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AUTHORS	Anel Du Plessis Merwe Oberholzer
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Anel Du Plessis (South Africa), Merwe Oberholzer (South Africa)

A framework for measuring and internal reporting of environmental costs at a mine

Abstract

The purpose of the study is to investigate the current *modus operandi* of measuring and reporting environmental costs at a South African platinum mine which will finally allow for a framework to be set to improve the mentioned measuring and reporting. This research follows a case study approach, which is both explanatory and exploratory, which is *inter alia* to do a gap analysis regarding to the current measuring and reporting of environmental costs. Documents and different activities of the two involved Departments, Environmental and Management Accounting, responsible for the measuring and internal reporting, are considered. The study found that environmental costs are currently being measured by the mine, but they are not classified as such and are absorbed into the overhead or utility accounts. Because of this, reporting of environmental costs are lacking in the integrated statements of the mine. The value of the study is that it provides a framework in order to assist mining companies to measure and report on environmental costs – in such a way that they can improve their environmental and economic performance.

Keywords: Environmental costs, internal reporting, measuring, platinum mine, South Africa.

JEL Classification: Q56.

Introduction

This research comprises a case study on the current measurement and internal reporting of environmental costs at a platinum mine. It is becoming increasingly important for shareholders and investors of such companies to ensure that the environmental footsteps are left behind upon which future generations can build (Heikkurinen and Ketola, 2012; Du Toit and Buys, 2013; Ju and Yoo, 2014). Furthermore, for informed decisions to be made on investing activities, potential shareholders should have data readily available relating to environmental activities and costs of companies. For this reason, the Corporate Social Responsibility (CSR) reports have to include environmental aspects of companies. These reports are published as part of the annual statements (Institute of Directors (KING III), 2009) as integrated reports. The aim of the integrated report of companies is, *inter alia* to communicate environmental information to external parties. This study aims to investigate what is happening ‘behind the screen’, in other words, the focus is on how the environmental activities and costs are measured and reported before the information is published in the public domain. The field of research is demarcated to a JSE-listed (Johannesburg Stock Exchange Limited) platinum mine in South Africa, where documents and different activities of the two involved Departments, Environmental and Management Accounting, responsible for the measuring and internal reporting, are considered.

The rationale of the study can be explained by referring to Roger Baxter, Head of Economics and Strategy of the South African Chamber of Mines, who cannot overemphasize the importance of mining for

the South African economy (McKay, 2013; Miningm^x, 2013). According to Chris Griffith, CEO of Anglo Platinum, input costs are increasing at a higher rate than inflation due to structural changes in the platinum industry (Miningm^x, 2013). To remain profitable, South Africa’s platinum mining sector needs to consider an extensive view on its current mining practices and how this can be ‘cleaned up’ to ensure sustainable growth in the sector (Nahman et al., 2009). Furthermore, environmental liabilities in mining are increasing and industries in this specific sector are becoming more aware of this; therefore, many recent studies focused on the environmental issues of mines (Glaister and Mudd, 2010; Prinsloo, 2010; Buys et al., 2011; Hindley and Buys, 2012). Nevertheless, there are still far more questions than answers in managing environmental issues (Valentine, 2012). It is currently difficult for most companies to link environmental liabilities to financial effects which are creating problems and authors use different strategies in this regard (Oberholzer and Prinsloo, 2011; Fujii et al., 2013). Furthermore, there is a lack in clear understanding on how to measure these liabilities and how to incorporate them into financial reporting of companies (De Beer and Friend, 2006). The research question is, therefore, how can mines improve their current measuring and internal reporting of environmental costs?

The answer to this question is closely linked to the purpose of the study: to investigate the current *modus operandi* of measuring and reporting environmental costs which will finally allow a framework to be set to improve the measurement and internal reporting of environmental costs. The argument of this study is that in order to create a sustainable environment, the mining sector needs to ensure that they mine economically, effectively and efficiently – not

only considering production costs, but also the reserves being mined – thus ensuring effective and efficient extraction of reef minerals. But this can only be done if all cost aspects are taken into account, including environmental cost information. Hence, this study will extend the literature by identifying gaps in current measurement and reporting of environmental costs, which will allow for further research aimed at developing accounting systems to accommodate the need for detailed environmental accounting applications, thereby adding value to the concept of the triple bottom line.

This research follows a case study approach, which is firstly explanatory; that is to explain the need and definition of environmental costs and the methods to measure them. Secondly, it is exploratory by exposing the nature and the complexity of the problem – that is to do a gap analysis of current measuring and reporting of environmental costs before launching long-term in-depth studies (Durrheim, 2006; Yin, 2009).

2. Background

2.1. The South African mining industry. The reason that the mining sector was chosen for this study is motivated by the research done by Antonites and De Villiers (2003) and Prinsloo (2010) which indicates that the environmental impact of mining is greater than in any other sector. For this reason mining industries need to disclose more environmental information and certain accounting policies force the mining sector to adhere to these disclosures (Hindley and Buys, 2012; Antonites and De Villiers, 2003). Platinum mining was chosen to serve the purpose of this study as the case study was easily accessible, information was readily available and full co-operation was given by the case study principal.

