Technological Change and Sustainable Development: The Case of Plastic Products Producers in Ghana

Alhassan Abdul Wakeel Karakara

Economics of Technology and Development, University of Cape Coast,

aawkarakara@yahoo.com, *+233 242312799 / 205832020*

Abstract

This paper explores the importance of technological change on measures relating to ecologically benign society. The purpose is to find what conditions technological innovation can foster and promote sustainable development. It considers forms of technological innovations that are potentially conducive to sustainable development, end-of-pipe technologies and clean technologies. This piece argues that significant technological changes are brought about by industries' desire to obey environmental laws and their desires to reduce cost of production. The paper examines how agents like governments, consumers, businesses and the technology designers can influence the technological change. It explains that to some extent these actors can use technologies that are environmentally sound.

The paper emphasizes theoretical research with some empirical explorations. The work sampled forty-five (45) out of 90 Plastic Products Producers (PPP) in Ghana using simple random sampling. The findings indicate that most companies concentrated on end-of-pipe technologies. The alternative to end-of-pipe technology is to adopt new 'clean' technologies that alter production process, inputs to the process and products themselves so that they are more environmentally benign. Also, it was found that the impact of the operations of these companies on the environment is moderately high. he paper recommended that Government should encourage the development and implementation of clean technologies by helping with finance; and industries should make efforts to adopt clean-technologies.

Keywords: *Technological Change, Sustainable Development, End-of-Pipe Technologies, Clean Technologies, Environmental Benign, Plastic Products Producers*

Introduction

Concerns about the environment by various public groups and environmentalist have raised world concern about the environment and the need to protect it. Many countries since 1970's have tried to put in measures for the efficient management and protection of the ecological environment and natural resources. Interest on how to sustain the environment has become a major issue following the Earth Summit in Rio de Janeiro in 1992. The need for and practice of sustainable development has gained support from most governments across the world, because it aims at preserving the environment for future use while still achieving the most greatest of development. Jean Luc Bourdages' explained that, (as cited in Sharon Beder 1993), sustainable development implies the integration of environmental issues with the imperatives of economic

development in order to meet the immediate needs of populations today without undermining the aspirations of future generations.

Sustainable development seeks to change the nature of economic development rather than limit it. In its introduction to the Australian edition of the Brundtland report, the Commission for the Future pointed out that "Rather than growth or no growth as the debate about environment and development has sometimes been cast, the central issue is what kind of growth. The challenge of sustainable development is to find new products, processes, and technologies which are environmentally friendly while they deliver the things we want" (Sharon Beder 1993, pg 32)

Technological change plays an important role in the context of environmental issues. The way in which energy and materials are transformed in the economic process depends mainly on the state of technological knowledge. Hence, "technological innovation can change the composition of the material basis of economic processes – a prerequisite for sustainable development" (René Kemp, Peter Mulder & Carl H.Reschke, 1994 pg 6).

Sharon Beder (1993) questions whether technology can give us environmental protection and economic development. Can it ensure equity between and within generations, so that everyone, now and in the future, our far neighbours and our great – grandchildren can enjoy the standard of living we do? Such an accomplishment would require more than just a few adjustments to existing technological system.

At the UN General Assembly in 1987, the governments of various countries signed on to sustainable development following a report issued by the World Commission on Environment and Development titled "Our Common Future". The Earth Summit in Rio de Janeiro in 1992 gave a boost to the issue of environmental care. The effort to design and redesign various types of technologies which can be ecologically friendly has been running for years.To fully understand the significance and effects of technological change on technology policy " in moving society in to more ecologically sustainable direction" (René Kemp, et al 1994, pg 25), there is the need to look at factors that affect technological change, not only the environment, but also a look at the designer of technology, the business industry, the government, citizen – consumer and R & D institutions.

Designer of Technology and Sustainable Development

Clearly technology should be attractive, but this needs not be limited to attractiveness to users. Social and environmental benefits should also be considered and may provide important reason for experimentation. The selection of technology can be done in a consultative and co-operative mode together with stakeholders or in a more competitive mode through the use of tenders in which people are asked to come up with proposals (Cécile Patris, et al 2001).

The designer of technology or researcher should always be mindful of the sustainability of the environment. Since he is the ultimate designer of technology, he knows the pros and cons of the technology to be developed. Whether radical innovation or not, technological innovations are necessary if "technological development is not going to compromise the needs of future generations" (Cécile Patris, et al 2001, pg 13).

