“Environmental management tools”

AUTHORS	Mishelle Doorasamy https://orcid.org/0000-0001-9320-3461

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Mishelle Doorasamy (South Africa)

Environmental management tools

Abstract

The aim of this study was to assess effectiveness of environmental management tools currently being used by manufacturing and their impact on the adoption of cleaner production techniques. The objectives of the study were to identify the benefits of adopting CP technologies as compared to end-of-pipe technology based on primary and secondary literature as well as empirical findings; to identify CP options available to management and other stakeholders by demonstrating the potential environmental and economic benefits of cleaner production processes and technologies, and to make recommendations that will assist the company in its decision making process. A survey on paper and pulp manufacturing companies was conducted to assess what environmental management tools that companies were using and the effectiveness of these tools in improving environmental performance.

Findings of the research suggest environmental costs are significantly underestimated by management. Environmental costs reflected on financial statements were not a true reflection of actual environmental cost incurred by the company. Cost allocation to cost centres, were based on traditional cost accounting system not on an environmental management accounting system. Thus, many companies were still investing in end-of-technologies and not on CP technologies.

Keywords: environmental management accounting (EMA), sustainable development (SD), cleaner production (CP), efficiency, company profitability.
JEL Classification: O31.

Introduction

Current levels of economic and industrial activities, as well as material consumption cannot be sustained by the earth's eco-system therefore the need for sustainable initiatives as part of corporate environmental management framework is essential to relieve the pressure of environmental impacts (De Beer and Friend, 2006). Economic, social and environmental efficiency are viewed as necessary steps towards sustainability (Callens and Tyteca, 1999, p. 41). International best practice technologies used in pulp and papermaking is based mostly on wood-based fibres with very few technologies available for non-wood fibres and is mainly developed and manufactured in Europe and Japan (Worrell, Price, Neelis, Galitsky and Nan, 2007, p. 31). Manufacturing is not 100% efficient therefore waste is generated during production.

This article contains background information about the industry and its environmental issues. A comparison of end-of-pipe technology to cleaner production technology is discussed as well as opportunities for improving environmental performance of paper manufacturing companies through the application of CP is presented. Case studies and empirical evidence of companies that have successfully implemented CP are brought to the forefront.

1.1. Limitations of the research. The scope of this research was limited to the steam generation process as bottom boiler ash disposal (waste) disposal was a major concern for pulp and paper manufacturers. Therefore the environmental costs analysis and technology assessed focused mainly on the boilers used and waste generated during the steam generation process.

1.2. Research methodology. A survey was conducted on three paper manufacturing companies in KwaZulu-Natal. A total of 60 respondents participated in the survey. The survey was restricted to managers only as information on how environmental issues were handled within the company was not disclosed to other employees.

A survey was done using a questionnaire to establish the managers' perception of the company's environmental performance and environmental cost allocation as well as to understand their perception on implementation of cleaner production and barriers to investing in cleaner production technology. The questionnaire was designed using the Likert scale method to collect data.

It has been reported that the reliability of Likert Scale is preferable to other methods because a wider range of answers are permitted from the respondents (Myers, 2013, p. 125). The researcher reviewed company's financial statement and production cost schedules of the steam generation process to assess how the environmental costs were being allocated.

In order to analyze the information a quantitative methods were implemented. The questionnaire was the primary tool that was used to collect data and was distributed to senior and middle level managers of the company. The data collected from the responses was analyzed with SPSS version 22.0. The results presented the descriptive statistics in the form of graphs, cross tabulations and other figures for the qualitative data that were collected. Inferen-

Mishelle Doorasamy, Lecturer, Department of Financial Accounting, Durban University of Technology, South Africa.

tial techniques included the use of correlations and chi square test values; which were interpreted using the *p*-values.

2. Literature review

2.1. Sustainability of pulp and paper mills. Bras et al. (2004, p. 5-7) state that environmental regulation impacts the paper and pulp industry in every aspect of the product life cycle, from forest management practices, to pulp and paper manufacture, to paper recycling and disposal. However research has shown that the paper and pulp industry has improved their environmental performance dramatically since 1970. The industry is the third largest user of fossil fuel energy and the largest user of industrial process water among US manufacturers. Half of the toxic release inventory (TRI) are methanol, by-products of the pulping process – over 50% of the industry's release to air and 40% of releases to water. Other substance released by the industry – non-hazardous waste water and sludge, acids, chlorinated compounds, ammonia, and air pollutants associated with combustion (SOx, NOx and particulates). Fossil fuels such as coal, oil and natural gases are primary sources of energy used in the world. The high degree of depletion of natural resources and environmental damages have tempted the world to try to reduce carbon emissions by 80% (Saidur, Abdelaziz, Demirbas, Hossain and Mekhilef, 2011, pp. 2262-2289).