The importance of the mining sector is emphasized by statistics that reveal that mining contributes 19 percent to South Africa's GDP, 50 percent to its exports, provides job opportunities to 1 300 000 people, and makes up 17.2 percent of the total corporate tax inflow. These statistics alone prove that South Africa needs to look after its mining reserves in order to maintain a healthy growth factor in the future (McKay, 2013; Miningm^x, 2013). South Africa provides 70 percent of the global platinum demand, and 21 percent of South Africa's mineral revenues come from this sector alone (Esterhuizen, 2013).

2.2. Conceptual scope. In order to improve current measuring and internal reporting of environmental costs in the mining sector, the logical route to follow will be to do some explanation which is firstly, that the need to measure environmental costs must be understood. As soon as the need is established it is secondly, important to define what environmental costs are, and which of these are applicable within

the sectors or industries of companies. Thirdly, the methods to measure these costs should then be identified and companies need to decide which method would be the most appropriate measure in consideration of their current costing procedures. The nature and complexity of the problem is fourthly, to expose the application of various methods that are available and only after these four aspects have been concluded, would reporting of environmental costs be possible. Environmental costs can now (fifthly) be integrated into internal reporting which management can use to improve daily decision making.

3. Literature review

3.1. Need to measure environmental costs. This literature review on the need to measure environmental costs serves as a further motivation for asking the research question of how mining companies can improve the measuring and internal reporting of environmental costs. If reports of mining companies can indicate the financial impacts of environmental costs and cost savings due to increased environmental management, companies worldwide would increasingly pay more attention to the current impacts of their production on the environment. Owing to the study of Bragdon and Marlin (1972), many other studies followed which emphasize the need to measure environmental costs in order to prove that it does pay to be green in the long term (Porter and Van der Linde, 1995; Bhat, 1999; Schaltegger and Synnestvedt, 2002; Salama, 2003; Ambec and Lanoie, 2008; Prinsloo, 2010; Nishitani and Kokubu, 2012; De Marchi et al., 2013; Fujii et al., 2013), although some criticism tends to indicate the opposite (Norman and MacDonald, 2004; Telle, 2006).

It is important to note that environmental issues are an increasing concern for internal and external stakeholders in mining industries (Frick, 2002; IFAC, 2005; Jenkins and Yakovleva, 2005; Hindley and Buys, 2012; Alewine and Stone, 2013). Environmental management accounting adds value to the internal management process with a specific focus on the environment. External reporting of environmental management accounting information is becoming more prevalent as shareholders and other stakeholders of companies increasingly require these types of information (IFAC, 2005). It is important, in particular for mining companies, to adopt strategies in order to provide evidence of good mining practices especially during these times where mining has had such negative impacts on landscapes and communities around the world (Pettersson, 2008).

Platinum group metals are being used in a wide range of environment-related technologies such as catalysts for chemical process facilities, catalytic converters for exhaust control in transport, electronic components, hydrogen fuel cells, a variety of

speciality medical uses, and so forth. The demand for these metals can only be expected to increase in future rising pressures to meet environmental challenges placed on companies (Glaister and Mudd, 2010). The extraction of natural resources from the earth's core has currently instigated several debates on how mineral extraction can be sustainable. By considering environmental impacts, mining industries can ensure environmental protection against natural resource exploitation and rehabilitate land to allow further use for following generations (Jenkins and Yakovleva, 2005). Mining companies can achieve this by considering their environmental costs and including them in their internal decision making processes.

3.2. The scope of environmental costs. This section identifies what environmental costs categories should include on a platinum mine when environmental costs are measured. Environmental costs can be categorized into two categories: costs applicable to environmental protection and costs applicable to material and energy flows, all of which can be reduced by spending on environmental protection costs. From this viewpoint environmental costs can be defined as all costs directly and indirectly related to material and energy use and their results on the environment (Schaltegger and Wagner, 2005); however, environmental costs can be viewed differently depending on the views of companies of what the term environment entails (Burritt, 2005).

The following cost categories were identified through literature and were adjusted in order to indicate which are applicable to the platinum mining sector in specific. The data analysis completed on the detail accounting entries of the case study principles as the physical unit reporting of environmental impacts in the sustainability report found that these cost categories are applicable to the platinum mining sector [Jasch (2009) and IFAC (2005) used as a base and their research was included to determine the applicable cost categories specifically for the platinum mining sector]:

(a) Waste and emission treatment costs:

- ◆ Chemicals used in processing and refining stages.
- ◆ Depreciation of related equipment.
- ◆ Maintenance of equipment.
- ◆ Personnel costs.
- ◆ Fees, taxes, charges.
- ◆ Fines and penalties.
- ◆ Insurance for environmental liabilities.
- ◆ Provisions for clean-up costs.

(b) Prevention and environmental management:

- ◆ External services relating to environmental management (contractors).