Technology designer should not await until government regulations forces them to come out with technologies that are environmental benign. They should advocate in pushing out only the environmentally beneficial technologies from the lab doors in to society.

Given that there are many environmentally beneficial technologies are already designed and available for implementation, there is the need to look beyond the designer of technology to other people in society who affect decisions about technological choice including businesses, governments and consumers (Sharon Beder, 1993)

The Public or Citizen – Consumer and Sustainable Development

Achieving sustainable development is a long run process of everybody's involvement including the consumer of the product that the technology will produce. Citizen – consumers are drivers of technological change by their consumption behaviours.

The Green Consumer Guide (Elkington and Hailes, 1989) have given many people the impression that the environment can be saved if individuals are responsible in their shopping habits and buy only environmentally sound products. David Pearce, former advisor to the Late Margaret Thatcher, and his colleagues stated that "sustainable development means a change in consumption patterns towards environmentally more benign products and a change in investment towards augmenting environmental capital (Pearce, Markanya & Barbier 1989: pg XIV).

For instance, a "citizen – consumer expresses his/her need for transportation in a form that is not immediately met by buying a new car, but instead by supporting a sustainable transportation system" (Philip J. Vergragt, 2006 pg 27).

The tendency for consumer to prefer environmentally sound products has become evident. Surveys show that high – income countries make an effort to buy green products such as pump packs, unbleached papers and items made of recycled paper (Philip J. Vergragt, 2006).

The extent to which the consumption patterns of individuals can determine technological change and hence environmental sustainability is limited. Consumers get to know about environmental sensitive products through, most at times, advertisements. Advertisement claim of most businesses may not reflect what is on the ground.

The debate over whether plastic packaging is better or worse than paper packaging for the environment, or whether milk bottles are better than cartons, are sure ways to confuse consumers (Sharon Beder, 1993) because most consumers, especially Ghana, are not well educated or have enough information on products that are environmentally sensitive.

The Ecologically Sustainable Development (ESD) working group, of Australia, on manufacturing points out that any judgment about whether a product is ecologically sustainable is extremely complex, requiring long term assessment from manufacturing to disposal … Other matters that need to be considered include the way the product will be used, transported, distributed marketed and packaged (Sharon Beder, 1993).

While consumers may influence packaging and some ingredients of products, they are usually unable to influence more hidden aspects of a product. They are unlikely to affect more fundamental production decisions that may lead to clean technologies rather than end-of-pipe technologies (Sharon Beder, 1993).

The Business Industry and Sustainable Development

Firms and industries are at the heart of technology usage. Firms use technology directly to produce their products or services.

At the Earth Summit in Rio de Janeiro, the governments of 170 nations signed Agenda 21, the action plan for sustainable development, which said that "through more efficient production processes, preventive strategies, cleaner production technologies and procedures throughout the product life cycle, hence minimizing or avoiding waste, the policies and operations of business and industry, including transnational corporations, can play a major role in reducing impacts on resource use and the environment. Technological Innovations, development, applications, transfer and the more comprehensive aspects of partnership and cooperation are to a very large extent within the province of business and industry" (Sharon Beder 1993).

Technology can help in sustaining or destroying the environment. Technological change seems to lie with the business and industry. The user of technology is at the mainstream in harnessing technological change for sustainable development.

Efforts to clean up the environment have tended to concentrate on technologies that are added to existing production process to control and reduce pollution (end-of-pipe technologies and control devices) rather than changes in the production processes itself (Sharon Beder, 1993). A clean technology, which is a better option to end-of-pipe technologies, are at the heart of using technological change to achieve sustainable development. End-of-Pipe technologies refers to technical measures for reactive environmental protection such as filtering plants, wastewater treatment plants etc, which serve to contain emissions (exhaust gases, wastewater, noise), pollutants and other polluting substances which have already occurred or to render them controllable or disposable. End-of-Pipe technologies are usually expensive and become effective when damage (e.g. occurrence of material problem or pollutants) has already occurred.

The Ecological Sustainable Development (ESD) working group on manufacturing, (as cited in Sharon Beder, 1993), has outlined, in terms of ranking, how waste management can be effectively achieved based on a hierarchy. Beginning from clean technologies as the highest most efficient way and waste disposal measures as the least desirable way.