It is also a highly capital intensive industry in the US and there is therefore limited opportunities for investment in new, more efficient technologies.

The industry's machines and much older and smaller than their competitors in Europe and Asia, and they tend to have a higher fixed cost per ton of paper produced. Industrial operations cause significant environmental liabilities which have financial effects. Companies however still find it difficult to relate environmental liabilities to financial effects (De Beer and Friend; Liu et al., 2013, pp. 7-12). New European machines are less polluting, hence less vulnerable than Americans to increasing costs of environmental regulation and control. Investor reports (2012) on a paper mill in North America indicated that through planned maintenance of equipment and process upgrades, the mill was able to improve machine efficiency and reduce production costs. The mill had replaced the drives and pumps on paper machine 3 which resulted in over 50% reduction of horsepower required as well as less water consumption and stream to maintain the same capacity (Investor reports, 2012). However, mill managers view investments in pollution abatement technologies as "unproductive – with no marketable and quantifiable effects in terms of productivity".

According to Porter, the cost of environmental equipment is made up of capital cost and cost of non-value added activities (associated with regulatory compliance, operation and maintenance of equipment, permitting and reporting (Bras et al., 2004)). The United States had installed pollution-control technologies to remove specific from the air and water releases since the 1970s. Recently pollution prevention technologies, a more conservative approach to environmental protection than pollution control had been introduced. Total composition of effluents discharged and its potential environmental impacts is not completely known to many, therefore pollution-prevention is the only solution to help reduce the probability of unwanted surprises being released into the environment (Pulp and Paper Mills Industry Profile, 2013; Despeisse et al., 2013, pp. 31-41).

The international community committed itself to sustainable development at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. Sustainable deve-lopment centres around the concept of meeting the needs of the present generation without compro-mising the ability of future generations to meet their needs, also interpreted as 'environmentalism dressed up for the 21st century' (Environmental strategies, 2013). Sustainability development is aimed at job creation in a fair and equitable manner whilst protecting the environment. Sustainable development is also known as 'The Triple Bottom Line' involving doing business to ensure economic, social and environmental benefits.

At the 2002 World Summit on Sustainable Development held in Johannesburg, a shift towards Sustainable Consumption and Production was noted. Greater emphasis was placed on inefficient and wasteful use of natural resources (Resource Efficient and Cleaner Production, 2013). Issues raised at the summit clearly showed that much of the wealth generated in the country was at the expense of natural assets. Therefore, it was emphasized at the forum that businesses need to take an active role in protecting these natural assets and reducing the environmental impact of operational activities (Ambe, 2007, p. 3). In 2006, a draft Strategic Framework for Sustainable Development in South Africa was used to reaffirm South Africa's commitment to implementing full measures to ensure that businesses cooperate and adopt a sustainable development approach to their business activities (Ambe, 2007, p. 4).

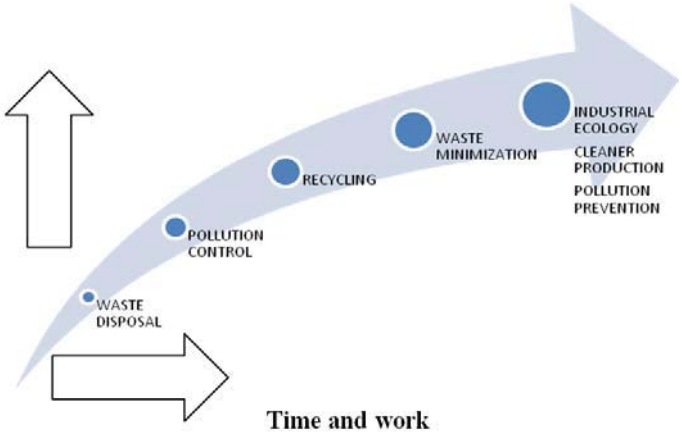
Some researchers have argued that the root cause for environmental problems is the lack of environmental management policy (Ahmad, Saha, Abbasi and Khan, 2009, p. iv). Environmental and social aspects of business are not adequately recognised by current accounting systems and these issues may not

be fully accounted for during decision making. Non-financial information is now being used to supplement the traditional financial information flows for external reporting and internal management needs. Sustainability accounting and production has encouraged companies to review their processes and products to take into account and respond to changing cost structures and risks (Bennett, Schaltegger, and Zvezdov, 2013).

