

The merit of environmental impact assessment for civil engineers in South Africa

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ABSTRACT

Environmental Impact Assessment (EIA) has been successfully adopted in South Africa in line with international trends. A number of international scholars found that EIA offers distinct advantages to a proposed project (Bartik, 1988; Porter & van der Linde, 1995; Annandale & Taplin, 2003). The widespread successful adoption of EIA could be an indication that the benefits of conducting EIAs outweigh the potential economic loss due to delays and costs related to the EIA. However, there are negative perceptions about EIA and its influence on development. But the question is whether South African engineers are experiencing these benefits at project level?

South African civil engineers are faced with the legislative requirements of EIAs on a daily basis. Through a survey of professionally registered civil engineers this research examined the merits that EIA has for civil engineers.

It was found that EIA helps engineers to ensure that they have all the legal aspects of the development in place before the development starts. Furthermore EIA creates the opportunity for the engineers to design out the most significant adverse environmental impacts.

It was found that since the implementation of EIA engineers are observing a shift towards more environmentally sound design alternatives. Therefore, if the EIA process is influencing engineers to review their designs from an environmental point of view, it could significantly minimise environmental impacts. According to engineers it was found that, EIA is assisting them in taking all the potential impacts of a new development into account during the design process. The engineering design normally determines the true environmental impact of a development. According to the respondents, the majority were aware of projects where the design was changed as a result of potential impacts highlighted by the EIA. It was found that for the majority of the respondents the environmental review of the design was a key component of the design process.

According to the engineers that took part in the survey, they were aware of projects where the EIA improved the sustainability of the design by effecting a change to the

design or to the construction materials. Since the implementation of EIA they have become more aware of, not only the life cycle, but also the sustainability of the development. EIA is therefore creating awareness about sustainability in the engineering fraternity. The engineers experienced EIA as a useful tool for improving the sustainability of the design.

However, it was found that EIA also caused a significant delay in the majority of the projects where the respondents were involved. The delays were sometimes so severe that it jeopardised the economic feasibility of the projects in question. According to the respondents, the delays are mainly due to slow decision making by the competent authority. Due to this slow decision making process, the engineers blame the competent authority if they start with the construction of the project before authorisation. However, in spite of these delays, the engineers are still of the opinion that EIA is doing more good to the environment than harm to the economy.

It was found that what the majority of the engineers knew about the EIA process was what they had learned from their own experience. They agreed that there was very little focus on environmental sustainability during their undergraduate studies and that EIA training during their undergraduate study would have been useful. But in spite of this, the majority of respondents did not complete any environmental short courses or post graduate studies.

It was found that EIA does in fact have a positive influence on the work of civil engineers and that they experience these benefits at project level. The engineers have a positive attitude towards EIA and it is increasingly influencing their work positively.

Keywords: EIA, civil engineer, environmental review, sustainability, awareness

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LIST OF ABBREVIATIONS

EAP	Environmental Assessment Practitioner
ECSA	Engineering Council of South Africa
ECA	Environment Conservation Act no 73 of 1989
EIA	Environmental Impact Assessment
IAIA	International Association for Impact Assessment
I&APs	Interested and Affected Parties
NEMA	National Environmental Management Act 108 of 1998
NEPA	National Environmental Policy Act of 1969
PP	Public Participation
SAICE	South African Institute of Civil Engineers
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment

1. INTRODUCTION

1.1. CONTEXT OF THE STUDY

The value of EIA for civil engineers has not been well documented in the literature. There are numerous examples in the literature where industry representatives expressed the opinion that environmental regulations could have a negative impact on business, or even cause them to take their business to other countries where the environmental legislation is less stringent (Charlier, 1993; Hancock, 1993; Morgan, 1993; Dyson, 2000).

In some instances, evidence is presented of environmental regulations negatively affecting performance and investment opportunities (Jubb, 1990; Trewin *et al.*, 1992; Palmer *et al.*, 1995). These lost investment opportunities, resulting from environmental regulations, directly imply loss of income for civil engineers.

Other scholars in the field argue that there is little evidence of negative impacts on companies as a result of environmental regulation, and that the contrary could even be the case where it helped improve financial performance (Bartik, 1988; Porter & van der Linde, 1995).

Annandale and Taplin (2003) conducted a research project that investigated the influence that EIA has on a proposed new development in the mining sector. The results of a survey, of senior mining company executives in Australia and Canada, revealed that they considered environmental approvals as an important factor influencing investment strategies. The study revealed that only a small number of companies considered EIA as an impediment to new development. The majority of senior executives of mining companies considered EIA as a, *“catalyst for integrating environmental design into the early planning of a project, thereby alleviating the need to spend money on overcoming environmental problems once a poorly designed project has been commissioned”*. The conclusions drawn by Annandale and Taplin (2003) are encouraging for EIA practitioners and enforcement agencies.

The widespread international adoption of EIA is an indication in itself that the benefits of conducting EIAs outweigh the potential economic loss, or even the direct and indirect costs related to the EIA itself. However, the question remains whether South African civil engineers are experiencing these benefits at project level?

