



International Journal of Multidisciplinary Research and Development



Volume: 2, Issue: 9, 637-641
 Sep 2015
 www.allsubjectjournal.com
 e-ISSN: 2349-4182
 p-ISSN: 2349-5979
 Impact Factor: 4.342

Emetumah, Faisal C.
 Department Of Geography &
 Environmental Management
 Imo State University, Owerri

Duru Patricia N.
 Department Of Geography &
 Environmental Management
 Imo State University, Owerri

Implementing Sustainable Development through Efficient Reuse of Brownfields

Emetumah, Faisal C., Duru Patricia N.

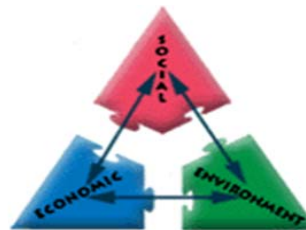
Abstract

Environmental, economic and social development on the earth surface has always been anthropogenic; we consume the earth's resources without care. However, this trend began to reverse towards the end of the 20th century with the sustainable development principles enshrined in the Brundtland Commission report of 1987. In order to reduce impact on virgin land, redevelopment of brownfields which are readily available in many urban areas should be explored. However, brownfields apart from being old and underused can be polluted thus may have pernicious effects on human health and environment if used without proper deconstruction and remediation. Deconstruction of brownfields should be done in stages: the preliminary stage involves a Life cycle Assessment; potentially hazardous materials on the site should be appropriately identified; the demolition stage involves taking down derelict structures; the recycling stage involves putting salvageable materials to good use. Before deconstruction can begin, appropriate remediation techniques must be employed to militate against contaminated parts of the brownfield which may be harmful to people and the environment. Design and deconstruction on brownfields should integrate sustainable practices which can significantly reduce the carbon footprint of new structures. Environmental considerations centering on pollution control should be made during the entire process. In addition, sustainable urban drainage systems (SUDS) should be integrated in the design process to reduce the impact of excess runoff. The essence of redeveloping brownfields is to significantly reduce environmental impact of land use thereby expounding the principles of sustainable development.

Keywords: sustainable development, brownfield, deconstruction, remediation

Introduction

Sustainable development as defined by the World commission on environment and development (WCED) report (Brundtland Report) of 1987 is quite logical and clear. According to the report, sustainable development looks at the capacity of the present generation of humankind to meet its current needs and at the same time realizing that future generations also have a right to meet their own needs (WCED report, 1987). Sustainability describes how we interact and benefit from environmental resources in order to provide solutions to our economic needs in a way that is socially harmonious as well as beneficial to both humanity and the environment. Figure 1 illustrates how the facets of sustainable development (social, economic and environment) are intertwined. The principles of sustainable development which centers on meeting 'human needs', can only be implemented if these facets are in equilibrium.



<p>Services Household Needs Industrial Growth Agricultural Growth Efficient Use of Labor</p>	<p>Equity Participation Empowerment Social Mobility Cultural Preservation</p>	<p>Biodiversity Natural Resources Carrying Capacity Ecosystem Integrity Clean Air and Water</p>
Economic	Social	Environment

Correspondence
Emetumah, Faisal C.
 Department Of Geography &
 Environmental Management
 Imo State University, Owerri

Fig 1: Facets of Sustainable development. Source: DEP, World Bank Group; 2001

Vargas (2000) ^[27] opined that the Brundtland Commission demonstrated the importance of the social unit of sustainability to the overall success of the entire system. It provides conditions and interactions through which the environmental and economic facets can interact and be put to adequate use. On that note, individuals or organizations that operate within any society and who want to implement sustainable development must be perceived to be 'sustainably responsible'. Corporate social responsibility looks at making additional provisions for the wellbeing of society (man and the environment) that are not mandatory on the organization or individual in question (McWilliams *et al* 2005) ^[17]. Sequel to that, Filizova & Fisne (2011) ^[13] stated that corporate social responsibility involves streamlining organisational and societal goals to mean the same thing so that society is not negatively affected by the organizations' profit making plans.