The figure below demonstrates the key concepts aimed at sustainable development.

Figure 1. Staircase of concepts aiming sustainable development.

Scope and results



Source: Nabais (2011, p. 4).

Fig. 1. Environmental management systems

The figure above highlights key concepts of sustainable development. Each step involves more time and greater effort on the part of organization aimed at achieving zero emissions. Sustainable development is a long-term strategy involving step-by-step processes of development and progress towards achieving the ultimate goal, as depicted in the figure above.

3.1. Environmental management. *3.1.1. International standards of organization (ISO 14001).* Bennett, Schaltegger and Zvezdov (2013) describe environmental standards such as ISO14001 and Environmental Management Accounting Systems (EMAS) as voluntary standards that act as a form of regulatory governance as they become institutionalized and internationally recognized. Its aim is to make cost relationships transparent and provide guidance during process and product design decisions by adopting conventional costing systems. They believe the purpose of ISO 14001 is to help companies implement environmental management systems (EMS) that fulfil certain criterion. Ahmad, Saha, Abbasi and Khan (2009, p. v) concur that the ISO 14001 environmental management system could be used by managers to assess and measure progress and performance by providing standard auditing, communicational and reporting protocols. Complementary standards such as ISO 9001 have been found to be the most relevant factors for adopting ISO 14001 or EMAS Li (2004, p. 1) found an enhanced development of EMA among companies that were ISO 14001 certified. This has also encouraged governments to promote EMA implementation within countries.

The availability of win-win possibilities and leadership by individuals in the company management had been reported as the most common internal factors that influence the implementation of standards.

3.1.2. "Best practices" of environmental management. Christmann (1999, pp. 13-17) analyzed three process-focused "best practices" of environmental management during his research to identify their direct effect on cost advantage:

Best practice 1: Use of pollution-prevention technologies. Pollution-prevention technology has the potential to increase the efficiency of the production through reduced input costs, substitution of less costly inputs, savings from recycling or reusing materials, and reduction of waste disposal costs.

Best practice 2: Innovation of proprietary pollution-prevention technologies. Internal innovation of pollution-prevention technologies contribute to the firm's cost advantage in many ways:

First, managers become aware of inefficiencies in current production processes and products that were not previously recognized, by developing new pollution-prevention technologies. Second, innovation of pollution-prevention technologies has greater potential for cost-saving changes in the production process. Third, the technologies are proprietary to the firm therefore the firms are likely to appropriate

the rents that are created by these internally developed technologies. Competitors are not easily able to imitate these internally developed pollution-prevention technologies.

Best practice 3: Early timing. Addressing environmental issues earlier than competitors or before environmental regulation is established contributes positively to cost advantage by minimizing disruptions of the production process usually caused by the implementing compliance technologies, allowing the firm to gain cost advantage through the learning curve effects, by addressing environmental problems early and influencing regulations can raise their competitors costs.

Holt (2009) views ISO 14001 as a logical extension of quality management system ISO 9001.

King Commission (2002, p. 240) cited the nine reasons for businesses to improve its environmental performance, as per The United Nations Global Compact, noted by Mohr-Swart (2008, p. 102):

- Implementing cleaner production and eco-efficiency improves resource productivity;
- Clean companies are being rewarded by new economic instruments;
- Stricter environmental regulations;
- Cleaner companies are seen as low risk and also preferred by insurance companies;
- Banks are more willing to provide financial assistance to cleaner companies;
- Positive effect on company's image;
- Health and safety of employees;
- Negative impact of pollution to human health;
- Pressure from customers for cleaner products.

Radonjic and Tominc (2007, pp. 1482-1493) concluded that ISO 14001 certified firms were more productive and achieved better environmental performance.

They also found that the adoption of cleaner technologies were more likely among certified companies as ISO 14001 was considered a useful tool for technology changes in companies which were committed to the IPPC directive. Hence, it can be suggested that being ISO certified means that an organization has committed to ensuring that they comply with the continual improvement policy and therefore would be more likely to consider implementing cleaner production techniques and technologies to achieve sustainable development. However, even though companies are ISO 14001 accredited, many of them are unaware that this is just the start towards their commitment to sustainable development and greater effort and change is required to actually reach targets set in their policies. Much of the goals stated in environmental policies have not been achieved due to lack of commitment to move past pollution control and waste disposal strategies. Most companies are just content to satisfy the minimum requirements of an ISO 14001 audit without changing or improving their production processes or technologies.