Civil engineers are one of the professions that are often involved in projects where EIA is a legal requirement. The question that arises is whether they experience EIA as a catalyst for integration of environmental considerations in the planning stages of a project, or if the South African environmental legislation (environmental assessment in particular) is merely perceived as a financial and an administrative burden. If the EIA is a useful tool for civil engineers for integrating environmental considerations into the planning stages of their projects, these considerations will be reflected in their designs. Therefore, if EIA is influencing engineers to review their designs from an environmental point of view it could significantly minimise environmental impacts (Teurlings & Howard, 2010). However, according to Teurlings and Howard (2010), this happens only for a very limited number of projects, even though it is the engineering design that determines the true environmental impacts. This study investigated the influence that EIA has on the designs of civil engineers as well as the contribution of EIA in ensuring environmental legal compliance according to civil engineers.

South Africa faces extreme sustainability challenges, having largely a coal and mining based economy, but nonetheless extensively embraces the concept of sustainable development (Morrison-Saunders & Retief, 2012). Sustainability is inherently part of the intention of EIA and even though EIA has limitations, it has the potential of promoting sustainable development in a number of ways that are yet to receive attention in the literature (Cashmore *et al.*, 2004).

In the South African context the EIA process incurred severe criticism and even calls for reconsideration due to the need for job creation and the potential economic loss, and especially due to the delays caused to the housing schemes (Macleod, 2006; van Schalkwyk, 2006). In 2011 the Water and Environmental Affairs Minister, Edna Molewa, asserted that project developers cited EIA delays as the reason for projects starting late (van der Merwe, 2011). This study investigated the influence of EIA on

the time schedule of the development as experienced by South African civil engineers.

Questions have been raised about the economic valuation of environmental assessment in South Africa (Crookes & de Wit, 2002) and the effectiveness of the administrative capacity in South Africa (Duthie, 2001). In addition to this, the cost of EIA in South Africa was found to be high in relation to the total project cost, which means that numerous EIAs are conducted for relatively small projects and this places a cost burden on small to medium enterprises (Retief & Chabalala, 2009).

It seems that, in the South African context, the benefits of environmental assessment discussed by international scholars (Bartik, 1988, Porter & van der Linde, 1995, Annandale & Taplin, 2003) are not yet being experienced at project level. In this study, the merit of EIA for civil engineers in South Africa has been investigated.

1.2 PROBLEM STATEMENT

The merit that EIA has for civil engineers in South Africa is not fully understood. The way in which EIA influences the design of civil engineers is still unknown. It is also uncertain whether the EIA process is assisting engineers in ensuring environmental legal compliance. The role that EIA plays in the sustainability of engineering designs is also unknown, and the effect that EIA has on the time schedule of projects is not fully understood.

In this study, the merit of EIA for civil engineers will be investigated. The aim is to study the perception civil engineers have of the influence of EIA on the environmental sustainability, the legal compliance and on the time schedule of the project, as experienced by civil engineers, and not to determine the actual efficacy of EIA per se. The degree of, or exposure to environmental education and the awareness of civil engineers has also been explored in order to put the responses to this study into perspective.

1.3 RESEARCH QUESTION

In view of the problem statement described in the previous section the main question of the research is: What merit does the EIA have for civil engineers?

1.4 RESEARCH SUB-QUESTIONS

In order to answer the above-mentioned research question, the following sub-questions were distilled from the literature:

- 1.4.1 To what extent do the EIA requirements and processes influence the designs of civil engineers to be more acceptable from an environmental point of view?
- 1.4.2 To what extent does EIA assist in ensuring environmental legal compliance by civil engineers?
- 1.4.3 To what extent does EIA lead to more sustainable designs from a life cycle point of view?
- 1.4.4 How does the EIA process influence the time schedule of the development?
- 1.4.5 To what extent is the environmental education acquired by civil engineers adequate?

2. LITERATURE SURVEY

2.1 INTRODUCTION

EIA is a legal requirement in numerous South African projects in which civil engineers are involved. If the EIA is influencing engineers to review designs from an environmental point of view, it could significantly minimise environmental impacts (Teurlings & Howard, 2010). However, before the merit EIA has for civil engineers can be assessed, a sound understanding of the objectives of EIA has to be obtained and compared with the objectives of the professional obligations of civil engineers. The extent to which the objectives of the EIA are aligned with the objectives of the design engineer could provide an indication the potential synergy or conflict between the two disciplines. In this literature study the basic objectives of EIA and the work of civil engineers will be discussed. A conclusion will be drawn about the similarities between the objectives.

2.2 OBJECTIVES OF EIA

EIA was initially developed in the United States as part of the National Environmental Policy Act (NEPA) of 1969. The global widespread adoption of EIA reflects the global need to integrate environmental concerns into the decision-making process. This widespread adoption was promoted by the Rio Declaration on Environment and Development at the 1992 Earth Summit. According to Principle 17 of this declaration: *“Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority”* (United Nations Environment Programme, 1992). South Africa promulgated the ECA (Environment Conservation Act), No 73 of 1989. Section 21 provided that the Minister could identify activities “which may have a substantial detrimental effect on the environment”. EIA subsequently became mandatory in 1997 when the list of

activities and regulations for EIA was promulgated. Since then, consultants and other stakeholders became familiar with the process. In 2006 new EIA regulations were promulgated in terms of Section 24 of NEMA (National Environmental Management Act 108 of 1998). EIA was developed to inform decision-making in response to increased environmental concerns associated with continued development and the potential to sustain economic growth without jeopardizing the environment. EIA was intended especially for projects with the potential of posing significant environmental impacts.

For the purpose of this study, a number of the basic objectives of EIA have been identified and will be discussed below.