Background

According to Wedding (2007) ^[28], a Brownfield is defined by the condition of the site; they are usually old under-utilized or abandoned sites that are not fresh or agricultural land found mostly in urban areas. Many brownfields are contaminated due to their previous uses and cannot be put to use without intervention; deconstruction and remediation must be undertaken before brownfields can be put to any new meaningful usage. Because they are found in urban areas, redevelopment of brownfields are very important in implementing sustainable development because reusing these derelict sites help in reducing the need for fresh and virgin lands. On that note, Thornton & Nathanail (2005) ^[24] observed that the European commission in its quest to provide a holistic, logical and sustainable strategy for future soil protection, proposed integrated cost effective methods that can be used to sustainably prevent and restore contaminated soil as part of its environment action plan. Vanheusden (2009) ^[26] affirms that EU directive 2004/35/CE on environmental liability provides the needed direction in brownfield redevelopment as it covers prevention of environmental contamination or damage that are likely to occur. The directive stated who is liable if it does occur; and advocates the 'polluter pays' principle as those liable bear financial cost of remediation.

In the United Kingdom, part IIA of the Environmental protection Act 1990 (c.43; 1990) ^[11] gives the local authority the power to determine when land is contaminated and monitor remediation. It becomes a 'special site' if contamination risks are high and require the attention of relevant authorities.

Stages in the Reconstruction of Brownfields

Preliminary stage

Ortiz *et al* (2009) asserts that to cover a project from inception to demolition as well as social aspects/impacts, Life Cycle Assessment (LCA) should be used in undertaking the deconstruction of a brownfield. This will help outline strategies to be adopted; it considers a projects' economic viability, environmental assessment and the remediation exercise to be carried out on the site.

Deconstruction will involve an appraisal of the current structures on the brownfield. This will be carried out with other stakeholders in the design and construction process (builders, planners, architects) so that they can help identify materials that can be recycled or reused and also enable them understand as well as participate in the sustainability drive of the project. Reusable and recyclable components like

detachable metal fittings and tanks, window frames, metal or timber doors, glass materials etc. will be carefully removed from existing structures for subsequent recycling or reuse. Recyclables can be sorted into different categories for recycling in situ or sent to the nearest appropriate recycling centre for transformation into raw materials or finished goods.

Identification of potentially hazardous materials

According to Klang *et al* (2003) ^[15], several precarious materials can be found in the deconstruction of derelict structures; they opined that these have to be handled carefully by authorized personnel and as stipulated by relevant legislations. Some of these materials include polychlorinated biphenyl (PCB) materials, chlorofluorocarbon (CFC) – gases in cooling systems, asbestos containing materials, lead containing materials etc. However, the nature of hazardous materials in brownfields depends on their makeup as well as their previous uses.

Sites previously used as textile factories have a lot of potentials to be contaminated due to the processes involved in textile manufacturing. Das (2011) ^[8] highlights that textile manufacture processes like washing, dyeing and stabilizing use chemicals that contain heavy metals like copper chromium and cobalt, compounds such as trichloroethylene (TCE), phosphates, surfactants, formal aldehyde and acetonitrile which are very pernicious to the human and environmental health/safety.

Potential hazardous materials from brownfields previously used for furniture manufacturing usually comes from additives and chemicals that are used to treat, tone and polish wooden materials. Kruopienė *et al* (2004) ^[16] affirm that several solvents (Di (2-ethylhexyl) phthalate (DEHP), toluene, butyl acetate, xylene etc.) used in furniture manufacturing are toxic to humans and the environment and have been in use for decades.

Brownfields previously used for vehicle manufacturing and servicing contain hazardous materials mostly from heavy metals, heavy oils, petroleum derivatives and additives. Uno *et al* (2008) ^[25] opined that many hydrocarbons which can be aromatic or aliphatic are toxic to human health, flora and fauna if they find their way into the soil or washed away as effluent into natural water systems. CONCAWE (1998) ^[5] stated that heavy fuel oils have the potential to be carcinogenic to humans and cause significant pollution to soil and water organisms especially when they slip into natural water ways.

Demolition stage

Implosion method: is a demolition procedure that involves the use of explosive charges to bring down derelict structures that are very tall and would pose a lot health and safety risks to workers on site, people living nearby and neighbouring buildings if any other method is used. It involves carefully wiring sufficient explosive charges at strategic levels of the building so that when set off allows successive displacement of the buildings supports, resulting in the structure coming down uniformly (Rodriguez; 2011) ^[21].