- ◆ Personnel within environmental management departments.
- ◆ Additional expenditure for new technologies in extraction, processing and refining which will ensure 'cleaner' mining.

(c) Material purchase value of non-product output:

- ◆ Energy.
- ◆ Water.

(d) Environmental revenues:

- ◆ Subsidies and awards received for the implementation of preventative and corrective procedures concerning environmental impacts.

(e) Material costs of product output:

- ◆ Energy.
- ◆ Water.

(f) Research and development costs:

- ◆ New shaft or mine feasibility studies.
- ◆ Biodiversity.

(g) Rehabilitation provisions (this is of utmost importance in mining in creating a sustainable environment for future generations and thus, these provisions need to be indicated separately).

3.3. Methods of applying environmental management accounting in theory. Various different measurement methods can be applied, depending on how companies classify environmental costs. Measuring environmental costs became a focus point in research during the early 1970's. Standalone calculations were done in an attempt to control environmental impacts; however, this method was reactive in nature and did not take into account integrated technologies or environmental protection costs (Schaltegger and Wagner, 2005). It became apparent that a more structured approach to costing environmental impacts needed to be developed. At that stage current management accounting methods were taken one step further, to include environmental aspects. The four management accounting methods are:

Life cycle costing. Full cost accounting, also referred to as life cycle costing and total cost assessment (Norris, 2001; Shapiro, 2001; Hunkeler and Rebitzer, 2001; Hunkeler et al., 2007) is a method for estimating and accumulating costs for a product over its entire life cycle. This is done to ensure that the profits made during the manufacturing phase of the life cycle will cover expenses occurring during the pre- and post-manufacturing phases (Drury, 2012).

Life cycle analyses are currently done in mining industries to assist mining companies in assessing their environmental and economic performance. Data are not publicly available as data are consi-

dered to be confidential information of companies due to the nature and quality of data required to complete life cycle analyses. This tends to result in over simplified reports for mining processes. In order to address this shortcoming, a mining life cycle model (LICYMIN) has been developed using Oracle 9i Enterprise Edition. This model relies on site specific data and provides traceable as well as realistic allocations of environmental impacts (Durucan et al., 2006).

Platinum has numerous uses and; therefore, completing a full life cycle costing analysis from cradle-to-grave would be time consuming adding minimal value to the internal decision making of mining companies. An alternative approach would be a cradle-to-gate measurement, where the life cycle ends when the final product leaves the production site. For this reason, a cradle-to-gate approach is a preferred and the most suitable method when considering life cycle analyses and life cycle costing data for platinum mining. This will include all production, processing and waste handling activities (Durucan et al., 2006). Costs that should be included in a cradle-to-gate approach include all costs up to the point where platinum or other platinum group metals are sold into the market.

Activity based costing. Activity based costing is a cost accumulation system that makes use of activities and cost drivers to assign costs to products or services (Banker et al., 2008; Drury, 2012), thereby assisting companies in identifying production costs associated with each activity within the production process. This method was developed as an alternative to traditional costing methods which no longer accurately addresses the growing need for companies to allocate overhead costs to products and services. The application of activity based costing in companies improved their decision making processes by granting a better understanding on how resources are used within companies (Rundora et al., 2013).

Implementing activity based costing requires skills and knowledge as well as capital (Raiborn and Kinney, 2009); however, mining companies do have access to the necessary skills, knowledge and accounting systems which will allow for various costing structures. Implementing activity based costing, therefore, at platinum mines (if it is not implemented yet) should be possible without encountering too many obstacles.

Using activity based costing holds several benefits when measuring environmental costs. Management gain better understanding of why costs rise; thus enabling them to implement appropriate management approaches such as activity based management (Kaplan and Bruns, 1987; Banker et al., 2008;

Blocher et al., 2008; Khataie et al., 2011). Understanding cost behavior and the reasons why they occurred can assist management in identifying areas within companies that need improvement, whether it is product design, pricing decisions or market segments that need to be developed. Furthermore, this will assist management to improve their strategic decision making in the long run (Banker et al., 2008; Blocher et al., 2008; Rundora et al., 2013). Additionally, activity based costing also reveals where value is added and where value is destroyed within companies.

In using the activity based costing method; environmental analysis can be done after each stage of mining processes. In doing so, mining companies can identify which stages of their processes have the biggest impact on the environment as well as their cost structure. This problem area can then be managed to ensure more efficient and sustainable mining.

Material flow cost accounting. Jasch (2009) defines material flow cost accounting as “a tool for measuring the flows and stocks of materials for a company, production process or product in both physical and monetary units. It is based on an input-output analysis of material flows, but applies a different cost allocation procedure”. According to Strobel (2002) flow cost accounting can be considered as the quantification of factors within the material flow system.