2.2.1 Assess potential environmental impacts

One of the objectives of EIA, as listed by the International Association for Impact assessment (IAIA) (1999), is to “*anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals*”. In an effort to improve on the ability to assess impacts, significant research has been done on the quality of EIA (Lee *et al.*, 1999; Kruger & Chapman, 2005; Sandham & Pretorius, 2008; Sandham *et al.*, 2008a, b), the effectiveness of the EIA process (Baker & McLelland, 2003, Cashmore *et al.*, 2004) the influence of availability and access of data on effectiveness (Vanderhaegen & Muro, 2005) and the impact of context on effectiveness (Marara *et al.*, 2011).

The purpose of assessing the potential impacts before the project/development starts is to provide decision-makers with the information about the most significant environmental impacts that will be caused by the proposed development. If these impacts are considered to be too severe, the competent authority could refuse authorisation. If the impacts are significant, mitigation measures could be put in place to reduce the impact. Mitigation is regarded as a strength of EIA in South Africa (Wood, 1999). The whole focus is on avoiding, or reducing negative environmental impacts and increasing the positive ones.

The objective of EIA is therefore to assess all environmental impacts and these mitigation measures should include negative social and economic impacts and not only focus on biophysical impacts.

2.2.2 Informed decision-making

The next objective of EIA, according to the IAIA (1999) is, *“to ensure that environmental considerations are explicitly addressed and incorporated into the development decision-making process”*. It is unlawful to commence with a listed activity without authorisation from the competent authority. When the competent authority has taken a decision, an environmental authorisation must be issued to the applicant. An appeal can be made against the decision.

According to the IAIA, to inform this decision-making process is one of the primary objectives of EIA, and it must be taken into account that EIA is about *“making the best possible decision using the best available information in a systematic and proper manner”*. It is generally believed that EIA does influence decisions, but the degree to which this is happening is questionable. According to Cashmore *et al.* (2004), the contribution of EIA in decision-making is moderate and not substantial. However, Jay *et al.* (2007) found that EIA studies have shown that planning decisions are influenced by EIA to a small degree. This could be as a result of poor quality of EIA reports that are used for decision-making (Sandham *et al.*, 2010). According to Cashmore *et al.* (2004), as with its influence on decision-making, the effect of EIA on project design is also not substantial. If EIA has little influence on decision making, and if EIA has little influence on project design, then the success of EIA in satisfying its objectives is questionable. The influence of EIA on civil engineering projects, as experienced by civil engineers, will be investigated in this study.

2.2.3 Protect the biophysical environment

“To protect the productivity and capacity of natural systems and the ecological processes which maintain their functions” is another objective of EIA according to the IAIA (1999). There is still uncertainty about the extent to which EIA is successful in protecting the biophysical environment. However, if the impacts of a proposed development are properly assessed and mitigated the direct effect would be that the biophysical environment is protected. The EIA process aims to protect South Africa’s environmental heritage. These ecosystem services are the foundation of South African’s livelihoods and the economy. According to the Minister of Water and Environmental Affairs, South Africa’s rich natural heritage is threatened by unsustainable development (van der Merwe, 2011). This is evident since more than 50% of South Africa’s wetland systems have been destroyed and over 80% of the country’s river systems are threatened (van der Merwe, 2011).

2.2.4 Promote sustainable development

EIA has been identified by Sheate (2009) as an existing tool that has sustainability as the fundamental purpose, and even though it might not have been the original intention of EIA, it certainly has the potential to deliver on sustainability expectations. According to the IAIA (1999) one of the objectives of EIA is to *“promote development that is sustainable and optimizes resource use and management opportunities”*. Sustainability has become a buzz word in recent years and extensive research has gone into sustainability assessments. Hacking and Guthrie (2008) refer to EIA and SEA (Strategic Environmental Assessment) as *“widely promoted sustainability tools”*, but even though strategic assessments are necessary to achieve sustainable development, they are intended to be done at policy level. EIA is normally done at project level and may be considered as the only lower planning level sustainability-orientated tool with an adequate track record as a basis to judge its effectiveness (Hacking & Guthrie, 2008). EIA is the process whereby potential impacts of activities are assessed in order to ensure that when these impacts are too severe, they may be prevented, or measures to mitigate the severity of these impacts may by

incorporated. EIA should in principle, be able to spear head sustainable development. Bond *et al.* 2010 found that EIA consultants operate mostly from a personal interpretation of sustainability, but a knowledge gap exists about sustainability concepts. This is not ideal as sustainability should be promoted by the EIA.

Sustainability is inherently part of the intention of EIA and even though EIA has limitations, it has the potential to promote sustainable development in a number of ways that are yet to receive attention in the literature (Cashmore *et al.*, 2004). The contribution of EIA to design decisions should be regarded as a single component of incremental changes towards sustainability. The broader concept of EIA is schematically shown in Figure 2.1.