High reach arm demolition machines: These are commonly used to demolish masonry structures of about 20 meters or more; particularly if they contain reinforced concrete and steel materials. It usually consist of hydraulic arm excavator connected to a base machine where the excavator is controlled to demolish the structure as desired by the site engineers. In addition, smaller excavators, bulldozers and crushers are required for chomping large bits.

Crane & ball machines: composed of a heavy steel ball connected to a crane base machine. The demolition is carried out by swinging or dropping the steel ball into the structure (Rodriguez; 2011) [21]. Crane and ball machines like high arm machines require the use of other excavators to crush the large structural parts from the demolition into smaller bits. However, crane and ball machines have a lot of health and safety risks when used in densely populated locations; this should be considered during the LCA process.

Recycling stage: Stakeholders in construction industry established benchmarks which cover important areas like legal perspectives, sustainable components as well as the engineering methodology that guide the recycling and reuse of construction materials.

Masonry/concrete materials (Recycled concrete aggregates): masonry materials should be shredded into smaller components of coarse or fine aggregates depending on what is required, after which impurities are then removed through the use of electromagnets (Rao *et al*; 2007) [19]. Normally, concrete containing Recycled concrete aggregates (RCA) require more water when used in concrete mixes due to higher permeability levels unlike natural aggregates. Chen *et al* (2003) noted out that washing and increasing ratio of cement/water of recycled aggregates tremendously increased its flexural strength; this will allow its use for more tensile applications in the building structures. Study carried out by Abbas *et al* (2009) [1] opined that the use of RCA should consider that it already contains both natural aggregates and mortar. This implies that RCA should not be used as if it is a natural aggregate as this will definitely affect the strength of the concrete as well as its ability to withstand chemicals and environmental factors in new structures. The study proposed a method which involves using the equivalent mortar volume (EMV) to determine the quantity of mortar that can be added to a given RCA to produce concrete that is as strong as conventional natural aggregate concrete.

Glass materials: windows and any other structure with glass can be shredded and recycled into the construction materials for utilization in construction of new structures. These glass materials can be converted into cullet and can be used together with concrete aggregates (CTU Dundee, 2004) [6]. Glass cullet is gritty, pozzolanic and demonstrates significant strength when mixed with natural concrete aggregates. Furthermore, they do not contain much impurity as they are gotten from loosened glass from old structures. Other recyclables like metals from foundations and pillars frames, timber and wood components from the demolition/deconstruction should be separated and sold to recycling centres where they can be recycled or reused; wooden materials can be converted into woodchips and used as fuel for wood boilers or other systems while metals like aluminium and steel can be smelted and reused. Non recyclables like asbestos materials from the roof or insulation and damp proofing contaminated soil materials from the remediation of the site should be transported to suitable legally licensed landfills.

Techniques for the Remediation of Brownfield Sites

Studies have shown that Humic acids can be used to sustainably remediate sites that are contaminated by heavy metals. Humic acids arise naturally in organic materials and

make up 60 -70% and 30-50% of organic materials in soil and surface water respectively (Donati *et al*; 2004) [10].

A study carried out by SUBR:IM (2008) [22] noted that compost materials apart from being effective in helping return vegetation growth to contaminated soil, also helps in improving soil fertility by destroying activities of heavy metals and supports phytoremediation when added to other materials like organic fertilizers and natural additives. The study shows that compost when mixed with zeolite can be effective in remediating against heavy solvents, heavy metals like zinc, cadmium, copper and lead which can contaminate soil in brownfield sites. Phytoremediation which involves the use of plants like the lupin plant (*lupines albus*) to remediate contaminated soil can be used effectively to clean up brownfield sites especially when arsenic is present (Donati *et al*; 2004) [10]. The study further asserts that chemicals like Phosphate fertilizer facilitate the abstraction process of the arsenic by the lupin plants when added to contaminated soil. Monitoring is important after remediation and decontamination as some contaminants may still persist or re-emerge after a few years. In addition, an effective social responsibility mechanism is also effective in site monitoring long after the site redevelopment has been concluded.