3.1.3. End-of-pipe technology vs cleaner technology. 'Timing' is the key difference between pollution control and cleaner production. Pollution control is after the event whereas CP is a proactive approach focused on prevention. Bosworth et al. (2001) mentioned that there should not be a misconception that 'end-of-pipe' technologies will never be required. Using CP to handle the waste problems would merely reduce the dependence of 'end-of-pipe' technologies or in some cases, eliminate its use completely.

Jasch (2009, p. 833) states that focusing on end-of-pipe solutions rather than cleaner technologies which prevents emissions at its source, will not provide an accurate assessment of opportunities for potential savings of resource use.

Bosworth et al. (2001) concur that cleaner production options are more cost effective when compared to pollution control options and savings are generated through reduced cost of raw materials, energy and waste treatment. Market opportunities for 'greener' products are identified as an environmental benefit of CP.

Jonall (2008, p. 42) stated that although prevention and environmental management costs have been high in the cases studied but considered low when compared to waste and emission treatment which is by far the largest cost category constituting of about ¾ of estimated EMA costs. This ultimately means that the company has spent a lot on end-of-pipe treatment.

It should be however noted that improvements with existing technology is possible but with minimum amounts of savings. Production process efficiency is highly dependent on what efficiency is possible with the best affordable technology. Neither the best available technology nor the best affordable technology would be able to achieve 100% efficiency in output in relation to the input. Processes without losses of energy and or material is nearly impossible to achieve. However practical research in business organizations reveal examples where proactive prevention initiatives have brought about both environmental and financial benefits for firms as compared to reactive end-of-pipe approaches which are expensive and are camouflaged through hidden costs.

From the mid 1970's pollution prevention was realized to be the desired environmental management

strategy (Environmental strategies, 2013). The reduction and possible elimination of waste makes good environmental and business sense. Christmann (2011, pp. 14-16) investigated the characteristics of pollution-prevention technology (clean technology) as well as pollution control technology (end-of-pipe technology) and its effect on cost advantage and competitiveness of firms during his research. His findings were as follows: pollution prevention seeks to prevent or reduce emissions and effluent discharges through better housekeeping, material substitution, recycling or changes to the production process to minimize the creation of pollution and wastes.

Pollution control seeks to trap, store, treat, and dispose of emissions and effluents by using pollution-control equipment such as incinerators and scrubbers. Clean technologies reduce emissions below required levels hence lower compliance and liability costs. End-of-pipe technologies results in higher investment costs with no increase in the efficiency of production, as pollution-control technologies are non-productive assets.

Environmental technologies lead to sustainable cost advantage as they are difficult to imitate by competitors as compared to end-of-pipe technologies which are off-the shelf solutions and can be easily acquired in any market. Environmental technologies (clean technologies) require a firm's production process to be changed whereas end-of-pipe technologies are added to existing production processes.

Research into cleaner production technologies show that Illovo sugar had converted their 20ton/hour coal-fired boilers to fire Sasol gas due to Eskom power shortage. This led to improved boiler efficiency. It had been reported that in 2012 John Thompson was awarded a contract to upgrade and convert original boilers to gas-firing boilers resulting in steam output from each boiler being increazed from 20 to 25t/h (Conversion from coal-firing to gas-firing at Illovo Sugar by news and press 2013). The UNEP has combined the key elements of pollution prevention, waste minimization, eco-efficiency and 3R under the term cleaner production (CP) (Environmental strategies, 2013).

Improvements:

- Plain tubes replaced with spiral tubes (improve heat transfer).
- New, H-fin economiser with integral flue-gas bypass installed in each boiler to improve efficiency.

Equipment upgrade during the conversion improved boiler performance and increased steam output by 25% to 25t/h (Conversion from coal-firing to gas-firing at Illovo Sugar by news and press 2013).

Types of pollution-control technologies

Paper mills have adopted various types of pollution-control technologies in order to reduce environmental impacts of pollution.

Air emissions

Three control technologies are used to remove specific substances from air emissions of pulp and paper mills:

- Electrostatic precipitators physically remove fine particles.
- Scrubbers chemically transform gaseous sulphur dioxide, chlorine and chlorine dioxide so that they stay in the scrubber's chemical solution.
- Combustible gases are added to the chemical recovery system or to power boilers, where they are burned as fuel.

Solid waste disposal

More than 70% of solid waste generated by mill's, were sent to landfills. It has been found that the design of processes within a mill, can affect the potential reuse of mill residue.

A substantial amount of recycled paper manufacturers are trying to find ways to separate materials in mill residue into products that can be beneficially reused.