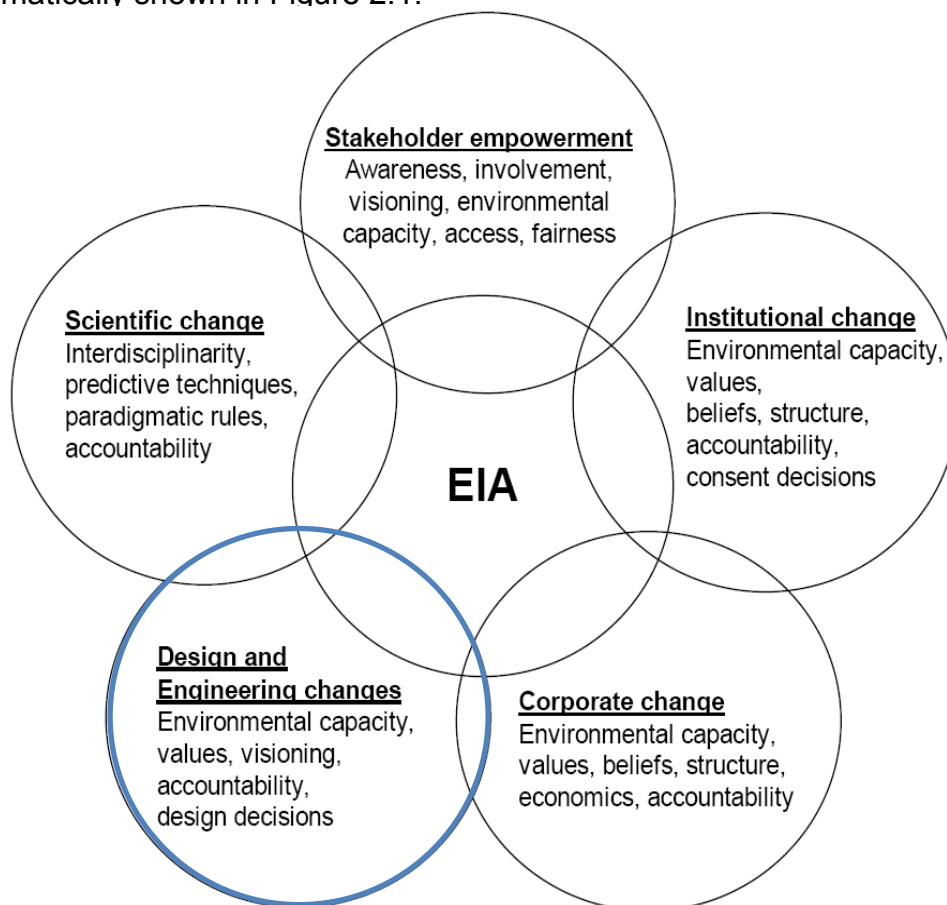


Figure 2.1: EIA as an agent of incremental change (Source: Cashmore *et al.*, 2004)

Morrison-Saunders and Retief (2012) assessed the existing objectives for EIA in South Africa in terms of sustainability principles in order to evaluate the effectiveness

of EIA in delivering these objectives. According to their findings, South Africa has a strong sustainability mandate through policy and legislation, but the EIA practise is not effective within this mandate. In order to make progress towards sustainability, the mandate, however, is not the barrier. Focus should, therefore, be placed on the behaviour of the professionals operating within this mandate (Morrison-Saunders & Retief, 2012).

Civil engineering is one of the disciplines of professionals that are operating within this sustainability mandate. The focus of this study is therefore on the civil engineers that are operating within this sustainability mandate of the EIA. Their experience of the South African EIA system has been investigated because, if the engineers are aligned with the sustainability principles, the engineering designs will also be sustainable. The contribution of EIA to engineering designs is the central focus of this study and has therefore been highlighted in Figure 2.1.

2.2.5 Consider alternatives

The consideration of alternatives is a critical element of EIA (DEAT, 2004). Alternatives have not been receiving adequate attention in EIA reports since the conception of EIA in South Africa. Mafune *et al.* (1997) reviewed case studies of the early years of EIA in South Africa. In their survey of 28 EIA reports, 9 considered alternatives while 8 of the 9 considered the “no-action” alternative. Another challenge with alternatives is that they are often biased towards a predetermined outcome and in the process more environmentally sound alternatives are overlooked. As a result, inadequate alternatives can undermine the purpose of impact assessment (Steinemann, 2001). Alternatives should be identified early in the project cycle, and the consideration of alternatives should be well documented and include the views of stakeholders (DEAT, 2004). The purpose of evaluating alternatives is to compare all potential impacts of the various alternatives in order to find the most environmentally sound way of meeting the requirements of the proposal (DEAT, 2004).

2.2.6 Ensure legal compliance

As far as the legal mandate of EIA is concerned in South Africa, there is the Constitutional framework and NEMA. Other legal mandates of EIA, in South Africa, include the Development Facilitation Act 67 of 1995, the National Water Act 36 of 1998, the Minerals and Petroleum Resources Development Act 28 of 2002, National Environmental Management: Air Quality Act 39 of 2004, National Environmental Management: Waste Act 59 of 2008. It also includes the Petroleum Pipelines Act 60 of 2003, the Gas Act 48 of 2001, Genetically Modified Organisms Act 15 of 1997, and the National Environment Management: Biodiversity Act 10 of 2004 as well as the National Heritage Resources Act 25 of 1999.

The EIA process could draw attention to projects that would historically have been conducted without the knowledge of authorities or the community. In some cases the EIA will be done with an application for a licence and the associated monitoring will have to be included. This makes EIA an effective mechanism to improve environmental legal compliance.

2.2.7 Address socio-economic issues

There is a definite mandate for including the socio-economic environment in the EIA process in NEMA. It is acknowledged that the current South African legislation may generally contain greater emphasis on socio-economic issues having been written in the post-1994 South Africa. This was an era right after the dismantling of the previous regime where the social injustices and unsustainable practices were embedded in legislation. South Africa is a developing country, and per definition, development is a prime requirement and a prime objective of government. EIA assesses socio-economic impacts even though a specialist study is not always included. When a specialist study is needed, it is done by means of SIA (Social Impact Assessment). SIA includes the analyses of social consequences of planned interventions. The purpose of SIA is to promote a more sustainable biophysical and social environment (Vanclay, 2003).