Managing material flows will assist in increasing efficiency of inputs, leading to cost reductions and also having a positive impact on the environment (Strobel, 2002). A considerable percentage of production costs consists of material costs, and a large share of these costs comes from material losses within production systems (waste) (UNSD, 2001; Strobel and Redmann, 2002; Gale, 2006). Naturally, waste does not create value within companies and where it was previously only measured in physical terms material flow cost accounting now measures waste in monetary terms as well (Onishi et al., 2008). This assists companies in identifying hidden waste material costs in order to increase production efficiencies and reduce the environmental impacts of these companies. As material flow cost accounting links environmental impacts with cost implications, it is likely to assist in improving the quality of internal decision making (USEPA, 2000; Onishi et al., 2008).

Material flow cost accounting; however, only assists in calculating the costs of product and non-product (waste) output, and does not calculate the *total environmental costs* (waste and emission treatments, prevention and environmental management costs) incurred by organizations, whether processes or products (Jasch, 2009). The implication is that other methods will need to be applied in conjunction with

material flow cost accounting in order to measure the total costs of all environmental impacts.

Combination of methods. Several studies indicate that in order to measure environmental costs more accurately, a combination of methods should be applied (Busch and Liedtke, 2006; Jasch, 2009). This will not only assist in the application of environmental management accounting, but will also have additional benefits with regards to environmental performance management. Using activity based costing over and above the life cycle of products can improve productivity and efficiency, leading to higher net margins (Kreuze and Newell, 1994). Material flows are traced within companies and allocated back to the cost centre that is responsible for the environmental impact. This will improve environmental performance and ultimately profitability (Jasch, 2009).

4. Method and materials

4.1. Data collected. This section will summarize the data that have been collected from the case study principal in the attempt to expose the current *modus operandi* of measuring environmental activities and costs. The data collected from the case study principal cannot be reproduced due to the classified nature of the information provided and the confidentiality agreement signed. In light of this matter, the following summary of the data collected from the case study principal is provided: detailed accounting entries of overhead accounts; process flow chart; environmental reports; life cycle assessments; procedures pertaining shaft closures and rehabilitation of mine sites; and IAS 37 applications and notes.

4.2. Interviews held with the case study principal.

Three scheduled interviews were held on site with the case study principal during 2013. These interviews were scheduled in order to obtain the views of the different Departments on environmental costs and how they perceive the role of these costs within a platinum mine.

4.2.1. Management accounting department. The first interview was held with the mineral process management accountant.

- ◆ The case study principal currently reports on environmental costs – in total for the company as well as per shaft. Confirmation was given that these reports can be provided to verify which environmental costs are included.

The second interview was held with a senior management accountant.

- ◆ The attitude towards additional line-item reporting was not positive. The senior management accountant pertained that it will only be extra

work with no real benefits, but that he would like to see the outcome of such an exercise.

- ◆ The Department applies responsibility accounting which makes it more difficult to identify environmental costs in their accounting system as there are no responsible people to account for these costs.
- ◆ According to the Management Accounting Department there are enough data readily available on input-output quantities to complete a material flow cost accounting analysis. Upon asking why the Environmental Department does not have access to this information, the answer was given that they should be able to access this information on the system.

4.2.2. Environmental department. The third interview was held with three environmental specialists on site including the Head of Department.

- ◆ Life cycle assessments are not currently done by the case study principal. They are busy researching the possibility of introducing it in the near future, but the attendees present at the interview were not entirely convinced that this will work at this specific mining company. The reason that they believe this will not work is that there are not enough people employed to assist with the workload associated with such a task. The implication thereof is that this exceedingly complicates the calculation of cradle-to-gate life cycle costing.
- ◆ Activities involved in environmental cost flows will be identifiable and will be used to allocate costs, making activity based costing methods easy to introduce.
- ◆ Their current accounting system does not provide for an environmental cost element when entering cost data into the system, making it particularly difficult to identify environmental costs in the accounting system, and consequently, these costs ‘disappear’ in overhead accounts. This is easily rectifiable by simply having the accounting system administrator add a cost element to their current accounting system. Training is required to ensure that the correct costs are allocated to this element.
- ◆ Budgets are currently done with a line-item that refers to environmental costs, but actual data pulled from the accounting system do not have a line-item with which to compare actual versus budgeted figures.
- ◆ Input-output quantities that can be used to calculate environmental costs using material flow cost accounting are not readily available. According to the Environmental Department, identifying this will be a difficult and time consuming task.

4.3. Data analysis. Three methods of data analysis were used in this study to ensure that all possible outcomes have been taken into account when the case study was concluded. The first method used was explanation building; the second, an organizational-level logic model; and the third, testing the theory against a rival explanation (Yin, 2009).

Explanation building

(a) A theoretical statement on how environmental costs should be measured and reported on.

Environmental costs should be measured using one of three methods or a combination of methods that include activity based costing, material flow cost accounting and life cycle costing (cradle-to-gate). Environmental costs should be reported on in a separate line-item with an explanatory note in the financial statements of mining companies.

(b) Initial findings of the measurement methods and reporting of environmental costs by the case study principal.

In the published Consolidated Financial Statements rehabilitation provision calculated by using estimates, is the only item that appears as a separate line relating to environmental costs. The case study principal reports on monetary units of the following items under 'Environmental' in their Sustainable Development Report of 2013, namely Land Management: Rehabilitation Liabilities and/or Current Costs; and Rehabilitation Provisions.

