soil to function within ecosystem and land use boundaries; to sustain biological productivity, and maintain environmental quality (Krishnakumar *et al.*, 2013). Plant nutrients, organic and inorganic are the essential components of soil health, at least with respect to sustaining biological productivity. The standard measure of soil health is soil fertility, which is itself determined by soil parameters such as soil nutrient availability (macro-and-micro-nutrients), cation-exchange-capacity, organic matter content, aeration, percolation, etc. The principal parameter in soil fertility assessment is the cation-exchange-capacity of soil (CEC). Cation-Exchange-Capacity, is the ability of the soil to both hold and release positively-charged nutrients (cations). Whereas, fertile soils hold high cation-exchange-capacity with abundant “base cations” (calcium, magnesium, and potassium), infertile soils are dominated by acidic, toxic cations (aluminum, hydrogen, and sodium) and prone to nutrient-leaching sandiness (<https://www.taurus.ag/plantnutrition/2025>).

In a fertile soil, the Permanent Nutrient Pantry (PNP) holds a high capacity of nutrients, typically ranging from 10-30 cmol/kg or higher depending on the clay content and organic matter. Calcium (Ca^{2+}) usually occupies the largest percentage of the exchange sites (65-80 %), and is critical for cell walls, root development and balancing soil structure. Next to calcium, is magnesium (Mg^{2+}) occupying approximately 10-15 % exchange sites. As the central atom in chlorophyll molecule, magnesium is crucial for photosynthesis. Potassium

(K⁺) occupies about 3-5 % of exchange sites, and regulates the opening and closing of plant stomata, and therefore, vital for disease resistance and water regulation (<https://www.taurus.ag/plantnutrition/2025>).

Infertile soils generally have a low cation-exchange-capacity, often below 5 cmol/kg, because they are unable to hold nutrients against heavy rainfall, causing them to wash away or leach out (<https://www.taurus.ag/plantnutrition/2025>). Aluminum (Al³⁺) is the primary driver of soil infertility in highly-weathered, acidic soils (pH < 5.4). At low pH, aluminum becomes highly soluble and toxic, stunting plant root systems (CAES Field Report 2). Hydrogen (H⁺) at elevated levels displace beneficial base cations. Hydrogen ion (H⁺) dominance at the exchange site indicates high soil acidity and low overall nutrient retention. Sodium (Na⁺) is essential to soil and plants health in trace amounts, but high sodium saturation (>15 %) leads to “sodic” soils. Excess sodium degrades soil structure, cause clay particles to disperse, and create waterlogging and toxicity..

In an infertile soil, the percentage base saturation (the proportion of the CEC occupied by the beneficial Ca²⁺, Mg²⁺, and K⁺) drops dangerously low [6] (CAES Field Report 2).

GALAMSEY (ILLEGAL OPEN-CAST SMALL-SCALE GOLD MINING)

‘Nature is, but a name for an effect whose cause is God’ (William Cowper). He who fights nature, fights against himself. Land is a prime natural resource in agriculture, forestry, mining and quarrying, industrialisation, real estate, recreation, nature conservation, and more! Preservation, sustainable use, renewal, and restoration are critically important to protect land resources.

Ghana’s geological space is prospective with diverse natural minerals such as gold, diamond, and bauxite, legally-mined on both small and large-scale. Mining is important to the economy of Ghana, but illegal small-scale open cast gold mining called *galamsey* in particular, woefully fails to strike the balance between the nation’s economic and social well-being resulting from the sale and utilisation of mined resources and the protection of the environment and agricultural productivity (Danyo and Osei-Bonsu, 2016).

As most environmentally-destructive, *Galamsey*, disturbs the agricultural land base more than any other type of non-agricultural land use. In the Ghanaian experience, the adverse impacts of *galamsey* by surface mining method include: deforestation, reduction of soil fertility through stripping of top and subsoils, aggravated soil erosion, chemical contamination of surface and underground water, air pollution, physiological disorders in crop plants and low yields, food price hikes and high cost of living, displacement and general increase in air and water-borne diseases (Danyo and Osei-Bonsu, 2016).

Public outcry against the degrading and polluting effects of open-cast gold mining and the realization that, land expansion potential is reaching its limits in agro-ecological zones, due to population explosion, rapid urbanization and the industrial revolution in Ghana, is being addressed through reclamation or rehabilitation of degraded *galamsey* lands, primarily for agricultural purposes (Danyo and Osei-Bonsu, 2016). But agriculture is not the only compelling imperative for land reclamation and restoration. Reclamation and restoration are important to sustain biodiversity; protect birds and wild life, to decrease soil erosion and minimize the pollution of rivers and streams, to protect and maintain water

supply, to prevent and eliminate hazards to health and safety, to protect and enhance land use management and planning, restore soil health, etc. (Krishnakumar *et al.*, 2013).

From scientific, technical and ecological perspectives, land reclamation is not land (ecosystem) restoration. Reclamation (web dictionary) is the conversion of wasteland into land suitable for habitation or cultivation. Restoration is the act of bringing back to a former place, state or condition. Land restoration therefore, is returning a disturbed land system to a state that approximates the condition prior to disturbance (US National Research Council, 1992).

The philosophical dichotomy is premised on the fact that, value is not normative and that nature cannot be replaced without depreciation because origin and history are congenital elements of value (Elliott, 2000). The empirical dichotomy is premised largely on structural (physical and chemical) and biodiversity (biological) differences between a reclaimed or re-developed land ecosystem and intact or native climax land ecosystem. Land reclamation is the important first step in the long journey to land ecosystem restoration and resilience; it is not an end in itself.

The empirical dichotomy is analogous to 'asset retrieval and restoration phenomenon' in burglary, involving thief-police-owner chain. Take a mobile phone theft for an illustration. When the police retrieve a stolen phone from a phone thief; the phone is only reclaimed, not yet restored to the rightful owner. The retrieval by the police is the important action that ultimately leads to restoration of the mobile phone to the rightful owner for regular use. If the restored phone suffers defect, say cracked screen in the course of retrieval, then legally-speaking the phone is not restored (the damage must be compensated). Reclamation is the means to an end; not an end!