Social issues that are typically encountered in major projects are employment, migration, infrastructure, health and visual impacts, economic competition, increased pressure on bio-physical resources and infrastructure, and the question of who pays the price and who gets the benefit. If these issues are not addressed the likely result is that vulnerable communities will be exposed, livelihoods of people threatened, increased poverty and no social licence to operate. The outcomes of SIA are in line with the intentions of engineering projects in the sense that it is a risk management tool; it promotes effective stakeholder engagement and can secure trust with local communities, regulatory authorities and the workforce. It is also important to consider the socio-economic costs of a project (like resettlement) or the resources required for mitigation measures. Socio-economic issues are normally sensitive as it involves the lifestyles and livelihoods of communities. Communities rely on job creation and EIA is often criticised for potential economic loss due to the delays caused to the housing schemes (Macleod, 2006; van Schalkwyk, 2006; van der Merwe, 2011).

On the other end of the scale, the EIA in itself also comes at a significant cost with its own economic impact. In a study done by Retief and Chabalala (2009), the cost of EIA in South Africa was found to be high in relation to the total project cost, which means that numerous EIAs are conducted for relatively small projects and this places a cost burden on small to medium enterprises and this cost also has the potential of rendering some smaller projects unprofitable. In South Africa, a very limited number of EIAs include economic valuation (Crookes & de Wit, 2002). Even though it is difficult to calculate the economic implication of EIA, what remains unmeasured, remains unmanaged.

Public Participation (PP) refers to the involvement of people that will be affected by, or are interested in a proposed project that is subject to a decision-making process (André *et al.*, 2006). In South Africa, the proponent and the EAP (Environmental Assessment Practitioner) are responsible for consultation with the local communities and not the authority. This is often handled by a specialist or a PP consultant. The EIA regulations make provision for participation in the scoping and the EIA report. The EIA guidelines recommend that I&APs (Interested and Affected Parties) should be involved in reviewing the scoping and in the EIA report. EIA is therefore not only an anticipatory, but also a participatory environmental management tool (Jay *et al.*,

2007). The potential benefits from the contribution of stakeholders are often underestimated (Enserink & Monnikhof, 2002).

2.3 OBJECTIVES OF CIVIL ENGINEERING

The design of buildings, bridges and other civil infrastructure is controlled by design specifications. The purpose of these specifications is to provide the engineering principles and procedures required to achieve a safe design in terms of the integrity thereof that would satisfy the requirements of the developer as well as being cost effective. Developers want to minimise the cost of the project while achieving acceptable quality and safety standards and satisfying technological, architectural and other requirements. The designer and the contractor, on the other hand are concerned with company growth, market share, the time schedule of the development and their professional reputation. A number of basic objectives of civil engineering have been identified and will be discussed below:

2.3.1 Safety

Progressive collapse in buildings occurs, when a primary structural element fails resulting in the failure of connecting sections, and a domino effect ensues.

There are a number of examples of progressive collapses that occurred in the past. Some of the most recent ones include Windsor Tower, Madrid on 12 February 2005 (0 fatalities), World Trade Centre, New York City on 11 September 2001 (2,757 fatalities), Sampoong Department Store, Seoul on 29 June 1995 (501 fatalities) and the Alfred P. Murrah Federal Building, Oklahoma City on 19 April 1995 (168 fatalities).

Failures such as these are the result of natural disasters like earthquakes (Cagatay, 2005), accidents and attacks (Luccioni, 2004), low quality of construction materials (Ahzahar *et al.*, 2011), or bad design (Pinto *et al.*, 2011).

The number of lives lost, as mentioned above, stresses the importance of having standards for safe buildings. The minimum acceptable level of safety for buildings and structures is specified by a building code for example, SANS 10400-1990. These are basically a set of rules, relating to the construction and occupancy of buildings, which were developed to protect public health and safety. Structural design codes provide the tools that engineers should use to produce safe and economic structures (Aktas *et al.*, 2001). It has taken the industry almost a century to develop codes and standards for the design of structures that can withstand significant loads.

Over the past decades, much of the focus of scholars in the field of civil engineering has been on safety optimisation of the civil engineering design (Soltani & Corotis, 1988; Choi & Chang, 2009; Wang *et al.*, 2011; Beck & Gomes, 2011). During this period, very little consideration was given to the impact on environmental sustainability and the life cycle of these structures.

2.3.2 Economic feasibility

Economic feasibility of the design is one of the most important objectives of civil engineers. If a proposed project does not present economic benefit to investors, it will most likely never be executed. With the growing population and increased urbanisation, there is an increased requirement for housing. This leads to increased prices of land and building costs which makes cost optimisation indispensable (Senay, 2009). The building material, fabrication, transportation, erection and maintenance cost are contributing to the total cost of a structure. Cost optimisation is an important aspect of the design. Research in this field has been done on the optimisation of fabrication costs (Jármai & Farkas, 1999).

Aktas *et al.* 2001 developed a procedure to calibrate load factors for structural design specification based on cost and safety optimisation. They used the total expected lifetime cost in the optimisation to account for initial construction costs and future equivalent failure costs.