Design & Reconstruction Issues

After deconstruction and remediation of the brownfield site, the next step would be to design and construct a new structure on the site. In doing this, adequate attention should be paid to the type of use the new site will be put to bearing in mind its previous condition. For example, if the brownfield site will pose more risk to people if a residential structure is built on it, a public structure can be put up instead. However, no matter the type of structure that is eventually put up on the site, the principle of sustainable development should be upheld in all ramifications. Energy efficiency of structures can be increased by insulation (increased U-values for building components) and reducing carbon footprint by using renewable technologies to provide energy in buildings. The new design can be bioclimatic thus becoming energy efficient; this involves designing in such a way that there are interactions with surroundings (trees shades/shelter) (Chwieduk; 2003) [2]. In addition, sustainable energy technologies like solar PV cells, wood boilers, combined heat and power (CHP) systems can be integrated to provide renewable energy to the complex thereby improving its energy performance. Construction and redesign issues in the new structure should utilize recyclables as much as possible. For instance in Wembley stadium London, its carbon footprint has significantly reduced; all energy requirements are provided by a CHP system and recycling rate in the complex is about 60% (Wembley website; 2011) [29]. Furthermore, builders utilized recycled granite and steel pipe in the construction of the Olympic stadium in Stratford, United Kingdom (Metro Newspaper; 2011) [18].

Fine and coarse RCA materials can be used in landscaping sections of the site that will be paved. RCA, glass cullets and recycled tyre rubbers can also be used in addition to other materials for road paving and asphaltting, culvert pavements, gutters, and interlocking surfaces all over the redeveloped site. Roofing systems and cladding should be designed with sustainability in mind. There must be adequate insulation to ensure maximum bioclimatic benefits and also room for integration of renewable technologies like solar PV panels for energy generation for the building. For instance, solar PV panels integrated in the roof of the Kaohsiung football

stadium in Tai wan produces about 1.14 million kWh of energy a year; more than enough to meet the annual energy demand of the complex (Daily mail; 2009) [7]. In the same vein, Dartford stadium complex, United Kingdom integrated solar PV systems in its roof which provided energy for water and under floor heating (The independent; 2006) [23].

Environmental Consideration

The entire process of deconstruction and reconstruction must consider the following:

- *Noise pollution:* This is a common problem with construction sites. Noise emanating from the site must be reduced as far as reasonably practicable through the use of less noisy mechanical equipment, excavators, bulldozers and generators. Furthermore, work hours should be restricted to certain hours when noise is less likely to disturb the neighbours.
- *Air & water pollution:* Construction sites generate a lot of dust and debris which can cloud the air and cause harm to people and the environment. Sequel to that, generators, power machinery must be used in such a way that the level of air pollution is significantly reduced and sprayers

can be used to clear dust in the atmosphere as often as possible. Water runoff and effluent from construction work may contain hazardous contaminants therefore must be treated before release.

Integrating Sustainable Urban Drainage Systems (Suds)

Conventional drainage management systems in many urban areas are based on suppressive principles which try to hide and contain runoff in pipes. Inefficiencies in this method like flooding are always clear for all to see anytime there is excess precipitation, a leakage or rupture (Jones & Macdonald; 2007) [14]. On that note, sustainable urban drainage system (SUDS) has some advantages like managing runoff naturally, adding to the groundwater aquifer, lowering runoff volume and lessens flow rate mechanisms leading to efficient runoff control. In line with the sustainable development of brownfield sites, SUDS should be integrated in the redesign and deconstruction of brownfields because it considers unique characteristics of the site (landscape, soil properties, approximate runoff quantities) and provides a simple process of managing the runoff so that maximum environmental and social benefits are reaped (CIRIA; 2007) [4].