Both chemical and biological conventional methods of removal of pollutant heavy metals from soils and water are available. Ion exchange, chemical precipitation, ultra-filtration, infrared, ^{13}C nuclear magnetic resonance, and gas chromatography mass spectrometric analysis are some examples of chemical methods. An efficient biological alternative is biosorption: the ability of biological materials to accumulate heavy metals through metabolism or physico-chemical uptake.

Land reclamation bridges the gap between land degradation and restoration. Reclamation of *galamsey*-degraded arable lands in Ghana is an imperative, because land expansion potential is reaching its limits in most agro-ecological zones, due to population explosion, rapid urbanization and the industrial revolution in Ghana (Danyo and Osei-Bonsu, 2016).

The consequence of synonymy of land reclamation with land ecosystem restoration is biodiversity simplification or artificial ecosystem. For agricultural purposes, such an artificial ecosystem requires constant human intervention (highly input-dependent), whereas in natural ecosystems the internal regulation of function is a product of plant biodiversity through flows of energy and nutrients (Altieri, 1999). The error builds complacency that weakens our collective revulsion for the insensate destruction of nature by illegal small-scale gold mining; believing that, remedy lies in merely covering up dugouts or levelling up degraded areas and revegetating them.

The conflation of disapproval from the moral society and eco-conscious minority is muffled by the oratory artifice of utilitarians and financial might of local political financiers

who front for international gold merchants. The *coup de grace* is delivered by unpatriotic, unethical, and compromised, environmental scientists whose acquiescence legitimized the false scientific narrative of synonymy between land reclamation and land ecosystem restoration. The net effect of this tragic misrepresentation of environmental science is the insensate destruction of Ghana's land cover (forests and water bodies) in search of gold, believing that, the environmental assault is easily remedied by re-filling dug-outs or leveling up degraded arable lands.

Beyond the fallacy also lies the ticking public-health-time bomb, due to bio-accumulation or chemical toxicity of food crops grown in the heavily-polluted soils of reclaimed degraded lands. For instance, cases of multi-deformed newborn babies are rife in the epicentre communities of galamsey; babies without eyes, limbs, anuses, genitals, etc. Recommendations in my 2016 publication (**Danyo and Osei-Bonsu, 2016**), for such lands to be ceded to non-edible tree crops such as teak and rubber have not been fully-adopted.

The interchangeable use of land reclamation and land restoration is a veneer by insincere political actors to shirk responsibility for a national course, and unwitty euphemism by unprincipled and opportunistic scientists and scholars to outwit unsophisticated politicians and plunder national resources in a course which does not fully address a national tragedy! Presently (August, 2026), the periodic and ever-changing estimated cost of reclaiming a hectare of galamsey-degraded arable land is \$ 48 thousand; \$ 264 million for the over 5 500 hectares degraded so far. But, the overall national budgetary estimate for reclamation and short-term restoration (arable purpose only) of the 5 500-plus hectares, is a whopping \$ 17 billion! (**Joy News, Ghana; 7/09/2026**).

Yes, degraded lands must be reclaimed at all cost but, further efforts must be expended to attain land ecosystem restoration in the end. Land reclamation or re-development is only the important first step in the long journey to land ecosystem restoration; it is not an end in itself. This is the thesis of this scientific masterpiece.

RE-DEVELOPMENT OF LAND FOR AGRICULTURE AND ECOSYSTEM RESTORATION AND RESILIENCE

Ecology is the scientific study of the relationship of organisms to their environment. Environment is the immediate (physical, chemical, and biological) surroundings of an organism. The environment includes all biotic and abiotic factors impacting upon the organism. Combination of living and non-living components of the environment constitutes the ecosystem. Organisms of the same species or function interacting in an environment constitute a population. Summation of the populations in a particular ecosystem constitute the community. That is, a community is an association of plants and animals interacting in an environment.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (**SER-ISPWG, 2004**). **Elliott 2000** vehemently objects the "restoration thesis"; he argues, the creation of nature with equivalent value to compensate for that which was destroyed definition undermines conservation goals by suggesting that nature is replaceable (**Elliott, 2000**). Further, he postulates, value is not normative and that nature cannot be replaced without depreciation, because origin and history are congenital elements of value (**Elliott, 2000**). Bradshaw 1997 proposed the

alternative terms reclamation and rehabilitation to describe practices aimed at improving a system state to some combination of structure and function outside the “original” condition (**Bradshaw, 1997**).

Hobbs and Norton 1996 proposed a conceptual framework for restoration ecology that presents ecological restoration as a continuum of human-facilitated improvement of a system state, without regard to the degree of degradation (**Hobbs and Norton, 1996**). Furthermore, they outlined key processes that need to be understood (e.g., the degrading influence on a system; the realistic ability to remove that influence perpetuating the degraded state; and ecological, socioeconomic, and cultural constraints to removing the cause of degradation) to develop achievable restoration goals.

Restoration ecology applies ecological theory for ecological restoration; to reconstruct the composition, functions, and services of degraded environments (**Young, 2000**). The major issues in restoring nature are where to source individuals for initiating communities or augmenting populations; which systems serve as appropriate references; and whether modified or entirely different restoration targets should be considered in light of rapid climate and other global changes (**Falk *et al.*, 2006**).

The State Factor Theory of Soil Development for Agriculture and Land Ecosystem Restoration and Resilience

Combination of living and non-living components of an environment constitutes the ecosystem. Interactions of total ecosystem properties on soil development were described succinctly by **Jenny (1941)** as the state factor theory. Jenny’s theory opines, factors that moderate soil development include regional climate, biotic factors, the potential flora on the landsite, topography, parent material, and time (**Jenny, 1941**). The theory was modified by Amundson and Jenny, 1991, to include anthropogenic influences; the current ecosystem type as well as those preceding have combined to produce the soil of interest (**Amundson and Jenny, 1991**).