Effluent treatment

Wastewater discharged from mills, generally undergoes two stages of treatment. The primary treatment removes suspended matter such as bark particles, fibre debris, filler and coating materials in the effluent. Secondary treatment systems use microorganisms to convert the dissolved organic waste in the effluent into a more harmless form. Dioxins and other compounds that do not dissolve in water are often transferred to the sludge during secondary treatment.

Pollution-Prevention Technologies for Pulp and Paper Manufacturing

Pollution prevention approaches reduce the amount of waste released into the environment through raw material substitution, process control, technological changes and improved training, maintenance and housekeeping.

Examples include the development of the recovery boilers and chemical recovery systems that reduce the discharges of chemicals to the environment by allowing the pulping chemicals to be re-circulated and reused within the mill. The approaches to pollution prevention adopted by a mill, depend largely on the type of pulp the mill produces.

Mechanical and unbleached kraft pulp mills focus on improving the operations of the mill, such as spill

prevention and water conservation as well reduced energy consumption. The quality of effluents in unbleached kraft mills can be improved by improving spill control and upgrading pulp washing to send more of the spent pulping liquor back to the chemical recovery system.

Recovered-fibre processing technologies use energy more efficiently and is therefore an economic and environmental priority for paper mills.

Pollution-prevention approaches for bleached kraft mills include:

- Improved pulping processes by extended delignification and oxygen delignification that remove more lignin from the wood before the unbleached pulp enters the bleach plant. This results in fewer bleaching chemicals being used, organic waste generated is reduced, less waste treatment is required and energy use is also lower.
- Improved bleaching processes by using elemental chlorine-free (ECF) bleaching instead of chlorine dioxide in the bleaching process. This reduces the quantity and improves the quality of effluents generated during pulping process.
- Low-effluent processes such as ozone ECF, totally chlorine-free bleaching and chloride removal processes.

Bleached kraft mills reduce discharges to the environment and potential environmental impacts from mill's effluent by installing pollution-prevention technologies. New pulping processes are being researched and developed in America that include the addition of polysulfide to digesters to improve delignification, new bleaching agents including enzymes, peracids, activated oxygen and novel metallic compounds.

Installing metallurgy in recovery boilers that would allow for increased combustion of chlorinated waste products are also being investigated (Pulp and Paper Mills Industry Profile, 2013).

New processes and technologies may be developed during research, that enhance the environmental benefits of using other sources of raw material for papermaking (Pulp and Paper Mills Industry Profile, 2013).

3.2. Data analysis and findings

Table 1. Reliabilities

	Number of Items	Cronbach's Alpha
Company's environmental performance	-	-
Environmental issues addressed	8 of 8	.948
Investment in environmental performance	3 of 4	.621
Tools to measure and manage environmental performance	8 of 8	.896
Benefits of a system designed to measure and manage environmental performance	7 of 7	.927
Challenges of applying systems to measure and manage environmental performance	6 of 6	.797
Overall	33 of 33	.883

All of the sections have reliability scores that exceed the minimum required value of 0.700, except for Investment in environmental performance which is slightly below the standard value. This was due to a negatively worded statement in this section. The first question only had one statement which does not allow for a reliability calculation.

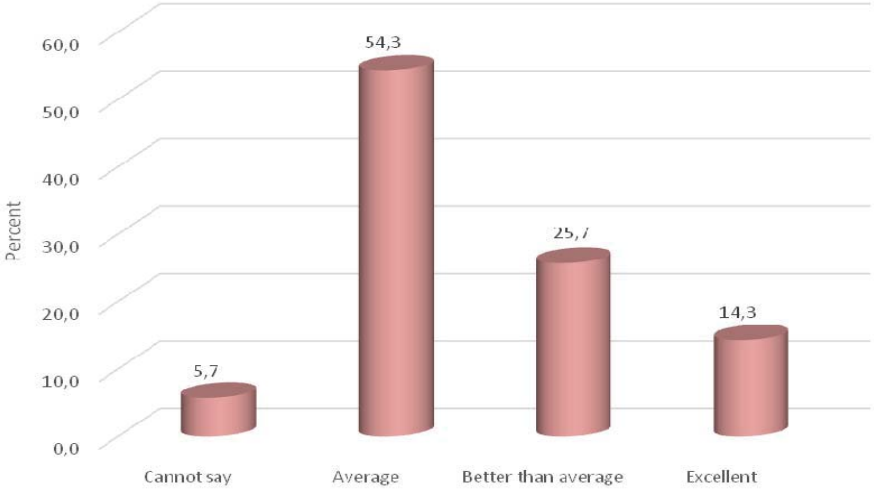


Fig. 2. Company's environmental performance

Forty percent of the respondents indicated that their organisation's performance was above average, with a little more than half (54.3%) indicating that the rating would be average. The chi-square results indicate varying scoring patterns across the options (p = 0.000). In general, the overall response indicated that ma-nagers were satisfied with organization's environmental performance.