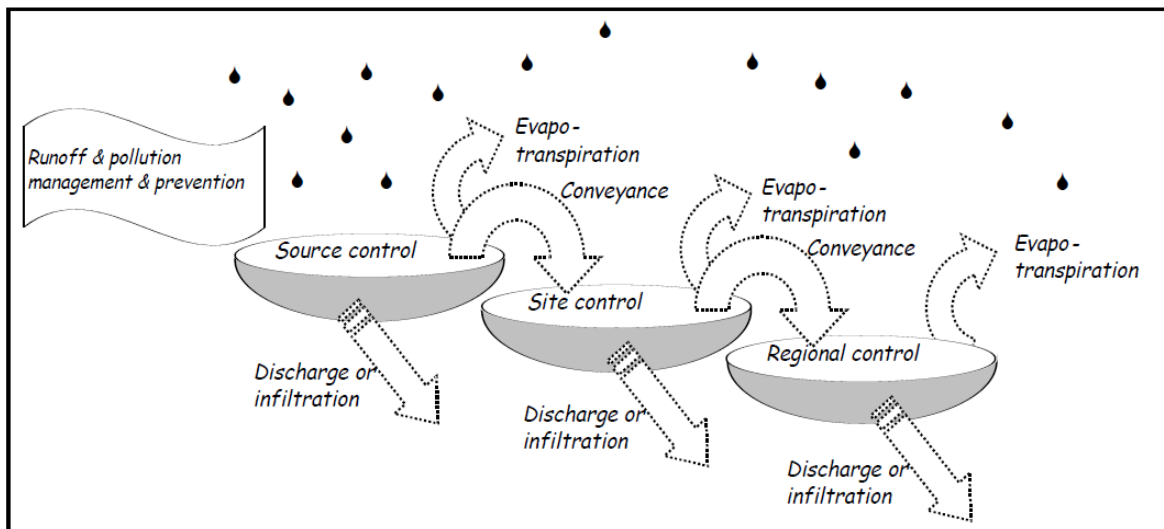


Fig 2: SUDS surface water management train (Source: CIRIA 2001)

Conclusion and Recommendations

Studies carried out by the Scottish Executive development department show that about 4173 kilo tonnes of C&D is dumped in landfills while the quantity recycled or reused is only 19% Rao *et al* (2007) [19]. This will have to change as landfill tax increases the cost of dumping recyclables. The realization of the consequences of unsustainable constructions calls for a holistic approach in brownfield development which will ensure economic, environmental and social benefits. It is important that the entire regulatory and legal frameworks for redeveloping brownfield site in the specific location are adequately considered. This will go a long way in reducing bureaucratic bottle necks that can arise and become problematic when the actual redevelopment of the brownfield site commences.

Appraisals should be carried out to determine hazardous contaminants and subsequent remediation techniques. There should also be a holistic deconstruction and demolition using suitable methodology with least cost and best probable results. Due to the high volume of waste generated from deconstruction and demolition, it is crucial that a substantial

amount be reused or recycled rather than being landfilled. As much Reusable and recyclable materials from the site as well as other nearby sites as possible should be utilized in the design and construction of the new structure instead of using virgin resources.

Sustainable drainage systems should be in place to ensure that runoff from the site is well managed just like natural water management techniques. Using this methodology will ensure that development of derelict buildings will not add to the flooding problems experience in many urban locations where most brownfield sites are located.

References

1. Abbas, A., Fathifazl, G., Isgor, B., Razaqpur, G., Fournier, B. & Foo, S. (2009) Durability of recycled aggregate concrete designed with equivalent mortar volume method Cement & Concrete Composites (31) 555–563
2. Chwieduk, D. (2003) Toward sustainable energy buildings Journal of Applied Energy (76) 211-217
3. CIRIA (2001) Sustainable urban drainage systems: best practice manual for England, Scotland, Wales & N.