Biotic properties of an ecosystem are not limited to natural traits, but include any consequence of anthropogenic intervention or interaction in the environment. But anthropogenic factors are usually distinguished in evaluation of ecosystem function because human interactions commonly alter the nature and properties of the biological community. Anthropogenic interventions modify the properties of the soil biological community when they sufficiently modify a controlling property of the soil ecosystem to shift the equilibrium of the specific soil ecosystem. This alteration of system descriptors is exemplified by the three preconditions for amendment of a chemical to a soil to shift the biological equilibrium effectively:

1. The chemical (amendment) must be added in concentrations that significantly change the levels of pre-existing in the soil. For example, nitrogen contained in sewage effluent could be major nitrogen source to plant communities in land disposal systems;
2. The chemical (amendment) must be added in sufficient quantity to alter the steady-state equilibrium. For example, dealing with the impact of acid rain on environmental systems. In well-buffered, calcareous soils, the impact of the acid

content of the rain water is modulated by the buffering action of the calcium carbonate and soil organic matter; and

3. The chemical may be toxic to the soil organisms. Biodegradable toxicants temporarily inhibit microbial processes. Examples of biodegradable compounds commonly encountered by soil communities are pesticides and petroleum components contained accidental spills or used as carriers during pesticide application. In contrast, a non-biodegradable compound would have a more lasting impact on ecosystem function, if toxicant-resistant microbial communities are not developed.

Ecosystem restoration and resilience is largely a biological process and anchored on biodiversity. Indeed, natural biodiversity is the foundation for all agricultural plants and animals. What makes agriculture possible is not the physical or chemical soil properties. Instead, the presence of soil microbes; their inter-relationships and interactions with the physical and chemical soil properties. But evaluation of ecosystem dynamics must not be limited to the metabolic capacity of the soil microbial community, and their physical and chemical needs, but also the impact of higher organisms on the vitality and survival of front-line matter mineralisers (bacteria, fungi, and actinomycetes).

The Critical Roles of Soil Physical, Chemical, and Biological Properties and their Associated Biodiversity in Re-development of Land for Agriculture and Land Ecosystem Restoration and Resilience

The major soil physical properties are the soil texture and structure. Soil texture is the relative size of the soil particles or fragments in a soil. It is most important in designating soil types as sand, clay, and silt. Soil texture controls all fundamental soil properties, namely physical, chemical, and biological. The soil structure is the relative arrangement or assemblage of the soil particles in the soil. It is more important than texture in determining the habitat of microorganisms. It has direct effect on soil aeration, water infiltration, percolation, and nutrient circulation, as well as plant root growth.

The major soil chemical properties are pH, soil nutrients, organic matter, water, and growth factors (temperature, light, and soil air). Generally, rarely will one soil property preclude life processes; mineral nutrients, organic matter, and growth factors exist within appropriate temperature, moisture, and pH ranges in the soil for growth and community development. But the soil also contains a variety of growth inhibitors (e.g. heavy metals and organic and inorganic acids).

Soil nutrients are the most important part of soil health. In agriculture, forestry, environment, and the ecosystems, soil or plant nutrients are the essential components of soil health, at least with respect to sustaining biological productivity. Soil health is the capacity of a soil to function within ecosystem and land use boundaries; to sustain biological productivity, and maintain environmental quality.

Soil organic matter (SOM) through mineralization and humification contributes to soil quality development in soil environment (FAO, 2005). Like clay particles, organic matter is negatively charged, and so attract positively-charged ions or cations, from the soil solution. These ions are held by relatively weak electrostatic forces and easily replaced by other cations of similar charge. Thus, soil organic matter acts as a colloid, attracting positively

charged elements and compounds including cations and other nutrients. This process of exchange allows nutrients to remain available to plants while minimizing losses due to leaching. The balance of cations adsorbed on these sites influences soil structure, aggregation, and nutrient availability (Table 1) (<https://taurus.ag>). In loose soil particulates, such as sand and silt organic matter binds soil particles and also conserve soil moisture.

pH (soil reaction) directly influences soil nutrient availability, and indirectly affect concentrations and toxicity of environmental substituents, as well as (Tate, 1995). Another indirect effect of acidic soil pH conditions on biological activity relates to the potential for solubilisation of toxic compounds or elements. Aluminum is more available under acidic conditions; toxic levels of this cation are commonly detected in acidic reclaimed soils.

Moisture or Water serves as an essential material for flora and fauna (hydrolysis and hydroxylation reactions, involved in gas exchange in soil, acts as the transport medium of microbial nutrients supply to the cell and of waste materials away from the cell, as growth-medium for microbial colonies, and responsible for soil temperature regulation (Tate and Ensign, 1974); (Hirschberg and Ensign, 1972).

Temperature is one of the most important abiotic factors influencing growth and development in biological systems. Temperature is important in germination, development, yield and dispersal or distribution of crop plants. In green plants, besides photosynthesis, ideal sunlight is necessary for flowering and fruiting; otherwise, floral and fruit abortion are high. Light is essential for the formation of chlorophyll and photosynthesis. Inadequate light results in weak, etiolated or spindly crop plants liable to attack by pathogens. Excessive light destroys chlorophyll, however. Also, time of flowering in some crop plants is affected by daylength.

Soil air or molecular oxygen in soil is primarily a terminal electron acceptor. Oxygen is the highest energy-producing electron acceptor. The greatest cell yields are produced by the total oxidation of an organic-carbon-containing substance to carbon dioxide and water. This important function of molecular oxygen in aerobic metabolism is augmented by its direct incorporation into molecular structures of such compounds as aromatic-ring-containing substances and alkanes by oxygenase. Observably, and except for consistently-inundated or flooded soils, most microbes in surface soils are aerobes. Indirect limiters of soil oxygen are therefore, soil moisture and the concentration of metabolizable organic matter.