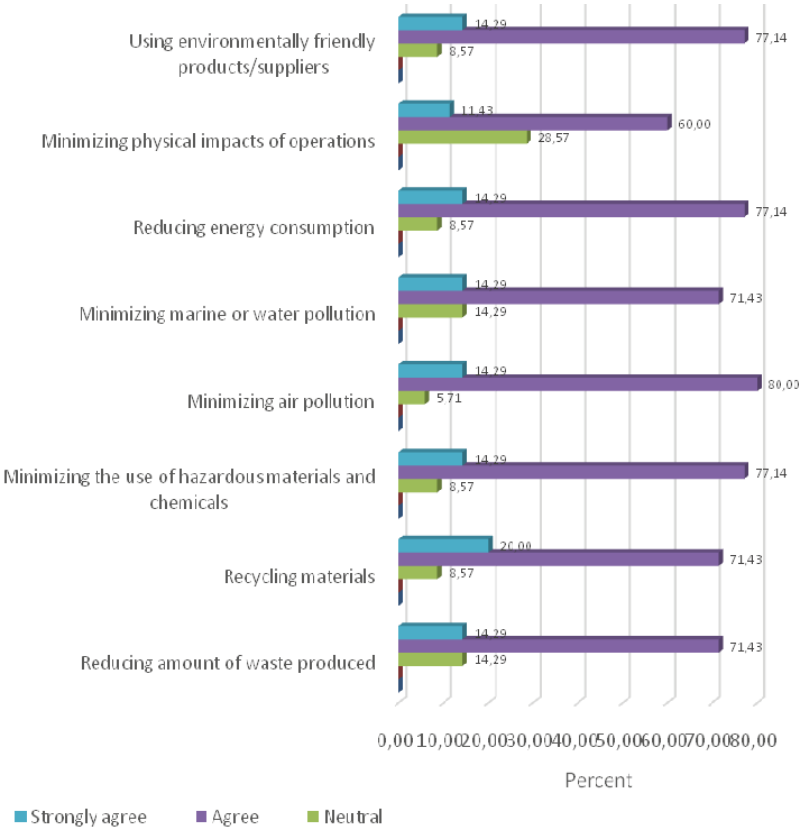


Fig. 3. Environmental issues addressed

The analysis detailed in the table above indicates that 85.75% of the respondents agree that the company has invested sufficiently in improving its environmental performance. It can be perceived that managers may consider further investments to improve environmental performance in the future. However, not much can be done to improve environmental performance with the above information as the company currently uses a traditional cost accounting system. This system is adequate to provide additional information needed to make future investment decision to reduce environmental costs. Shaltegger et al. (2010, p. 144) concur that a company will only adopt an EMA system as an environmental management tool, if they are made aware of what can be gained by using it. They argue that more accurate awareness of process and product cost is an insufficient reason and offer uncertain benefits. Accountants need to know how much they can save with particular emphasis on non-product output costs.

The chi-square results show that all of the p-values are less than 0.05, the level of significance. Hence, the scoring patterns for each statement across the options were not similar.

Table 2. Investment in environmental performance

	Totally disagree	Disagree	Neutral	Agree	Strongly agree
The company does not feel a need to invest in improving its environmental performance	14.29	74.29	8.57	0.00	2.86
The company is willing to invest in improving its environmental performance , but only a small amount	14.29	65.71	11.43	8.57	0.00
The company is willing to invest what is necessary to improve its environmental performance	8.57	20.00	34.29	31.43	5.71
The company has invested sufficiently in improving its environmental performance	0.00	2.86	11.43	71.43	14.29

All of the p-values are less 0.05, the level of significance. Hence, the scoring patterns for each statement across the options were skewed.