The economic feasibility of a project is normally dependant on the time frame of the project and this is where the EIA process is often criticised in the literature due to the significant delays that are experienced as a result of the EIA process as well as slow decision making by the competent authority (Hancock, 1993; Charlier, 1993; Morgan, 1993; Dyson, 2000) and even in the media (Davenport, 2006).

2.3.3 Durability

The education of civil engineers traditionally placed more emphasis on the structural engineering with little or no focus on performance and the durability of engineering materials. With the global focus shifting towards sustainable development and life cycle management, the engineering societies are recognizing that infrastructure not only has to be built, but also maintained and renewed. During the past decade, the durability performance of building materials started receiving its rightful attention in the literature (Bournazel & Moranvill, 1997; Larsen-Basse & Chong, 2001; Chen *et al.*, 2007; Debieb *et al.*, 2010).

Ugwu *et al.* (2005) developed a framework for durability assessment and life cycle costing of highway bridges. They attempted to integrate durability factors and achieve design objectives that account for life cycle costs and the sustainability of design options instead of merely focussing on the initial design and construction cost. Narasimhan and Chew (2009) developed a durability design procedure for reinforced concrete structures that attempts to integrate considerations of durability into the structural design process while ensuring lifetime cost optimisation. Traditional methods are based on implicit and prescriptive requirements for materials and structural specifications, which make it difficult to get an impression of the durability (and satisfactory levels of durability at optimum cost) over the lifetime of a structure.

The majority of buildings and structures need inspection, repair or replacement after a couple of decades. Due to the numerous developments that took place during the 1960s and 1970s, many structures are in need of maintenance that often comes at a significant cost (Neves *et al.*, 2004). Rackwitz *et al.* (2005) developed a design and

maintenance strategy where structures are renewed by reconstruction or repair. They established an appropriate objective function for cost-benefit analyses based on a renewal model for sustainable building activities. They found that the only replacement strategy fulfilling the requirements of sustainability is systematic reconstruction after failure or preventive repair. According to their study, a preventative approach should be followed in which the repairs have already been included in the design phase or a suitable inspection and maintenance strategy has to be developed for a deteriorating structure in order to achieve sustainability (Rackwitz *et al.*, 2005). Neves *et al.* (2004) developed a model that considers the influence of the maintenance cost on the reliability index of a structure in order to determine an optimum maintenance scenario.

2.3.4 Sustainability

Sustainability is an important aspect of civil engineering infrastructures, not only from a technical perspective, but also from a financial perspective (Rackwitz *et al.*, 2005). Infrastructure development has significant impacts on the society, the economy and the environment and could therefore contribute significantly to the drive towards sustainable development. The sustainability of civil engineering structures has been a challenge since the inception of codes and standards (Chidiac, 2009). As a first step to address sustainability requirements of concrete structures, new standards are being developed by the ACI, CSA and ISO on durability and environmental management for concrete and concrete structures (Chidiac, 2009).

We live in a world with only a limited amount of non-renewable resources. The construction industries are among the largest consumers of materials and energy and are also significant polluters.

It is only in more recent times that the life cycle of the design has started receiving the attention of scholars. Life cycle orientated concepts like including the rehabilitation costs, the repair or replacement costs, the losses sustained as a result of an injury or fatality, road user costs as well as indirect socio-economic costs with the initial cost of the structure or development were studied by Lee *et al.* (2004). This

is often referred to as the cost of ownership. They found that life cycle cost effective optimum design of steel bridges led to a more economical and safer design compared with a design alternative only optimised by economic aspects.

Van Noortwijk and Fragopol (2004) made a comparison between two maintenance models for deteriorating civil structures. This is useful in determining the adequate level of reliability at the lowest possible life cycle cost. Banaitiene *et al.* (2005) developed a methodology for the multi-variant design and multiple criteria analysis of the life cycle of a building as a decision-making tool on the building's life cycle. Their methodology allows all the role players (client, investor, and contractor) to consider design alternatives of the building life cycle. Hong *et al.* (2011) developed a simulation model to evaluate the sustainability performance of highway infrastructure projects. They also explored, by means of a case study, some initiatives to improve sustainability performance. They explored solutions for improving poor sustainability performance areas through policy scenarios.

This shows that times have changed and that, during the past decade, there has been a focus on energy efficiency (Kristl & Krainer, 2001; Liu *et al.*, 2009), conservation of resources (Mutz & Geiseler, 2001) and initiatives to re-cycle building materials and to avoid pollution (Debieb *et al.*, 2010). Engineers are improving reliability and durability of materials (Bournazel & Moranvill, 1997; Larsen-Basse & Chong, 2001; Chen *et al.*, 2007; Debieb *et al.*, 2010) and even design solutions to increase the time span of the final product and thereby improving the sustainability of the infrastructure (Hong *et al.*, 2011).

2.3.5 Professional reputation

The undergraduate education of engineers sets the frame of mind from which they form opinions, design and carry out projects. In South Africa, qualified engineers may apply to be accepted at the Engineering Council of South Africa (ECSA). ECSA accreditation gives the client peace of mind that the engineer has the necessary qualifications and experience to do a professional job. The environmental education of engineers could have an influence on the type of design they produce.

Environmental education will also give engineers a better understanding of the purpose and intention of EIA. Environmental awareness could be integrated in undergraduate programmes of traditional engineering sub-disciplines, or as a separate new sub-discipline often called “Ecological Engineering” or “Natural Resources Engineering”. This could develop as a specialisation of another sub-discipline such as civil engineering (Painter, 2003). However, in this day and age, all undergraduate programmes should be pervaded throughout by sustainability ethics.