The case study principal reports on *physical units* of the following items under Environmental in their Sustainable Development Report of 2013 namely, ore milled, tailing disposed on dam, dump slag treated, furnace and converter slag generated and treated and platinum produced. Material consumption is reported as diesel, petrol, coal and industrial burning oil. Other physical units reported are water, energy and emissions.

In the Detailed Accounting Records of the overhead accounts no costs were indicated as environmental costs. The following costs, however, could be classified as completely or partially environmental costs:

- ◆ Total fuels and gases (accounted for in the fuel account, which is considered as variable overhead costs): oils greases gasses, diesel, petrol, industrial burning oil and coal.
- ◆ ISO accreditation (accounted for in the other overhead account, considered to be a fixed overhead cost).
- ◆ Water (accounted for in the utilities account, considered as a variable overhead cost).
- ◆ Electricity (accounted for in the electricity account at a fixed rate, considered as a variable overhead cost).

- ◆ Off-reef development costs (accounted for in the off-reef account, considered as capital development costs).
- ◆ Off-reef development material (considered as indirect material costs).
- ◆ Off-reef development utilities (considered as overhead costs).
- ◆ Chemicals (accounted for in the other account for the concentrator, considered as variable overhead costs).

The case study principal does not make use of life cycle analysis in their Environmental Department which makes the measurement of life cycle costing difficult. They are currently in the process of developing life cycle analysis procedures that should be applied in the near future.

The Closure Costing Report for 2013 only includes costs that refer to the closure of the specific sites, which includes rehabilitation costs, removal of structures and waste. These costs are calculated by using standard costs and a bill of quantities drafted by the Environmental Department and a consulting firm.

(c) Revised statement.

Environmental costs measured using activity based costing, material flow cost accounting or life cycle costing (cradle-to-gate), should be reported on a separate line-item and an explanatory note should accompany the financial statements to ensure a clear understanding of the environmental impacts certain internal decisions have. This will enforce triple-bottom-line reporting, thereby adding value to environmental disclosures.

(d) Findings based on the revised statement.

The case study principal does not report on environmental costs as a separate line-item, the main reason being that they apply responsibility accounting and at this stage there are no people responsible on site to take this activity one step further.

A clear definition of what should be included under environmental costs is lacking between Departments. Various Departments perceive environmental costs differently which creates a problem when costs are captured in the accounting system. Physical data is available for environmental inputs and outputs, but there is no link between the data and monetary values. This makes material flow cost accounting possible; however, the theoretical application of this method needs to be adjusted to suit the extraction industry.

In conjunction with responsibility accounting, the case study principal uses an activity based costing approach for their costing methods. Hence, including an environmental element as one of the cost drivers would be possible.

Firm or organizational-level logic model. The following organizational-level logic model has been derived from the collected data for the accounting of environmental costs at a platinum mine namely, the data entered in the first step of the accounting system has a large impact on the final reporting of the costs incurred as the flow of cost recording. Furthermore, each Department has various activities, each having a responsibility linked to it. Goods are required for each activity within the Departments and for each activity. There are several cost elements which may be valid. Persons responsible for each activity decide which cost element should be linked to each expense item that falls under their responsibility. The possibility does exist for certain expenses to be linked to incorrect cost elements. In the case of environmental costs it is essential that environmental costs be clearly defined in order to avoid incorrect cost allocation. During the visit to the case study site it was clear that various Departments had different understandings of what environmental costs entail.

Testing the theory against the rival explanation. Testing the theory against the rival explanation makes it possible to arrive at a conclusion regarding a gap analysis concerning the current measuring and reporting of environmental costs. Several studies have concluded that companies will not benefit from controlling environmental costs and reporting on a triple-bottom-line (Raar, 2002; Telle, 2006; Pava, 2007; Hacking and Guthrie, 2008). This opens the question of whether it really would benefit mining companies to spend time and effort on introducing a framework to measure and report on environmental costs. Nevertheless, the gap identified is that although the data collected

from the case study indicate that the mining company measures a large percentage of possible environmental costs with their current accounting systems, the problem is that they (1) do not refer to these costs as environmental costs; (2) input-output data are not linked to monetary values; and (3) the Management Accounting Department does not allow departments to conduct in-detail reporting on environmental costs.

Discussion

To summarize, this study has indicated that the need to measure environmental costs is that potential cost savings can be identified, due to increased environmental management. Data quality from management accounting departments and environmental departments will affect the accuracy of the measuring method applied – if data quality is not up to standard, changes within the information systems of departments will be required in order to improve data quality and hence the accuracy of the measurement of environmental costs. This factor is important to consider as it will affect the reporting possibilities regarding environmental costs. The study has also indicated in the gap analysis three shortcomings of the current *modus operandi* of the mining company.

From the experience of the literature review and the case study, the following framework has been developed to assist mining companies, specifically platinum mines, in identifying which factors to measure and report on within environmental costs. Both management accounting and environmental departments should estimate the current quality of their data (poor, average or good) and make the necessary changes accordingly.