- Ireland London, UK Construction industry research and information Association (CIRIA) publishers
4. CIRIA (2007) The SUDS manual London, UK Construction industry research and information Association (CIRIA) publishers
 5. CONCAWE (1998) Petroleum Products and Health Management Groups: heavy fuel oils Brussels, Belgium Conservation of clean air and water in Europe (CONCAWE) publishers
 6. Concrete Technology Unit (CTU) Dundee University (2004) Glass cullet in recycling [online] available at: <<http://www.azobuild.com/details.asp?ArticleID=7686>> Accessed on 25th November 2011
 7. Daily Mail (2009) Solar-powered 'dragon' stadium is world's first to supply all its power needs from the sun says report [Online] available at: <<http://www.dailymail.co.uk/sciencetech/article-1181327/First-solar-powered-stadium-used-World-Games.html>> Accessed on 24th November 2011
 8. Das, S. (2011) Some Issues of Ecological Hazards in Textile Industry [online] available at: <<http://www.fibre2fashion.com/industry-article/textile-industry-articles/some-issues-of-ecological-hazards-in-textile-industry/some-issues-of-ecological-hazards-in-textile-industry1.asp>> Accessed on 24th November 2011
 9. DEP, World Bank Group (2001) What is sustainability [online] available at: <<http://www.worldbank.org/depweb/english/sd.html>> Accessed 20th November 2011
 10. Donati, A., Rossi, C., & Brebbia, C. A. (2004) Brownfield sites II: assessment, rehabilitation and development. Southampton, WIT Press.
 11. Environmental protection Act 1990 (c.43) London, HMSO
 12. EU Directive 2008/98/EC on waste and repealing certain Directives EU; Official Journal of the European Union
 13. Filizöza, B. & Fisne, M. (2011) Corporate Social Responsibility: A Study of Striking Corporate Social Responsibility Practices in Sport Management Procedia Social and Behavioral Sciences (24) 1405–1417
 14. Jones, P. & Macdonald, N. (2007) Making space for unruly water: Sustainable drainage systems and the disciplining of surface runoff Geoforum (38) 534–544
 15. Klang, A., Vikman, P., Brattebø, H. (2003) Sustainable management of demolition waste: an integrated model for the evaluation of environmental, economic and social aspects Resources Conservation & Recycling (38) 317–334
 16. Kruopienė, J., Šemetienė, D. (2004) Use and Substitution of DEHP in Lithuanian Furniture Industry Environmental research engineering and management. No.4 (30) P.61-65
 17. McWilliams A., Siegel D. S. & Wright P. M. (2005). Corporate Social Responsibility: Strategic Implications. Rensselaer Working Papers in Economics
 18. Metro Newspaper (2011) how green is your stadium? Says report Metro Wednesday, November 23
 19. Rao, A., Jha, K.N., Misra, S. (2007) Use of aggregates from recycled construction and demolition waste in concrete Resources Conservation and Recycling (50) 71–81
 20. Reid, M. (2003) ICE: Protocols for alternative materials in construction Engineering Sustainability 156 Issue ES4 Pages 175–177 Paper 13539
 21. Rodriguez, J. (2011) Demolition Methods: Various demolition methods that can be used [online] available at: <<http://construction.about.com/od/Commercial-Remodeling/a/Demolition-Methods.htm>> Accessed on 25th November 2011
 22. Sustainable urban brownfield regeneration: Integrated management (SUBR: IM) (2008) SUB 10: The use of compost in the regeneration of Brownfield land Contaminated Land: Applications in Real Environments UK Contaminated land: application in real environments (CL: AIRE) publishers
 23. The Independent news report (2006) 'Dartford claims to have the world's first 'green' football stadium' Says report by Sara Newman [online] available at: <<http://www.independent.co.uk/environment/green-living/dartford-claims-to-have-the-worlds-first-green-football-stadium-424088.html>> Accessed on 29th November 2011
 24. Thornton, G. & Nathanail, P. (2005) Are incentives for regenerating UK Brownfield sites sustainable? Land contamination & reclamation 13 (4)
 25. Uno, S., Kokushi, E., Koyama, J. (2008) Toxicological Effects of Heavy Oil on Carp by NMR-based Metabolic Profiling of Plasma Interdisciplinary Studies on Environmental Chemistry—Biological Responses to Chemical Pollutants pp. 281–289
 26. Vanheusden, B. (2009) Research Article: Recent Developments in European Policy Regarding Brownfield Remediation Environmental Practice 11 (4) December
 27. Vargas, C.M. (2000) Sustainable development education: Averting or mitigating cultural collision International Journal of Educational Development 20 377–396
 28. Wedding, C.G., Crawford-Brown, D. (2007) Measuring site-level success in Brownfield redevelopments: A focus on sustainability and green building Journal of Environmental Management 85 483–495
 29. Wembley website (2011) Stadium guide: sustainability [online] available at: <http://www.wembleystadium.com/TheStadium/StadiumGuide/Sustainability>> Accessed on 23rd November 2011
 30. World Commission on Environment and Development; WCED (1987) Our Common Future Oxford, UK Oxford University Press.