The major soil biological properties are the soil biota and their associated biodiversity. Soil biota are the organisms living and communicating in the soil environment. They are the 'biological engine of the earth'; driving and transforming physical, chemical, biological and ecological processes in soils (Ritz *et al.*, 2004). They include the bacteria, actinomycetes, fungi and algae (the micro-flora); the protozoa and nematode (the micro-fauna); the collembolan, mites, termites, ants and other associated micro-organisms and meso-fauna and flora (Usman *et al.*, 2016) (Table 1). Soil organisms provide many supports in the transformation and development of soil physical and biological properties; are exclusively part of soil formation and decomposition processes of diverse plant and animal materials. The arrangement of soil particles into different shapes, sizes and forms are vital to the soil formation and soil development (FAO, 2007).

The activities of soil biota are essential for soil health, and sustainable function of all ecosystems, by acting as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission; modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation, enhancing plant health and maintain soil quality (Denef *et al.*, 2001); (FAO, 2005); (Dominguez *et al.*, 2014), (Table 1). Generally, without vital recycling processes of soil organisms, the soil would become a stockpile of dead plant and animal materials with no facilities to reprocess essential nutrients such as carbon, nitrogen and phosphorus in soil ecosystem (Eskelinen *et al.*, 2009).

Table 1: Functional services of soil biota to soil aggregate particles

Aggregate ecosystem functions		Soil biota
1.	Carbon transformations	Microfoodweb: 1. Microflora - fungi, bacteria, 2. Microfauna - protozoa, nematodes Littertransformers: 3. Mesofauna - enchytraeids, microarthropods, 4. Macrofauna- earthworms, macroarthropods
2.	Nutrient cycling	Microfoodweb Litter transformers Root/rhizosphere biota 1. N-fixers 2. Mycorrhizae 3. Free-living rhizosphere Microbes 1. Microbial pathogens 2. Root herbivores
3	Soil structure maintenance	Ecosystem engineers 1. Roots 2. Macrofauna 3. Earthworms 4. Macroarthropods 5. Fungi
4.	Biological population regulation	Microfoodweb Biocontrollers 1. Predators 2. (Hyper)parasites 3. Microbial pathogens 4. Root herbivores

Usman et al., 2016)

Biodiversity is life in its various forms all species of plants, animals and micro-organisms existing and interacting within an ecosystem (Vandermeer and Perfecto, 1995). Natural biodiversity is the foundation for all agricultural plants and animals. In addition to producing valuable plants and animals, biodiversity performs many ecological services. In natural ecosystems, the vegetative cover of a forest or grassland prevents soil erosion, replenishes ground water and controls flooding by enhancing infiltration and reducing water runoff (Perry, 1994). In agroecosystems, biodiversity performs a variety of ecological services beyond the production of food, fiber, fuel, and income. Examples include recycling

of nutrients, control of local microclimate, regulation of local hydrological processes, regulation of the abundance of undesirable organisms, and detoxification of noxious chemicals (Altieri, 1999); (Table 2).

Table 2: Influences of soil biota on soil processes in ecosystems

Soil Biota	Nutrient Cycling	Soil Structure
Microflora (fungi, bacteria, Actinomycetes)	Catabolize organic matter; mineralize and immobilize nutrients	Produce organic compounds that bind, entangle particles onto aggregates; hyphae structure
Microfauna (Acarina, Collembola)	Regulate bacterial and fungal populations; alter nutrient turnover	May affect aggregate through interactions with microflora
Mesofauna (Acarina, Collembola, Enchytraeids)	Regulate fungal and microfaunal populations; alter nutrient turnover; humification	Produce fecal pellets; creates biopores; residues promote structure
Macrofauna (isopods, centipedes, millipedes, earthworms)	Fragment plant residues; stimulate microbial activity	Mix organic and mineral particles; redistribute organic matter and micro-organisms; create biopores; promote humification; produce fecal pellets

(Hendrix *et al.*, 1990). In: Altieri, M. A. (1999).

DIFFERENCES BETWEEN RECLAIMED LAND SYSTEM AND NATIVE CLIMAXED COMMUNITY LAND ECOSYSTEM

Land reclamation is the conversion or re-development of degraded land into land suitable for habitation or cultivation, whereas restoration is returning a degraded land system to a state that approximates the condition prior to degradation or disturbance (US National Research Council, 1992). From scientific, technical and ecological perspectives, land reclamation is not land (ecosystem) restoration. Reclamation is the important first step in land ecosystem restoration; it is not an end in itself. The dichotomy is largely due to structural (physical and chemical) and biodiversity (biological) differences between a reclaimed or renewed land ecosystem and a non-degraded or intact or native climax land ecosystem.

Physical Difference

Like the characteristics of their associated microbial community, soil components and their interactions are variable. The soil physical and chemical properties and their variability limit the capabilities of the soil microbial community, and ultimately total ecosystem development and resilience, since the below ground determines the above ground development. When land (soil) is dug up, broken up or degraded for that matter, it can never be fully restored to its pre-destructive state, technically-speaking. The soil profile, particle configuration (physical), biological associations, pH (chemical properties), and general soil health of decades or centuries are adversely-altered, and cannot be fully-restored on the human life-scale, especially, the biological associations such as mycorrhizas. Filling up mine dug-outs (*galamsey* pits) or levelling up degraded mine lands, unavoidably results in the mixing up soil layers, adversely affecting soil structure and consistency.

Unlike intact or native lands, soils of reclaimed or renewed lands are usually loose, friable, water-pervious, easily eroded and leached. The reclamation process of degraded lands also involves soil compaction to increase mechanical strength, reduce erosion, and leaching of soil nutrients. But, if inappropriately compacted may hinder aeration, percolation, seed emergence, root penetration, and overall plant growth. Soil components and their interactions are just as variable as the characteristics of their associated microbial populations.

