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Technological tools for sustainable development in developing countries: The example of Africa, a review

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ABSTRACT

The development of Africa including industrialization such as chemical production, urbanization, agriculture, waste disposal, and electric power generation has a direct and diverse effect on the environment. These activities require effective planning, consultation, evaluation, risk assessment and monitoring techniques. Diverse environmental impacts can arise out of planning, construction, operation, and end-life of such activities. Impacts of global climate change, photochemical smog, and radioactive emissions have a direct link to development projects. Nevertheless, there is intensive research and innovation geared towards integrating development activities and the environment so as to achieve sustainable development. Herein, we review some of the technological innovation breakthroughs in various fields that include the built environment, chemical production, toxicants, municipal wastes, and electricity. The concept of sustainable chemistry is also discussed. It is found that Africa is at an advantage towards achieving sustainable development as it can easily adopt refined technological tools from developed countries. For instance, the use of comprehensive strategic environmental assessment tools for proposed policies plans and programs and environmental impact assessment for projects can see Africa achieve sustainable development. Mitigation measures for problems such as hazardous waste from chemical industries can be minimized using technological tools such as incineration of solid wastes, biological treatment of wastewater, batch and semi-batch conventional distillation, entrainer-based distillation, physical adsorption, and extraction etc. However, it is noted that although Africa should adopt some of these technological tools to help accelerate its sustainable development agenda, regional and cultural differences must be incorporated in the adoption process.

1. Introduction

Industrialization, the period of social and economic change, is accompanied by technological innovation leading to an extensive organization of an economy for the purpose of manufacturing (Steven, 2003). The unacceptable side effects of industrialization have led to environmental impacts such as global climate change, species extinction, eutrophication of water resources, the build-up of non-usable wastes, social stratification, generation of harmful radiations, power struggles, and environmental disasters. As a result, further industrialization activities and/or those economies starting to industrialize should include the concept of sustainable development that delivers both social and economic development with minimal negative effects on environmental quality. Therefore, new and robust technological tools are under development that is able to deliver the required products without unacceptable effects on the environment.

Abbreviations: CASBEE, Comprehensive Assessment System for Built Environment Efficiency. It is the green building management system in Japan; BREEAM, Building Research Establishment Environmental Assessment Method; LEED, Leadership in Energy and Environmental Design is a rating system devised by the United States Green Building Council (USGBC) to evaluate the environmental performance of a building and encourage market transformation towards sustainable design; HQE²R, It is an acronym for the approach of sustainable transformation of a neighborhood that is "sustainable renovation of buildings towards sustainable neighborhoods"

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Consequently, countries that are at the industrialization stage, and/or are about to enter this stage including most African countries should embrace technological tools in their endeavor to achieve sustainable development.

Sustainable development is defined by the United Nation as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It has been estimated that the world's population will grow from six to nine billion people between the years 2000–2050. It is expected that the preceding decades will witness significant economic development with an increase in international relations, social justice, biodiversity, human development, and human health (WARWICK, 2016). In Africa, African Institute for Development Policy (AFIDEP, 2012) recommends that: Sustainable development can be achieved if policies and programs are integrated and mainstreamed across all development sectors; that population should be prioritized in national development plans, so that adequate resources are assigned for effective implementation of programs; that there is need to meet women and their partners' needs for family planning; that there should be improvement of technical capacity in program design, research and application of research in decision-making processes; that there should be incorporation of population, reproductive health, and family planning data into global and regional institutional frameworks for sustainable development. A report by the United Nations Economic Commission for Africa on sustainable development in Africa (UNECA, 2017), shows that Africa is endowed with rich and diverse renewable and non-renewable natural resources, yet its people remain among the poorest in the world. Improving the welfare of people in Africa requires sustainable development supported with peace and stability, and with human, institutional and organizational capacities to address immediate challenges, such as poverty, diseases and cultural diversity (UNECA, 2017).

In most of the reports reviewed on sustainable development in Africa such as a case study on policies that support sustainable development in Africa (Toit, 2017), the role of technology in achieving sustainable economic development in Africa (Sally, 2016), the nutrition security and sustainable development goals in Africa (Ramadhani et al., 2016), education, law, strategic policy and sustainable development in Africa. As stated in Agenda 2063 (Onuora-Oguno et al., 2017). There has not been an article that details some of the best technological tools that can be applied in Africa to achieve sustainable development. And as such, this publication reviews some of these technological tools that might be of help to Africa in its endeavor to achieve sustainable development.