Most firms tend to concentrate on end-of-pipe technologies by putting in measures to control pollution, because "technologies to save energy, water or raw materials are mostly the kind of technologies firms want because it leads to direct reduction in production costs" (Cécile Patris, at al 2001, pg 4).

Patrick McCully's book on The Ecologist posits that "the reason that the USA is the most polluting nation in the world has little to do with a lack of energy efficient technologies or renewable methods of producing electricity, it has to do with the size of the country's oil, coal and automobile industries and the influence they have on political establishment".

Government State and Sustainable Development

The state/government forms the mainagent that affects and controls the economy. Government is therefore in a "much better position than consumers to influence decision" (Sharon Beder, 1993 pg 36) about the economy. Governments at all levels rank high among the most important drivers of technological change. In their role, they can help consumers to make better choices regarding products of sustainability impact.

Through policies of government, such as; investing in research and development (R&D) and in new technological innovation forms, purchasing sustainable products and services in order to pave the way for broad market introduction, setting criteria that foster sustainable and appropriate technologies….." (Philip J. Vergragt, 2006 pg 27) sustainable development may be achieved.

Government can influence many industrial innovations toward environmental friendly technologies by using environmental rules and regulations (Legislations). A study of 164 innovations in Europe and Japan found that regulations (mainly environmental and safety) not only promoted innovation but were a factor in the success of those innovations, particularly in the chemical and automobile industries (Royston, 1982 Pg 15 as cited in Sharon Beder, 1993).

This paper looked at technological change and sustainable development in Ghana, taking Plastic Products Producers in Ghana for the survey.

Plastic Products Production

History of Plastics

In 1600 BC, Mesoamericans used natural rubber for balls, bands and figurines. Early plastics were bio-derived materials such as egg and blood proteins, which are organic polymers. Treated cattle horns were used as windows for lanterns in the Middle Ages.

In the 1800s, the development of plastics accelerated with Charles Goodyear's discovery of vulcanization as a route to thermoset materials derived from natural rubber.Parkesine is considered the first man-made plastic. In 1900s, Baekelite, the first fully synthetic thermoset was reported by Belgian chemist Leo Baekeland. In 1923, Durite Plastics Inc. was the first manufacturer of phenol-furfural resins.

After the First World War, improvements in chemical technology led to an explosion in new forms of plastics; mass production began around the 1940s and 1950s. Polypropylene was found in 1954 by Giulio Natta and began to be manufactured in 1957. New polymers such as polystyrene (PS) was first introduced in 1930s and polyvinyl chloride (PVC) commercially produced in late 1920s.

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemical, but many are partially natural.

Process of Plastic Production

Plastic production is a highly complex process, involving machines that use natural plastic (e.g. chewing gum, shellac) to the use of chemically modified natural materials (e.g. rubber, galalite) and finally to completely synthetic molecules (e.g. Bakelite, polyvinyl chloride).

Warmer Fact Sheet 1992, (as cited inSolomon Kusi Ampofo, *The options for the effective management of plastic waste in Ghana(n.d) pg 4*) explains that plastics can be regarded as long chains of beads in which the so-called monomers such as ethylene, propylene, styrene, and vinyl chloride are linked together to form a chain called a polymer. Polymers such as polyethylene (PE), polystyrene (PS) and polyvinyl chloride (PVC) are the end products of the process of polymerization, in which the monomers are joined together.

From the Global perspective, the top three plastic machinery types are injection molding machine, extruder/extruder production line and blowing molding machine. Plastics extrusion is a high volume manufacturing process in which raw plastic material is melted and formed in to a continuous profile.Plastic extrusion is a process for converting plastic materials from solid to liquid states and reconstituting them as finished components. First, plastic pellets are

gravity fed from a hopper in to a jacketed screw. As the screw turns about its axis, it transports, melts, and pressurizes the plastic. From there, the molten material is forced through a die that shapes it into a specified cross-section, producing parts with a potentially wide range of lengths. During extrusion, plastics transform from solid to liquid and back again without sacrificing their distinctive properties. As a result, scrap parts can be ground and re-extruded with minimal degradation, making extrusion a popular method for reducing or recycling plastic waste[1].

Materials and Method

Plastic Products Producers were chosen as a case study. They are companies that produce plastic products, synthetic and non-synthetic. Plastic products have recently being the environmental threatening material in Ghana. The objective of this paper is to find out the type of technologies use by these companies, whether those technologies can help achieve sustainable development.