Chemical Difference

The enzymatic capability of living organisms is the basis of their ecology. The response of a soil biological activity to environmental perturbation is determined by ecosystem properties that control soil processes, and the nature of the reaction or activity. The spatial and temporal variability between native (intact) soil systems and renewed/reclaimed soil systems is conceptually clear. Temperature, moisture, nutrients (principally, carbon and nitrogen), pH, and aeration regimes are totally different. Surface soil temperature in renewed soils may be higher due to the absence of surface litter and close canopy. Differences between the soils relate primarily to the proportional increase in reaction kinetics with temperature augmentation (**Tate, 1987**).

Because many mining processes release harmful chemicals such as metal-sulfide-bearing slags, acidification is a major reclamation problem. Biological activity in these waste materials result in oxidation of the sulfide to more harmful sulfate. For instance, in reclaimed soils with elevated hydrogen ion concentration, cellular surface charge varies with environmental pH. This variation controls the interaction with soil particles as well as with charged nutrients. Trace mineral availability provides an excellent example of pH interactions with nutrient availability (**Tate, 1995**). The effect of soil pH on soil microbial community development and function, is one more distinctive difference between reclaimed degraded mined lands and intact or non-degraded land systems. Similar temporal effects can be described for others such as nutrient concentration, pH, and moisture. Chemically, the spatial and temporal variability between native (intact) soil systems and reclaimed soil systems is conceptually clear.

Biological Difference

The soil biological system modifies its environment to conditions more conducive for growth and community development (**Kardol and Wardle, 2010**). Unlike intact climax-community land ecosystems, reclaimed or renewed land systems are not in a steady-state, accounting for significant biological difference between the two land systems. Thus, in reclaimed land system, populations and/or their activities may increase to reach an augmented density or activity level allowed by the new prevailing environmental conditions, or alternatively, they may decrease to accommodate newly-imposed conditions or restrictions. The microbial index and function in an intact climax-community land ecosystem is higher than renewed/reclaimed land systems due to inherent soil nutrients deficit in reclaimed soils.

Biodiversity Difference

Renewal processes and ecosystem services are largely biological; therefore, their persistence depends upon maintenance of biological diversity (Altieri, 1994). The impact of an environmental insult (exogenous or anthropogenic) on the basic properties of undisturbed (intact or native climax community ecosystem) are totally different at the ecosystem level from reclaimed or renewed land ecosystem. This among others, constitute yet another major technical, scientific and ecological difference between reclaimed and undisturbed land systems. Indeed, the ultimate importance of any biotic or abiotic trait or interaction is its contribution to community stability, and resilience; the capacity of the ecosystem to be maintained and its resistance to disruptive perturbations.

Ecosystems in climax communities evolved over decades and centuries, and have stable physical, chemical, and biological associations. There is greater balance and stability in the population dynamics of say, hosts and pathogens, predator and prey, more-balanced nutrient, hydrological, and thermal cycles in climax land communities. To the contrary, renewed land ecosystems require time to fully-evolve to perform these functions. For example, mycorrhizal association supplying soils with useful soil nutrients such as nitrogen, phosphorus and sulfur, occurs only in matured ecosystems in association with matured (emergent) trees of particular tree species. Same can be said of other rhizosphere biological associations, but these are not possible in young non-climax ecosystems of reclaimed or renewed lands. Roots of emergent trees in native climax community ecosystems can reach great depths (far beyond soil water table), absorb and transpire water, cooling and creating favourable micro-climate for growth. Such trees also anchor climbing and arboreal plants/epiphytes, and shelter diverse community of insects, birds, reptiles, and small mammals, thereby enriching biodiversity.

Organic Matter Difference

Soil organic matter acts as a colloid, attracting positively charged elements and compounds including cations and other nutrients in soils. This process of exchange allows nutrients to remain available to plants while minimizing losses due to leaching. Leaf litter accumulation, their decomposition into humus or humic acids constitute major source plant soil nutrients, particularly in the surface and top soil horizons (Bardgett, 2005). Whereas, intact or native climax-community land ecosystems such as forests, have huge reserves of humic substances, young or renewed land ecosystems have significantly less because, they begin and remain as grasslands for considerable time period. The generally, loose soil particulate or reclaimed land systems lack adequate organic matter to bind the soil particles and also conserve soil moisture. The differences between these two ecosystems are huge, real, material, and almost inexhaustible and should never be glossed over.

DISCUSSIONS

Land reclamation is the conversion or re-development of degraded land into land suitable for habitation or cultivation, whereas restoration is returning a degraded land system to a state that approximates the condition prior to degradation or disturbance (US National Research Council, 1992). From scientific, technical and ecological perspectives, land reclamation is not land (ecosystem) restoration. Reclamation is the important first step in

land ecosystem restoration; it is not an end in itself. The dichotomy is largely due to structural (physical and chemical) and biodiversity (biological) differences between a reclaimed or renewed land ecosystem and a non-degraded or intact or native climaxed land ecosystem.

Physical Difference Between Reclaimed and Native Climaxed Community Land Ecosystems in the Development of Land for Agriculture and Land Ecosystem Restoration and Resilience

On face value, soil appears to be just particulate matter comprising, sand, silt, and clay fractions, and perhaps, rock and pebble contents. The presence of a living, respiring, and functioning microbial community is usually not apparent. But, living organisms are there; beneficial to the total ecosystem only to extent to which, they can function within the soil physical matrix; these organisms will be of no benefit to the total ecosystem if they cannot function within the soil physical matrix. Like the characteristics of their associated microbial community, soil components and their interactions are variable. The soil physical and chemical properties and their variability therefore, limit the capabilities of the soil microbial community, and ultimately total ecosystem development and resilience, since the below ground determines the above ground development. Even in situations where *a priori* considerations predict that water and temperature are growth-limiting, microorganisms occur in extremely specialized niches (Friedmann, 1982); (Johnston and Vestal, 1991).