Table 3. Tools to measure and manage environmental performance

	Not at all important	Not important	Neutral	Important	Very important
Be effective in reducing environmental impact	0.00	0.00	5.71	5.71	88.57
Be simple and easy to use	0.00	2.86	8.57	60.00	28.57
Be inexpensive to purchase and run	2.86	0.00	48.57	25.71	22.86
Be available on the internet	0.00	2.86	54.29	14.29	28.57
Guarantee the security of data and privacy of use	0.00	2.86	57.14	8.57	31.43
Be available in native language	0.00	2.86	54.29	8.57	34.29
Be continuously updated and improved	0.00	0.00	11.43	54.29	34.29
Training and development for all operational personnel must be available	0.00	0.00	2.86	17.14	80.00

All of the *p*-values are less 0.05, the level of significance. The analysis detailed above sought to identify the criteria used and the perceived level of importance according to managers, when investing in tools to measure and manage environmental performance. The results indicate that 'effect in reducing environmental impact' and 'training and development for all operational personnel must be available' as being very important.

3.3. Benefits of a system designed to measure and manage environmental performance. All of the *p*-values are less 0.05, the level of significance. Hence, the scoring patterns for each statement across the options were not similar. The average level of agreement is 96.73%. This is a high level of agreement with the statements that constitute this section. Only 1 statement has a 4% difference to the other levels of agreement of 97.14%. The analysis aimed to identify criteria implemented by the company to evaluate and select a system designed to measure and manage environmental performance taking into consideration the expected benefits to the company. The results indicate that majority of the respondents consider sustainability issues as very important, followed closely by level of environmental protection.

Table 4. Challenges of applying a systems to measure and manage environmental performance

	Not an important challenge at all	Somewhat important	Neutral	Challenging	Very challenging
Lack of resources	0.00	0.00	2.86	57.14	40.00
Lack of knowledge and understanding of computer skills	0.00	25.71	37.14	17.14	20.00
Lack of professional help and advice	0.00	5.71	40.00	42.86	11.43
Lack of interest in improving environmental performance	0.00	0.00	34.29	45.71	20.00
Difficulty in gathering data for environmental indicators	0.00	22.86	37.14	20.00	20.00
Difficulties in motivating staff	0.00	0.00	31.43	60.00	8.57

The data analysis was used to assess management's perception on the most important challenges in applying a system to measure and manage environmental performance. Results reveal that 'lack of resources' is the most important challenge with a response rate of 97.14%, followed by 'difficulties in motivating staff', at response rate of 68.57%. Interestingly, 'lack of interest in improving environmental performance' was also rated high with 65.71% of respondents indicating this as a challenge.

4. Correlations

Patterns reflected on the correlation sheet reveal that there is a positive correlation between the company's environmental performance and environmental activities implemented to reduce environmental impact and pollution. Hence, it can be concluded that environmental activities practiced by the company has had a positive effect on the company's environmental performance.

Interestingly, the company's investment in improving environmental performance also has a high positive correlation to environmental activities adopted. It can be inferred that as investments in pollution prevention activities increases, environmental performance also increases. Further, a positive correlation of 0.828 has been noted for the relationship between 'increased competitiveness of the company' and 'comparison of environmental performance with that of competitors'. This suggests that respondents agree that the level of environmental performance impacts on the competitiveness of an organization in comparison to its competing industries. Hence, an organization can achieve competitive advantage by improving its environmental performance.

5. Summary of findings

5.1. Environmental performance based review of the companies' documents. The company is ISO

14000 accredited and is committed to implementing continuous environmental improvement measures. According to survey questionnaire companies current environmental performance could be rated as average considering that paper and pulp production is resource intensive and does generate a lot of waste.

EMA system would give a clearer indication of the company's real environmental costs. However, what has come to the forefront is that most companies are not using an EMA to calculate environmental costs and measure environmental performance. Conventional costing systems are being used by companies which only account for waste disposal costs. Loss of raw material as waste (non-product output) is not accounted for and allocated as part of environmental cost. With an EMA system, environmental costs are accurately traced back to processes and products to assist managers in strategic decision making especially decisions regarding the investment in cleaner production technologies. Inefficiency production processes also become visible by adopting an Environmental Management Accounting system.

Cost of disposal and handling of boiler ash was not indicted as environmental costs in the company's financial statement. Environmental cost allocated to each process was nil. Environmental costs were hidden as production costs, for example the unburned coal ash lost as part of bottom boiler ash had large amount of unburned coal. However, this loss of raw material disposed of as waste was not calculated and disclosed as environmental cost.

The obsolete technology used in processes resulted in excess waste generated, higher disposal cost and poor environmental performance. The salary of the environmental manager and other staff members involved in environmental issues are also not included in environmental costs. Depreciation of end-of-pipe technologies used to treat pollution and reduce impact of production processes was also not included in environmental costs.