A population of Ninety (90) Plastic manufacturers companies was gathered through the website of the Association of Ghana Industries (AGI). Out of the Ninety (90), Forty – Five (45) companies were selected based on simple random sampling.

Data was gathered from many sources. This includes both primary and secondary data. Review from textbooks, journals, internet and other sources of publications were done. A survey method was used in interviewing and administering questionnaires to Forty-Five (45) companies. The questionnaires concentrated on finding out the technologies available to respondents incorporate environmental issues and whether those technologies are in one way or the other are end-of-pipe technologies or cleaner technologies.

Statistical Package for Social Survey (SPSS) was applied to the administered questionnaires to generate field data gathered by the author.

Discussion of Data and Results

Discussion of Preliminary data

These include analysis and discussion of the age of company, how the company was established and number of employees.

Age of company

The age composition of companies that responded to the questionnaires is shown below.

Table 1: Age of company

Year bracket	Frequency	Percent(%)
1 – 20	18	40
21 +	27	60
Total Respondents	**45**	**100**

Source: field work 2014

A total of Forty-Five (45) companies were interviewed with no one missing this question. Out of this 45 companies responded, Twenty-Seven (27) of them, representing 60% were companies that have been operating for more than twenty (20) years, while the remaining Eighteen (18) were companies that have been in operation for years below Twenty (20). Companies that

1 Retrieved from: http://en.wikipedia.org/wiki/plastic#cite-note-Applications-12).

have operated for more than 20 years appear to be the most dominant, as a mean value of 1.60 shows. As shown on Table 1.

Table 2: Number of employees

Number of employees	Frequency	Percent (%)
1 – 50	1	2.2
51 – 100	11	24.4
100 above	33	73.3
Total Respondents	**45**	**100**

Source: field work 2014

A total of Forty-Five (45) companies were interviewed with no one missing this question. Out of this 45 companies responded, thirty-three (33) of them, representing 73.30% had employees above one hundred (100) in number, while the remaining percentage are companies that had employees below 100. A mean value of 2.71 shows that most of the companies interviewed had employees above 100 in number.As shown on Table 2.

Discussion of Main data

These include analysis and discussion of production techniques available to respondents, what makes them adopt a new technology,technologies incorporates environmental issues, environmental casewith introduction of new technology, how they dispose technology waste product, impact of operations on the environment and measures taken on the impact.

Table 3: Technologies Available to the firm

Technology available	Frequency	Percent (%)
Extrusion, Starlinger, Botheven and loom	21	46.7
Extrusion and Stralinger	21	46.7
Extrusion	3	6.7
Total Respondents	**45**	**100**

Source: field work 2014

A total of Forty-Five (45) companies were interviewed with no one missing this question. Out of this 45 companies responded, twenty-one (21), representing 46.70% mentioned, extrusion, botheven, starlinger and loom as some of the technologies available in their company. Another 46.70% mentioned extrusion and starlinger, while the remaining 6.70% mentioned extrusion machines (Table 3).

Table 4: Adoption of technology

What makes you adopt new technology?

Technology adoption	Frequency	Percent (%)
When market demand increases	18	40
When market demand increases and when machine gets old	20	44.4
When market demand increases and or there is defect on our products	5	10.8
Whenever our mother company abroad introduces one	2	4.8
Total respondents	**45**	**100**

Source: field work 2014

A total of Forty-Five (45) companies were interviewed with no one missing this question. Out of this 45 companies responded, twenty (20), representing 44.40% answered that they adopt technologies when there is the need to increase production and or when their existing machines gets old or breaks down. Also, 40% adopt technology when there is a need for market increase of the products. The remaining 15.60% of the respondents adopt technology when market demand increases and otherwise (see Table 4).

Table 5: Technologies and environment

Do your technologies incorporate environmental issues?

Technology incorporates environmental issues	Frequency	Percent (%)
Yes	45	100

Source: field work 2014

All the respondent companies sampled admitted that their technologies incorporate environmental issues (see Table 5).

Table 6: Have you ever had environmental case with regard to introduction of new technology?

New technology and environmental case	Frequency	Percent (%)
Yes	18	40
No	27	60
Total respondents	**45**	**100**

Source: field work 2014

Out of the total respondents of Forty-five (45), eighteen, representing 40% admitted that they have ever had an environmental issue with regard to its operations while majority, which is 60%, said that they have never had such case (Table 6)

Table 7: What is the impact of your operations on the environment?