Perhaps, the greatest physical difference between soils of reclaimed degraded lands and non-degraded lands is disruption of the soil layers, alteration of the soil structure and its consistency (Figure 3). Soil structural consistency significantly influences soil aeration, percolation, nutrient circulation, root penetration, growth and development. When over-compacted and predominantly of clay consistency, they tend to be water-logged (creating anerobic conditions), resist nutrient re-circulation and root penetration, growth and development. When under-compacted, the structure of reclaimed degraded soils is fragile; loose or friable resulting in high rates of carbon flight (low carbon-sequestration), leaching, erosion, and lodging of crops/plants. Unlike steady-state intact or native land systems, reclaimed soil systems are either over- compacted or sub-compacted. These factors impact community development, and ecosystem resilience.

In my opinion, ecologically, a soil is nothing without a diverse and functional biological community within and without. A complete understanding of soil microbial behaviour and its contribution to total ecosystem function (growth and community development) is possible only with an appreciation of their physical environment. That is both the mix of individual soil components, as well as the physical impediments posed to the soil microbes by the assembly of these discrete particles into a defined soil structure, including horizontal development and aggregate formation (Tate, 1995).

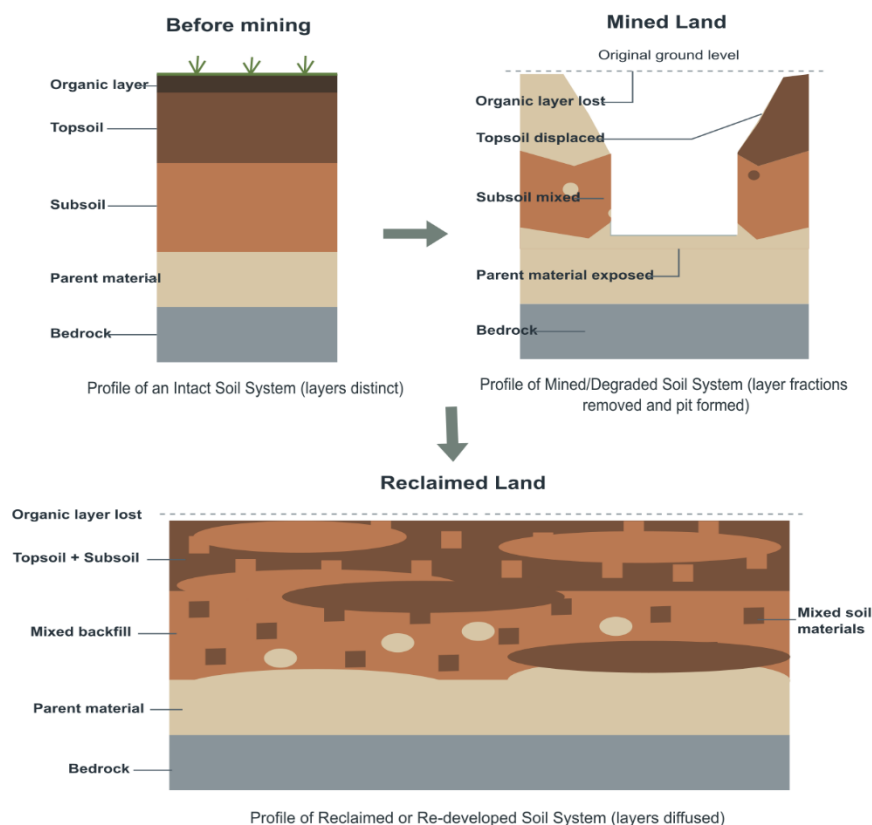


Figure 2: Depiction of the soil profiles of intact, degraded (mined), and reclaimed land systems. Created using Notebook Large Language Model-Based Research Tool (Google, 2006 Software)

Chemical Difference Between Reclaimed and Native Climaxed Community Land Ecosystems in the Development of Land for Agriculture and Ecosystem Restoration and Resilience

All soil processes are a summation of the activities of a variety of individuals, be it cell, multicellular complex, or even collection of enzymes. The response of a soil biological activity to environmental perturbation is determined by ecosystem properties that control soil processes, and the nature of the reaction or activity. The phenomenon of a soil-property-controlling biological activity (impact of the variation of chemical nutrients on microbial growth and activity) is termed the Liebig's Law of the Minimum.

The law states that, under steady-state conditions, the essential material available in amount most closely approaching the critical minimum needed by a given organism will tend to be the limiting one (Dommergues *et al.*, 1978). Generally, rarely will one soil property preclude life processes; mineral nutrients, organic matter, and growth factors exist within appropriate temperature, moisture, and pH ranges in the soil for growth and community development. But the soil also contains a variety of growth inhibitors (e.g. heavy metals and organic and inorganic acids). Now state the difference between the two systems.

Biological Difference between Reclaimed and Native Climaxed Community Land Ecosystems in the Development of Land for Agriculture and Ecosystem Restoration and Resilience

The soil biological system modifies its environment to conditions more conducive for growth and community development (**Kardol and Wardle, 2010**). Classically, the stability of the soil community is defined as homeostasis; the tendency of a biological system to resist change and to remain in a state of equilibrium. Maintaining the equilibrium that defines the existing ecosystem type is commonly accomplished by negative feedback (a change in one or more populations induced by modification of some environmental variable that brings about a response in other populations in such a manner that the original fluctuation is opposed/dampened). Negative feedback is the biological equivalent to the physics action-reaction principle; a change in one portion of the system must result in an opposing alteration in another part, for the existing condition to be maintained (**Tate, 1995**).