Table 1. Changes required in the Management Accounting Department and the Environmental Department (own research)

Management accounting department			
Data quality and/or system	Poor	Average	Good
Changes required	Information systems need to be upgraded to improve the quality of data and to ensure accuracy of data input. The system should accommodate environmental costs according to the costing method that best suits the company. Costing methods that should be considered include: activity based costing, material flow cost accounting and life cycle costing. Environmental costs need to be defined in accordance with the company profile.	The current information system should be audited to ensure that all the requirements for internal reporting are met. Costing methods should be aligned to the company profile to ensure improved usability of data. Environmental aspects should be considered when costing methods are reviewed. Environmental costs need to be defined in accordance with the company profile.	Minor adjustments are necessary to the accounting system in order to include environmental cost allocation under the required cost fields.
Changes required	A database with standard as well as actual physical unit quantities of environmental aspects should be designed. Detailed process flow charts should be drafted. This can be used to measure inputs and to assess the effects of the outputs on the environment. Expected rehabilitation of mining areas needs to be costed and provisions should be made for this in the accounting records. Closure costing should be done. Life cycle analyses should be introduced. The environment should be defined.	Detailed information with regards to processes should be entered to ensure that the quality of data is improved. Life cycle analysis assessments should be completed and used as a base to measure environmental impacts of all mining processes. The definition of the environment should be reviewed.	Minor adjustments will be needed to synchronize the Environmental Department and Management Accounting Department data so as to ensure accurate measuring and reporting of environmental costs.

Once the changes are made, environmental costs should be measured by using one of the three methods. Firstly, activity based costing that requires the identification of activities which relate to environmental aspects of companies. This will include activities that have a direct and indirect impact on the environment. Cost drivers will include water, energy sources and chemicals. Secondly, life cycle costing which requires that a detailed life cycle analysis should be done by environmental departments. Costs should be linked to each element of the life cycle analysis in order to derive life cycle costing (cradle-to-gate). Thirdly, material flow cost accounting in combination with either activity based costing or life cycle costing (cradle-to-gate). Detailed information with regards to input-output quantities for every process is needed. Materials input refer to water, energy, air (underground supply) and chemicals in the extraction sector and output quantities refer to product output, waste water, chemicals and emissions. After these quantities have been measured, costs should be allocated to these quantities by means of market values (water, energy, oxygen and chemicals), costs to direct and control oxygen underground and costs to minimize emissions.

If the environmental costs are successfully measured it will be possible to include these costs as a sepa-

rate line-item in internal management reports and external financial reports.

Conclusion

This research has extended the current literature by identifying the gap experienced in sustainable reporting. These findings can assist in further research on the application of triple-bottom-line reporting as well as linking social, economic and environmental performances.

The study found that environmental costs are currently being measured by a platinum mine, but these costs are not classified as environmental costs and are absorbed into the overhead or utility accounts. Because of this, reporting of environment costs are lacking in the integrated statements of this mine. A gap analysis on the reporting of environmental impacts concluded this as well – monetary units of measures with regards to environmental impacts are lacking within the integrated reports published by the mine. This gap needs to be filled in order to improve the current reporting of environmental costs at platinum mines. This study concluded with a framework in order to attempt to close the gap identified – to assist mining companies to measure and report on environmental costs – in such a way that they can improve their environmental and economic performance.

References

1. Alewine, H.C. and Stone, D.N. (2013). How does Environmental Accounting Information influence attention and investment? *International Journal of Accounting and Information Management*, 21 (1), pp. 22-52.
2. Ambec, S. and Lanoie, P. (2008). Does it pay to be green? A systematic overview, *Academy of Management Perspective*, 22 (4), pp. 45-62.
3. Antonites, E. and De Villiers, C.J. (2003). Trends in South African corporate environmental reporting: A research note, *Meditari Accountancy Research*, 11, pp. 1-10.
4. Banker, R.D., Bardhan, I.R. and Chen, T. (2008). The role of manufacturing practices in mediating the impact of activity-based costing on plant performance, *Accounting, Organizations and Society*, 33 (1), pp. 1-19.
5. Bhat, V.N. (1999). Does it pay to be green? *International Journal of Environmental Studies*, 56 (4), pp. 497-507.
6. Blocher, E., Stout, D.E., Cokins, G. and Chen, K. (2008). *Cost management: A strategic emphasis*, New York: McGraw-Hill/Irwin.
7. Bragdon, J.H. and Marlin, J.A.T. (1972). Is pollution profitable? Environmental virtue and reward: Must stiffer pollution controls hurt profits? *Risk Management*, 19 (4), pp. 9-18.
8. Burritt, R.L. (2005). Environmental risk management and environmental management accounting – developing linkages. In *Implementing Environmental Management Accounting: Status and Challenges*, Rikhardsson, P.M., Bennett, M., Bouma, J.J. and Schaltegger, S. (eds), Dordrecht: Springer.
9. Busch, T. and Liedtke, C. (2006). Resource Efficiency Accounting, In *Management models for Corporate Social Responsibility*, Jonker, J. and De Witte, M. (eds.), Berlin: Springer.
10. Buys, P.W., Oberholzer, M. and Prinsloo, T.F. (2011). Estimating scale efficiency of platinum mining companies' environmental performance: A South African Perspective, *International Business and Economics Research Journal*, 10 (12), pp. 11-22.
11. De Beer, P. and Friend, F. (2005). Environmental accounting: A management tool for enhancing corporate environmental and economic performance, *Ecological Economics*, 58 (3), pp. 548-560.
12. De Marchi, V., Di Maria, E. and Micelli, S. (2012). Environmental strategies, upgrading and competitive advantage in global value chains, *Business Strategy and the Environment*, 22, pp. 62-72.
13. Drury, C. (2012). *Management and Cost Accounting*, London: Cengage Learning.
14. Durrheim, K. (2006). Research design, In *Research in Practice: Applied Methods for Social Sciences*, Terreblance, M., Durrheim, K. and Painter, D. (eds.), Cape Town: UCT Press.