Legal compliance during all phases of a project is an important objective for engineers as it could help avoid litigation. However, the focus in the literature, regarding liability, is much more on threats to safety (D’Appolonia *et al.*, 1983). According to Peters (1998), it is a professional obligation and a personal responsibility of engineers to prevent liability.

2.4 SIMILARITIES BETWEEN THE OBJECTIVES

Seven objectives of EIA were identified and three out of the seven are aligned with four of the objectives of civil engineers. Even though the specific intention of some of these aligned objectives might not be the same, broadly speaking they should be striving towards the same goal. Other civil engineering objectives that are not aligned with the objectives of EIA might be conflicting with the objectives of EIA. This creates the possibility of opposing interests, but it also creates the opportunity for EIA to contribute to the project by introducing aspects that would otherwise not even have been considered. In Figure 2.2, the alignment of objectives of EIA and civil engineers are schematically shown.

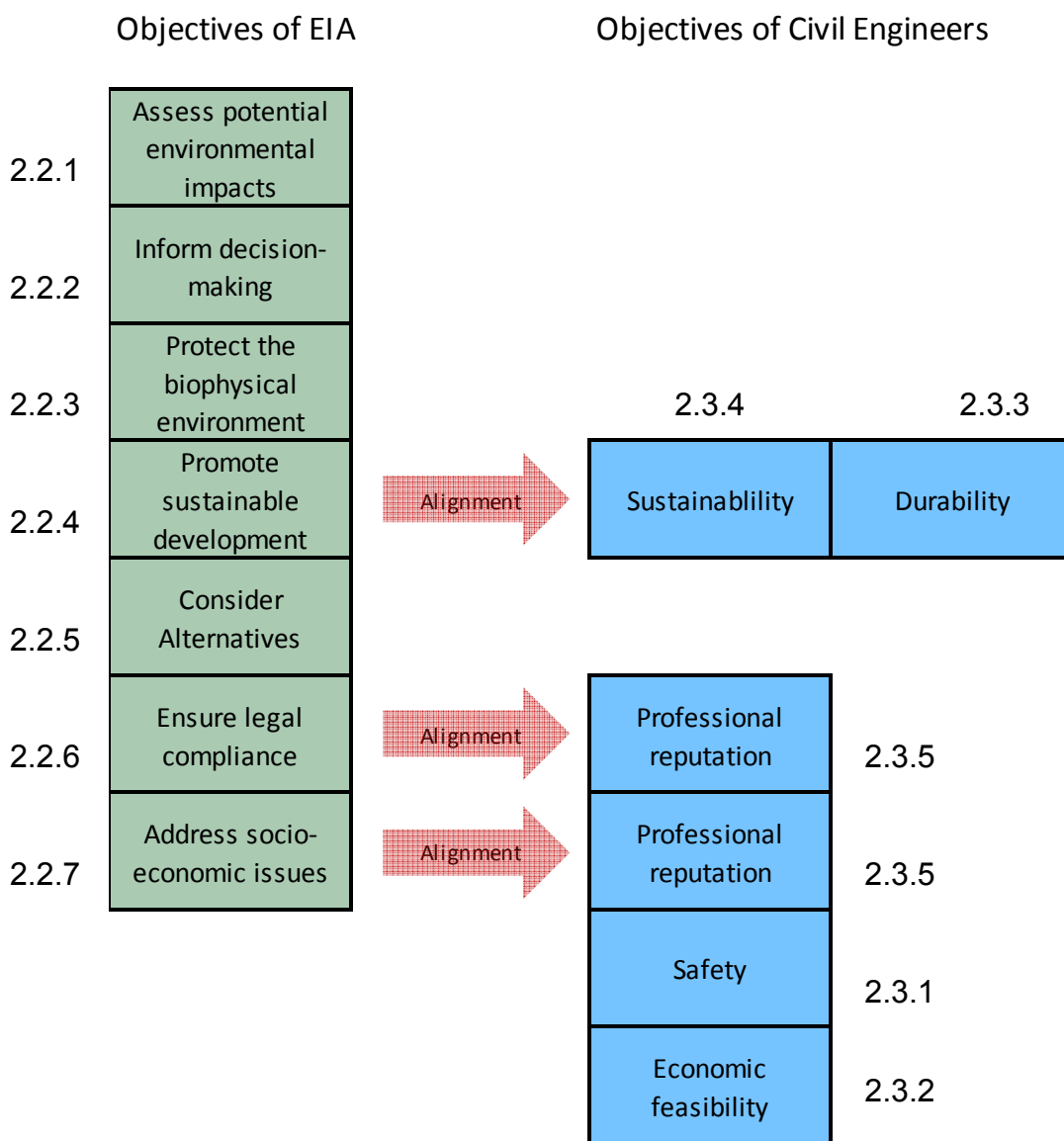


Figure 2.2: Alignment of objectives of EIA and Civil Engineers

The objective of civil engineers to improve the sustainability and the durability of their designs, are aligned with the objective of EIA to promote sustainable development. If a building is durable in terms of maintenance, and sensible from a life cycle point of view, or if sustainable building materials are used, or old materials are re-used it will go a long way to promote sustainable development. The objective of EIA to ensure legal compliance is aligned with the importance of the professional reputation of the engineer. If the EIA helps to ensure environmental legal compliance, it reduces the risk of litigation for the engineer. The objective of EIA to address socio-economic issues is also aligned with the importance of the professional reputation of the engineer. If a development is done at the cost of a local community it could harm the reputation of the engineer. The EIA could help prevent this through proper stakeholder engagement.