The soil environment is the most complex biological community, and the soil organism community has direct and indirect impacts on soil nutrient availability and land productivity (**Barrios, 2007**). The microbial index and function in an intact climaxed-community land ecosystem is higher than renewed/reclaimed land systems. Unlike reclaimed land systems, native climaxed land ecosystems are in a steady state, and the activities of vital soil microbes and their biological associations are optimal and in a dynamic equilibrium. Reclaimed land systems are fragile for many reasons such as the failure to capture and release useful soil microbes into re-developed land systems. Even when introduced, overall cellular proliferation is a slow adaptation to ecosystem modification, and so, often results in high microbially mortality. However, once the microbial populations develop, they may survive for decades or longer even though the conditions causing their replication no longer exist.

In intact/native climaxed land ecosystems, many rhizosphere organisms produce plant growth hormones such as indolacetic acid (IAA), gibberellins or gibberellic acid (GA), and cytokinins (**Nietko and Franhenberg, 1989**); (**Tien *et al.*, 1979**), to stimulate root tissue development, and enhance the capacity of the root system to provide nutrient and water required for above-ground biomass function. The roots together with associated soil microbes contribute to stable soil structure ideal for further plant community development. Perhaps, the greatest primary benefit of the rhizosphere microbial community to plant community is the mineralization of plant biomass. Organic nitrogen, phosphorus, and sulfur compounds are oxidized, thereby liberating ammonium, phosphorus, and sulfur. Thus, the non-bioavailable organic forms of these essential nutrients are converted to plant-available mineral forms in intact or native climaxed land ecosystems.

Death of the plant (caused by land degradation) results in a decline in the rhizosphere community, and its contribution to total soil health. Thus, the new or succeeding vegetation, to a large degree, determines its own rhizosphere community composition, when climax or steady-state is eventually attained (**Tate, 1995**).

Biodiversity Difference Between Reclaimed and Native Climaxed Community Land Ecosystems in the Development of Land for Agriculture and Ecosystem Restoration and Resilience

Biodiversity is life in its various forms all species of plants, animals and micro-organisms existing and interacting within an ecosystem (**Vandermeer and Perfecto, 1995**). Internal regulation of function in ecosystems is largely dependent on the level of plant and animal biodiversity present. The nature, activity, and future of any soil microbial community is determined by the capacity of individual members to adapt to or modify negative soil properties.

Modifying the physical, chemical, and biological properties of the community, results in induction of microbial processes to restore the homeostasis of the community. This adaptation may result in the re-emergence of ecosystem resembling that existing prior to degradation, development of a new community better suited to the newly-developed conditions, or total destruction of the biological activity. The ultimate fate depends upon the genetic diversity of the populations, the severity of the stress imposed, as well as the time allowed for recovery. Recovery in reclaimed land system may be in months, decades, or even centuries (**Tate, 1995**).

On the contrary, ecosystems in climax communities evolved over decades and centuries, and have stable physical and biological associations that are not easily disrupted by internal and external shocks. There is greater balance and stability in the population dynamics of say, hosts and pathogens, predator and prey, more-balanced nutrient, hydrological, and thermal cycles in climax communities. Renewed land ecosystems require time to fully-evolve to perform these functions. For example, mycorrhizal association supplying soils with useful soil nutrients such as nitrogen, phosphorus, and sulfur occurs only in association with matured (emergent) trees of particular tree species. Same can be said of other rhizosphere biological associations. Such useful biological associations are not possible in young ecosystems of reclaimed lands.

Organic Matter Difference Between Reclaimed and Native Climax Community Land Ecosystems in the Development of Land for Agriculture and Ecosystem Restoration and Resilience

Agro-chemical or inorganic fertilizers do not improve soil health quality. Like steroids that leave dependent athletes in worst state after their activity period, chemical fertilizers once exhausted, leave agricultural soils poorer, leading to diminishing soil productivity.

Soil organic matter (SOM) through mineralization and humification contributes to soil quality development in soil environment. Mineralization is the biochemical breakdown of organic materials by soil biota, whereas humification is the change of simple organic substances into larger molecules, which finally become humus (**FAO, 2005**).

Leaf litter accumulation, their decomposition into humus or humic acids constitute major source plant soil nutrients, particularly in the surface and top soil horizons. Whereas, intact or native climax-community land ecosystems such as forests, have huge reserves of humic substances, young or renewed land ecosystems have significantly less because, they begin and remain as grasslands for considerable time period. The differences between these two ecosystems are huge, real, material, and almost inexhaustible and should never be glossed over.

CONCLUSIONS AND RECOMMENDATIONS

Agriculture is not the only hypothetical imperative for land reclamation and restoration. Reclamation and restoration aim to reconstruct or manage land system processes to achieve abiotic and biotic conditions formed by geology, hydrology, climate, and biota. Land restorative practices on agricultural soil can simultaneously benefit soil structure, reduce erosion, conserve water and nutrients, decrease the rate of atmospheric carbon dioxide enrichment, and improve food security (Lal, 2004). In Ghana, reclamation, especially *galamsey*-degraded lands, is a categorical imperative! Because, land expansion potential is reaching its limits in most agro-ecological zones, due to population explosion, rapid urbanization and the industrial revolution in Ghana. The reclamation and restoration are necessary to sustain biodiversity; protect birds and wild life, to decrease soil erosion and minimize the pollution of rivers and streams, to protect and maintain water supply, to prevent and eliminate hazards to health and safety, to protect and enhance land use management and planning, restore soil health, among others.

From scientific, technical and ecological perspectives, land reclamation is not land (ecosystem) restoration. Reclamation (web dictionary) is the conversion of wasteland into land suitable for habitation or cultivation, whereas restoration (web dictionary) is the act of bringing back to a former place, state or condition. Ecologically, land restoration is returning a disturbed land system to a state that approximates some condition prior to disturbance; the creation of nature with equivalent value to compensate for that which was destroyed (US National Research Council, 1992). The philosophical dichotomy is premised on the fact that, value is not normative and that nature cannot be replaced without depreciation because origin and history are congenital elements of value (*sensu* appreciation of original artwork versus a reproduction) (Elliott, 2000). The empirical dichotomy is premised largely on structural (physical and chemical) and biodiversity (biological) differences between a reclaimed degraded or re-developed land ecosystem and a non-degraded or intact or native climaxed land ecosystem.