Impact of operations on environment	Frequency	Percent (%)
High	18	40
Moderate	23	51.1
Low	3	6.7
Total respondents	**44**	**97.8**

Source: field work 2014

Twenty-three, representing 51.10% of the total respondents, agreed that their operations have a moderate impact on the environment. Also, 40% said their operations have a high impact on the environment. However, one respondent did not answer this question (see Table 7).

Table 8: What measures have you taken or will take on those impacts?

Measure to take or taken	Frequency	Percent (%)
By recycling	**8**	**17.8**
By using machines that produce less waste	30	66.7
Total respondents	**38**	**84.5**

Source: field work 2014

Out of the total respondents of 45, thirty (30), representing 66.70% agreed that they have or intend to buy technologies (clean technologies) that will help to produce less or no waste whilst 17.80% have resorted to recycling as the way to reduce the impact of their operations on the environment. However, 15.6% of the respondents did not provide answers for this question (see Table 8).

Table 9: Do those measures lead to additional cost or reduced cost?

Measures lead to cost or not	Frequency	Percent (%)
Yes	33	73.3
No	12	26.7
Total respondents	**45**	**100**

Source: field work 2014

On whether their measures to reduce the impact of their operations on the environment lead to increase in cost or reduction in cost, thirty-three, that is 73.30% out of the forty-five respondents agreed that their measures to deal with their impact on the environment lead to additional cost, whilst 26.70% said their measures to deal with the impact of their operations on the environment lead to reduction in cost.

Table 10: Disposal of waste

How does the company dispose its technology waste products?

Waste disposal	Frequency	Percent (%)
Recycling	15	33.3
Recycling and disposal site	28	62.2
Total respondents	**43**	**95.5**

Source: field work 2014

On the methods of disposal of waste, 33.30% of the respondents said they always recycle their waste generated, while 62.20% dispose their waste by recycle and disposal site. However, two respondents did not answer this question.

The paper was able to find that most of the companies concentrated on end-of-pipe technologies. This is shown by the data analysis below. Sixty-five percent (65%) of the respondents tend to recycle their waste products, which is a measure of pollution control. Also, majority of companies interviewed (78.9%) has taken or is to take recycling or by using machines that produce less waste as a measure to reduce the impact of their operations on the environment. This is in line with Sharon Beder (1993) that effort to clean up the environment tended to concentrate on technologies that are added to existing production process to control and reduce pollution (end-of-pipe technologies and control devices) rather than changes to the production process themselves. The alternative to end-of-pipe technology is to adopt new 'clean' technologies that alter production process, inputs to the process and products themselves so that they are more environmentally benign.

Also, the paper established that the impact of the operations of these companies on the environment is moderately high. Even though all the respondents agreed that their technologies incorporate environmental issues, majority (93.20%) of them agreed that their operations have a high or moderate impact on the environment.

Finally, the paper established that measures taken or to be taken by these companies are good measures to dealt with maximum usage of resources in an environmental manner. On table 2.2d, it is shown that 84.50% of the total respondents are either using recycling or by using machines that produce less waste. This is in line with The British Pearce Report (1), which suggests that resource usage can be dealt with through recycling and minimizing wastage, and that the damage to the environment from disposing of waste can be minimized in a similar way: "Recycling, product redesign, conservation and low-waste technology can interrupt the flow of wastes to these resources, and that is perhaps the major feature of a sustainable development path of economic progress".

Conclusions

Sustainable development relies on technological change to achieve its aim. However, to achieve sustainable development is everybody's business; the technology designer, the business industry, citizen-consumer and government or state. This paper set out to find how technological change and sustainable development were related in the context of plastic products producers in Ghana.

The paper was able to argue that most of the companies concentrated on end-of-pipe technologies.The alternative to end-of-pipe technology is to adopt new 'clean' technologies that alter production process, inputs to the process and products themselves so that they are more environmentally benign.

Also, the paper established that the impact of the operations of these companies on the environment is moderately high.

The paper recommends that government should encourage the development and implementation of clean technologies by helping to finance R&D's that would lead to clean technologies. Industries should also make effort to adopt clean-technologies.

The paper needs to be expanded to cover most companies in Ghana. This is the area in which I have greater interest to cover in future research.

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