15. Durucan, S., Korre, A. and Munoz-Melendez, G. (2006). Mining life cycle modelling: A cradle-to-gate approach to environmental management in the minerals industry, *Journal of Cleaner production*, 14, pp. 1057-1070.
16. Du Toit, M. and Buys, P.W. (2013). An evaluation of the cooperative business model within the context of the Global Reporting Initiative, *International Business and Economics Research Journal*, 12 (12), pp. 179-192.
17. Esterhuizen, I. (2013). Long-term fundamentals of SA's platinum sector remain strong, *Mining Weekly online*. www.miningweekly.com/print-version/long-term-fundamentals-of-sas-platinum-mining-sector-renewvironmental-management-accounting-in-strong-2013-04-24, (accessed April 26, 2013).
18. Frick, C. (2002). *Direct foreign investment and the environment: African Mining Sector*, OECD Global Forum on International Investment – Conference on Foreign and Direct Investment and The Environment – Lessons to Be Learned by the Mining Sector, Paris: OECD Headquarters.
19. Fujii, H., Itawa, K., Kaneko, S. and Managi, S. (2013). Corporate Environment and Economic Performance of Japanese Manufacturing Firms: Empirical Study for Sustainable Development, *Business Strategy and the Environment*, 22, pp. 187-201.
20. Gale, R. (2006). Environmental management accounting as a reflexive modernization strategy in cleaner production, *Journal of Cleaner production*, 14 (14), pp. 1228-1236.
21. Glaister, B.J. and Mudd, G.M. (2010). The environmental Costs of Platinum Mining – PGM Mining and Sustainability: Is the Glass Half-Full or Half-Empty? *Minerals Engineering*, 23 (5), pp. 438-450.
22. Hacking, T. and Guthrie, P. (2008). A Framework for Clarifying the Meaning of Triple Bottom Line, Integrated, and Sustainability Assessment, *Environmental Impact Assessment Review*, 28 (2-3), pp. 73-89.
23. Heikkurinen, P. and Ketola, T. (2012). Corporate Responsibility and Identity: From a Stakeholder to an Awareness Approach, *Business Strategy and the Environment*, 21, pp. 326-337.
24. Hindley, A.T. and Buys, P.W. (2012). Integrated Reporting Compliance with the Global Reporting Initiative Framework: An Analysis of the South African Mining Industry, *International Business and Economics Research Journal*, 11 (11), pp. 1249-1260.
25. Hunkeler, D. and Rebitzer, G. (2001). Life-cycle Costing – Paving the Road to Sustainable Development? *Gate to EHS: Life Cycle Management*, www.scientificjournals.com/ehs (accessed November 15, 2013).
26. Hunkeler, D., Lichtenvort, K. and Rebitzer, G. (2007). *Environmental life cycle costing*, Boca Rotan: CRC Press.
27. IFAC (2005). *Environmental management accounting: International guidance document*, IFAC: USA.
28. Institute of Directors (2009). KING III: Code of Governance for South Africa 2009.
29. Jasch, C. (2009). *Environmental and flow cost accounting, principals and procedures*, Delft: Springer.
30. Jenkins, H. and Yakovleva, N. (2006). Corporate social responsibility in the mining industry: Exploring trends in social and environmental disclosure, *Journal of Cleaner Production*, 14 (3-4), pp. 271-284.
31. Ju, H-C. and Yoo, S-H. (2014). The environmental cost of overhead power transmission lines: The case of Korea, *Journal of Environmental Planning and Management*, 57 (6), pp. 812-828.
32. Kaplan, R. and Bruns, W. (1987). *Accounting and management: A field study perspective*, Boston: Harvard Business School Press.
33. Khataie, A.H., Bulgak, A.A. and Segovia, J.J. (2011). Activity-based costing and management applied in a hybrid decision support system for order management, *Decision Support Systems*, 52 (1), pp. 142-156.
34. Kreuze, J. and Newell, G. (1994). ABC and life cycle costing for environmental expenditures: The combination gives companies a more accurate snapshot, *Management Accounting US*, 75 (8), pp. 38-42.
35. McKay, D. (2013). Make or break for SA's mining sector, *Finweek*, April 11, p. 6.
36. Mining^x Higher Grade (2013). SA platinum embroiled in economic crisis, www.miningmx.com (accessed April 26, 2013).
37. Nahman, A., Wise, R. and De Lange, W. (2009). Environmental and resource economics in South Africa: status quo and lessons for developing countries, *South African Journal of Science*, 105, pp. 350-355.
38. Nishitani, K. and Kokubu, K. (2012). Why does the reduction of greenhouse gas emissions enhance firm value? The case of Japanese manufacturing firms, *Business Strategy and the Environment*, 21 (8), pp. 517-529.
39. Norman, W. and Macdonald, C. (2004). Getting to the bottom of "Triple bottom line", *Business Ethics Quarterly*, 14 (2), pp. 243-262.
40. Norris, G.A. (2001). Integrating life-cycle cost analysis and LCA, *International Journal of LCA*, 6 (2), pp. 118-120.
41. Oberholzer, M. and Prinsloo, T.F. (2011). Estimating the efficiency of sustainable development by South African mining companies, *Journal of Human Ecology*, 36 (3), pp. 179-184.
42. Onishi, Y., Kokubu, K. and Nakajima, M. (2008). Implementing material flow cost accounting in a pharmaceutical company, In *Environmental Management Accounting for Cleaner Production*, Schaltegger, S., Bennett, M., Burritt, R.L. and Jasch, C. (eds.), Delft: Springer.
43. Pava, M.L. (2007). A response to "Getting to the bottom of 'Triple bottom line'", *Business Ethics Quarterly*, 17 (1), pp. 105-110.
44. Petterson, M.G. (2008). Minerals sustainability, emerging economies, the developing world, and the 'truth' behind the rhetoric, *Estonian Journal of Earth Sciences*, 57 (2), pp. 57-74.
45. Porter, M. and Vander Linde, C. (1995). Towards a new conception of environment competitiveness relationship, *Journal of Economic Perspectives*, 9 (4), pp. 97-119.