The dichotomy is analogous to ‘asset-retrieval-and-restoration’ in burglary phenomenon, involving thief-police-owner chain. Take a mobile phone theft for an illustration. When the police retrieve a stolen phone from a phone thief; the phone is only reclaimed, not yet restored to the rightful owner. The retrieval by the police is the important action that ultimately leads to restoration of the mobile phone to the rightful owner for regular use. If the restored phone suffers defect, say cracked screen in the course of retrieval, then legally-speaking the phone is not restored (the damage or liability must be compensated).

Land reclamation is the important first step in the long journey to land ecosystem restoration and resilience; it is not an end in itself. Land reclamation bridges the gap between degradation and restoration; land degeneration and regeneration. When arable land is dug up, broken up or degraded for that matter, it can never be fully restored to its pre-destruction state, technically-speaking. The soil profile, particle configuration (soil textural arrangement), biological associations, pH (chemical properties), and general soil health of decades or centuries are adversely-altered, and may not be fully-restored on the human life-scale. Whereas, intact or native climaxed-community land ecosystems such as forests, have huge reserves of humic substances, young or renewed land ecosystems have significantly less because, they begin and remain as grasslands for considerable time period.

If the reclamation and recovery process requires the use of aggressive exotic plants and animals, indigenous species may be lost in the long run. Also, predators in native climax land community ecosystems may become preys to more aggressive introduced species, thereby altering the pre-existing predator-prey population dynamics. The differences between these two ecosystems are huge, real, material, and almost inexhaustible and should never be glossed over.

When a climax community such as a tropical rainforest is uprooted, dug up and polluted with obnoxious chemicals/heavy metals like mercury, lead, cadmium, arsenic, and other commonly-used mining chemicals, just re-filling the degraded land with earth does not restore it. Because:

1. The soil cannot be detoxified of these pollutants to pre-existing and pre-destruction level in a reasonable time-span, if at all;
2. The aerate, percolate, and permeable consistency of the degraded soil may never be achieved again in the short-term. The inevitable compaction of the soil may alter soil structure and consistency;
3. The destruction kills or changes the relative positions of soil micro-flora and micro-fauna, disabling them from their ecological niche or efficient ecosystem function;
4. Water courses are diverted and water bodies sometimes permanently destroyed together with aquatic life.

Just replanting trees on reclaimed degraded land is not ecosystem restoration, because:

1. The pulling down of trees destroys important biological associations such as mycorrhizas which take years to evolve, and which enrich soils with essential plant growth factors such as amino acids, organic acids, vitamins, and enzymes (amylase, invertase, phosphatase, protease, etc);
2. Predator-prey relationships take years to consummate and ensure ecological balance, putting predatory pressure on vulnerable prey populations and population dynamics of predators in renewed ecosystems. This in turn can lead to displacement or migration, competition and competitive exclusion, and even extinction;
3. Roots of emergent forest trees can reach incredible depths, binding soil particles from top soil to parent rock, taking soil water from great depths and cooling the atmosphere through evapo-transpiration. This cannot be accomplished by young trees resulting in severe soil erosion, and scorching of flora and fauna of reclaimed lands.

Land reclamation or renewal is not land (ecosystem) restoration. Reclamation mixes up the soil fractions, rearranges the alignment of soil horizons or layers so that, the top soil may become the parent or mineral soil; the organic layer may become the subsoil, or any other such arrangement that takes nutrients far from the reach of the roots of most food crops (Figure 3). It destroys soil structural consistency which weakens the strength of soils to support heavy duty agriculture; sinks and collapses easily; causes lodging of crops, creating erosion gullies, etc.

Land degradation by killing or displacing most of the soil biota, even when renewed deprives the land system from most of the activities of these useful members of the soil

community ecosystem. Fundamentally, the activities of soil biota, and associated biodiversity are essential for soil health, and sustainable function of all ecosystems, by acting as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission; modifying soil physical structure and water regimes, enhancing the amount and efficiency of nutrient acquisition by the vegetation, enhancing plant health and maintain soil quality (Denef *et al.*, 2001); (FAO, 2005); (Dominguez *et al.*, 2014); and (Castro-Huerta *et al.*, 2015).

Therefore, the result of erroneous synonymy between land reclamation and land (ecosystem) restoration, especially for agricultural purposes is biodiversity simplification or artificial ecosystem. Such an ecosystem requires constant human intervention, whereas in natural ecosystems the internal regulation of function is a product of plant biodiversity through flows of energy and nutrients, and this form of control is progressively lost under agricultural intensification (Swift and Anderson, 1993). The interchangeable use of land reclamation and land restoration in Ghana, is a veneer by insincere political stakeholders to shirk responsibility for a national course and sophism by opportunistic scientists and scholars to plunder national resources in a course which does not fully address a national tragedy!

Ignorance or conceptual oversight is not an alibi. There should be no room for complacency from the erroneous synonymy of land reclamation with land restoration. Such is likely to weaken our collective revulsion for the insensate destruction of nature by illegal small-scale gold mining; believing that the remedy lies in just covering up dugouts or pits, or levelling up degraded areas and greening or revegetating them. What happens to the obnoxious or pollutant heavy metal deposits in the reclaimed soils, and the danger they pose to food and water (chemical residue or bioaccumulation), the ageless complex and useful biological associations, predator-prey population dynamics, long-established hydrological and geological cycles, etc? Yes, degraded lands must be reclaimed at all cost, but, further efforts must be expended to attain land ecosystem restoration in the long run. This is the thesis of this conceptual scientific masterpiece.

Declaration of Generative AI and AI-assisted Technologies in the Manuscript Preparation Process

During the preparation of this work the author used **Notebook Large Language Model-Based Research Tool (Google Notebook AI Software, 2026 version)** to create Figure 3. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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