It is noted that on 18th May 2017, a team of experts comprising of innovators, policymakers, business people, civil society and technology experts met with member states at United Nations Headquarters in New York to discuss how science, technology, and innovation can help achieve Sustainable Development Goals (SDGs) and improve people's lives by the year 2030 (Sustainable Development Knowledge Platform, 2017). Hence this article articulates how Africa and any other underdeveloped country/continent can achieve sustainable development.

2. Environmental legal frameworks

There are legal frameworks for assessing impacts of developmental activities on the environment and methods are designed, detailing how these impacts should be mitigated including termination and/or alternatives (Briggs and Hudson, 2013; Zhang et al., 2013; Zhou and Sheate, 2011a). These frameworks include environmental impact assessment (EIA) of a project before authorization or strategic environmental assessment (SEA) of any policy, plan, or program before it is implemented. The Rio Declaration on Environment and Development at the 1992 Earth Summit proposed that signatory nations must employ EIA 'For proposed activities that are likely to have significant adverse impacts on the environment by virtue, inter alia, of their nature, size or location and the EIA process must be subjected to a decision of a competent national authority'. However, this did not include policies, plans, and programs hence the development of SEA. Another framework used in assessing the impacts of policies is the Regulatory Impact Assessment which will not be discussed in detail but the reader may look it up in the cited references (Ballantine and Devonald, 2006; Hertin et al., 2009).

2.1. Environmental Impact Assessment in Africa

The EIA process evaluates possible impacts of a proposed project or development activity on the environment. It takes into account interrelated socio-economic, cultural and human-health impacts that might be of benefit or have adverse effects on the environment. This process was introduced by US National Environmental Policy Act of 1969 (NEPA, 1969).

After independence, development in most African countries experience crises escalated by negative effects from large populations, unplanned urbanization, modernization of agriculture and emergence of industries (Kidane-Mariam, 2003). There is a rush into development by most African countries such that many projects and development activities initiated by both national governments and foreign direct investment projects do not consider adverse impacts of the projects on the environment and natural resources (Campion and Essel, 2013). The result of which is a statistically significant environmental damage that goes unchecked for many decades. Partly, it has been noted that territorial division in combination with inequitable development patterns that were established in the colonial period has led to such significant economic and environmental damages (Campion and Essel, 2013). Such differences have resulted in civil conflicts and wars. In addition, natural disasters such as droughts, bush fires, and famine continue to wreak havoc on the African continent.

Despite the above-mentioned problems facing Africa, some African countries have established EIA processes as a requirement for any proposed development activity since 1980 (Campion and Essel, 2013). Such African countries include Kenya, Senegal, Zambia, Algeria, Togo, Gabon, Burkina Faso, Gambia, Mauritius, and Nigeria (Bekhechi and Mercier, 2002). Recently, almost all African countries are embracing EIA. Although the EIA process in Africa varies from country to country and it is hoped that the process will borrow a leaf from the experience of developed countries.

2.1.1. Problems affecting EIA in Africa

Some of the requirements by the EIA process such as the provision of economically favorable mitigation measures, alternatives and the possibilities of termination of projects greatly challenge the existence of the EIA process in Africa. Political will and the willingness of the public to influence the agenda including public empowerment/participation in cases where the public is indifferent and/or illiterate also challenge the very existence of EIA (Briggs and Hudson, 2013; Jay et al., 2007; Lawrence, 2003; Zhang et al., 2013; Zhou and Sheate, 2011a). Furthermore, the low quality of baseline survey data, its interpretation and even sometimes completely missing data make the credibility of EIA legal frameworks in Africa questionable. However, it is noted that most countries in the world still need to have several cycles of baseline data acquisition and interpretation before making a decision on an environmental problem such as the recent plastic ban in Kenya (NEMA, 2017). Additionally, lack of trained and competent staff to carry out the EIA process is probably the greatest challenge for successfully implementing EIA and SEA in Africa". The success of the EIA processes rests in the expertise of a team of experts chosen at inception or towards the end of the planning period to prepare a report for assessment. Time and financial constraints are among the major factors likely to affect these reports. There are times when the cost of carrying out these reports outweighs their total implementation budget leading to readjustments hence compromising their effectiveness. Furthermore, the need to involve the community in the EIA processes so as to ensure a