Therefore it can be deduced that the environmental costs reflected in the company records are incorrect as most of the costs that should be included in the cost calculation are omitted. The reason for this is strongly attributed to the conventional accounting system being used by the company. A complete framework categorizing the different environmental costs as well as guideline to allocate costs should be used by management. This will allow managers to identify benefits of an EMA system and to appreciate the amount of detail it provided together with increasing the visibility of the company's 'true environmental costs'. This will assist in the company's strategic decision making process regarding the adoption of EMA and using MFCA model to estimate the costs of non-product output. This information could be used to perform a cost-benefit analysis of investing in cleaner production technologies to ensure future sustainability of the organizations. Cleaner Production Technologies are expected to improve both environmental and economic performance by reducing raw material consumption and reducing the amount of waste generated as well.

5.2. Questionnaire measuring environmental performance.

- Assessment of company's environmental performance.

Majority of managers assessed the company's environmental performance as above average.

- Steps taken to improve environmental performance.

The companies have implemented various measures to address environmental issues such as using environmentally friendly products, reducing energy and water consumption, recycling materials, reducing waste produced and minimizing the use of hazardous chemical and their impact on the environment.

In 2004, one of the company's spent approximately R60 million to upgrade the bleach plant in order to change the pulping process to chlorine free pulping. This was done in order to reduce the impact on aquatic life caused by dioxins contained in the chlorine.

- Investment by the company to improve environmental performance.

Managers are of the opinion that the company would be willing to invest what is necessary to improve environmental performance.

- Tools to measure and manage environmental performance.

Managers believe that systems designed to measure and manage environmental performance should be inexpensive to purchase and run. The effectiveness in reducing environmental impact as well as convenient means to continuously update and improve the system are considered important when considering investing in tools to measure and manage environmental performance.

- Benefits of a system designed to measure and manage environmental performance.
- Respondents consider cost saving and increased profitability as being the most important benefit of an EMA system, followed by customer satisfaction and contribution to sustainability issues.

- Challenges of applying a system to measure and manage environmental performance.

Lack of resources has been reported as most challenging in implementing environmental management systems. Difficulty in motivating staff has also been identified as a major challenge.

5.3. Recommendations for sustainable, minimum-impact mills. It is important that paper and pulp manufacturers maintain 'sustainable manufacturing' based on pollution-prevention technologies in order to gain public acceptance of resource-intensive businesses over the long-term. Recommendations for minimum-impact mills are as follows.

The goal is to minimize natural resource consumption and quantity of waste generated. A minimum-impact mill is a holistic manufacturing concept that encompasses compliance with environmental laws and regulations, environmental management systems and manufacturing technologies.

- Practicing good environmental management and investing in manufacturing processes that prevent pollution go hand-in-hand. Continuous environmental improvement is limited in mills that use obsolete manufacturing technologies.
- Operating minimum-impact mills make it possible for manufacturers to develop cost effective strategies that improve economic competitiveness and provide environmental benefits.
- Minimum-impact mills are long-term goals which may require an evolution of technologies.
- Technological and process innovation would depend on products manufactured, types of wood available, mill's location, operator expertise, the age and configuration of the equipment, availability of capital and stages that the mill has reached in its capital investment cycle.

5.4. Assessment of the level of minimum-impact mill performance. Vision and commitment to the Minimum-impact mill.

- Well defined goals and progress towards achieving targets set must be assessed continuously.
- Plans to make process modifications or implement pollution-prevention measures must be clearly stated.
- Integration of minimum impact goals into investment strategy for new projects and the replacement or renovation of individual pieces of equipment.
- Investment decisions on specific manufacturing technologies must be consistent with achieving progress toward minimum environmental impact.

Environmental management systems

- Features of the environmental management system (EMS) – Mill must be able to demonstrate how the EMS has improved environmental performance.
- The role of EMS in ensuring regulatory compliance.

Pulp and Paper Manufacturing Technologies and Research Programs

- Assessment of manufacturing technologies will provide information on current technological impact on the environment.
- Research and development programs indicate the company's commitment towards continuous environmental improvement and provide information on pollution-prevention approaches and technologies available to improve manufacturing process.
- When considering investment in new technologies, the company must consider whether these technologies reduce natural resource consumption and discharges to the environment.

Companies can use environmental performance indicators to assess their general environmental performance.

Factors that affect indicator values are as follows:

- The manufacturing technology at a mill.
- The type and operation of the pollution-control equipment.
- Local environmental conditions (including the presence of other industrial facilities that discharge into the river, size of the river and ecosystems near the mill).

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