46. Prinsloo, T.F. (2010). *Does it pay to be green? An empirical study of the South African mining industry*, Potchefstroom: North-West University (Mini-dissertation, M.Com).
47. Raar, J. (2002). Environmental initiatives: Towards triple bottom line reporting, *Corporate Communications: An International Journal*, 7 (3), pp. 169-183.
48. Raiborn, C.A. and Kinney, M.R. (2009). *Cost accounting: Foundations and evolutions*, Mason: South Western/Cengage Learning.
49. Rundora, R., Ziemerink, J.E.E. and Oberholzer, M. (2013). Activity-based costing in small manufacturing firms: A South African study, *Journal of Applied Business Research*, 29 (2), pp. 485-498.
50. Salama, A.I. (2003). *A Median Regression Analysis of the relationship between environmental reputation and corporate financial performance: Empirical evidence on UK firms* (Rensselaer Polytechnic Institute Conference, October), New York: Rensselaer Polytechnic Institute.
51. Schaltegger, S. and Synnæstvedt, T. (2002). The link between 'Green' and Economic success. Environmental Management as the crucial trigger between Environmental and Economic performance, *Journal of Environmental Management*, 65 (4), pp. 339-346.
52. Schaltegger, S. and Wagner, M. (2005). *Current trends in Environmental Cost Accounting*, In Implementing Environmental Management Accounting: Status and Challenges, Rikhardsson, P.M., Bennett, M., Bouma, J.J. and Schaltegger, S. (eds), Dordrecht: Springer.
53. Shapiro, K.G. (2001). Incorporating costs in LCA. *International Journal of LCA*, 6 (2), pp. 121-123.
54. Strobel, M. (2002). *Flow cost accounting – system for reducing material costs*, Corporate Social Responsibility & Governance for Sustainability, June 23-26, 2002, Göteborg: 10th International Conference of Industry Network.
55. Strobel, M. and Redmann, C. (2002). *Flow cost accounting, an accounting approach based on the actual flows of material*, In Environmental management accounting: informational and institutional developments, Bennett, M., Bouma, J.J. and Wolters, T. (eds.), Dordrecht: Kluwer.
56. Telle, K. (2006). "It pays to be green" – A premature conclusion? *Environmental and Resource Economics*, 35, pp. 195-220.
57. UNDSO (2001). *Environmental management accounting: Procedures and Principles*, Department of Social and Economic Affairs, New York: United Nations Division for Sustainable Development.
58. USEPA (2000). *The lean and green supply chain: A practical guide for materials managers and supply chain managers to reduce costs and improve environmental performance*, EPA 742-R-00-001.
59. Valentine, S.V. (2012). Policies for enhancing corporate environmental management: a framework and an applied example, *Business Strategy and the Environment*, 21, pp. 338-350.
60. Yin, R.K. (2009). *Case study research: design and methods*, Los Angeles: Sage publications.