On the other end of the scale, the objective of EIA to protect the biophysical environment could be in conflict with the objective of economic feasibility if the more cost effective option holds greater risk for the environment. The objective to consider alternatives could also be conflicting with the objective of economic feasibility.

This study will further investigate how the EIA is complementary in assisting or influencing civil engineers in their designs. This was tested by means questionnaire based research as explained in Chapter 3.

3. RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology for this study comprised both a literature and an empirical study. The aim was to evaluate the merit that the EIA tool has for civil engineers. For the empirical part of the study a questionnaire was developed based on the issues identified in the literature study. The outcome of the data was used to evaluate the merit of EIA for civil engineers.

Aspects that were taken into consideration included: 1) The influence that EIA has on the designs proposed by civil engineers, 2) Whether EIA assists engineers in ensuring environmental legal compliance, 3) Whether EIA leads to more sustainable designs from a life cycle point of view; 4) What the influence of EIA is on the time schedule of the development; and 5) The environmental education of civil engineers was also taken into account.

3.2 LITERATURE REVIEW

The literature review was conducted in order to obtain a sound understanding of the information related to this field of study that already exists and included books, journals, conference presentations, the internet and other sources. Surprisingly little research about the influence of EIA on engineering designs or the merit of EIA for engineers has been done. The literature survey was used to identify the objectives of EIA and civil engineering. The objectives of EIA and the objectives of civil engineering were studied to identify similarities and potential beneficial influences. This was subsequently used to develop research questions. The questionnaire was in turn developed to address these research questions.

3.3 EMPIRICAL STUDY

3.3.1 Population

The population in this study is defined as professionally registered civil engineers that are currently working in South Africa. The engineers that formed part of this survey are registered with ECSA.

3.3.2 Questionnaire

The literature survey was used to identify the objectives of EIA and civil engineering in order to identify alignment or potential conflict. These objectives were used to develop research questions and the questionnaire was subsequently designed to answer the research questions.

The questionnaire consisted out of 33 questions, of which the first three were about the demographic characteristics of the survey respondents. The remaining 30 questions were aimed at the five research questions. These questions were answered by means of a 5-point Likert based scale ranging from 1 to 5 (strongly disagree to strongly agree). The questionnaire was pre-tested by a few engineers who completed the questionnaire in order to see if the responses were aligned with the intention of the questions. After reviewing these responses, the questionnaire was reviewed before distribution. The questionnaire is presented in Appendix A. the questions were randomly posed to respondents except for the questions in Part I.

The data collection involved the online distribution and submission of questionnaires. The questionnaire was hosted on the Qualtrics.com questionnaire service provider's domain. E-mails with an introduction and a hyperlink to the questionnaire were sent out via the South African Institute for Civil Engineers (SAICE), to a group of one thousand professionally registered civil engineers in two batches of 500 each. The questionnaire was available for submissions online for a period of 3 months after each of the two distributions. Respondents that clicked on the link were directed to

the online questionnaire and all the data was captured as soon as the questionnaire had been completed.

3.3.3 Results

The statistical analysis of data was conducted, in co-operation with Prof. H.S. Steyn from the Statistical Consultation Service of the North West University, with focus on questionnaire validation and data reliability. For each section the mean of the results of each question and the Cronbach's alpha was determined.

These two concepts are briefly described below:

3.3.3.1 The Mean (\bar{x})

The mean is the arithmetic average of a set of values or distribution.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

Where

n is the number of respondents, and x_i is the value returned by each respondent.

3.3.3.2 Cronbach's alpha (α)

Cronbach's alpha (α) is a coefficient of reliability. It is used as a measure of the internal consistency or reliability of a test score for a sample of respondents. Cronbach's alpha will generally increase as the inter-correlations among test items increase, which is the internal consistency estimate of reliability. Cronbach's α is defined as:

$$\alpha = \frac{K}{K - 1} \left(1 - \frac{\sum_{i=1}^K \sigma_{Y_i}^2}{\sigma_K^2} \right)$$

Where

K is the number of components,

σ^2_x is the variance of the observed total test scores, and

$\sigma^2_{y_i}$ is the variance of component i for the current sample of persons.

The standardised Cronbach's alpha can be defined as:

$$\alpha_{\text{standardised}} = \frac{K\bar{r}}{(1 + (K - 1)\bar{r})}$$

Where

\bar{r} is the mean of the $K(K-1)/2$ non-redundant correlation coefficients.

3.3.3.3 Reliability of data generated

When the reliability of data is good, it means that the consistency of the measurement is good. A measure is said to have a high reliability if it produces consistent results under consistent conditions. Reliability does, however, not imply validity. Reliability is analogous to precision, while validity is analogous to accuracy. A measurement could be unreliable (measurements different), but valid (close to the truth). Likewise it could be reliable (measurements the same), but not valid (close to the truth).

Cronbach's Alpha is therefore simply a measure to express how consistent (or similar) the measurements (or the results from different questions in a specific part of the survey) are.

The reliability of the Cronbach- α must therefore be high in order to use the result as a representative conclusion of the entire section. When the individual correlations of each item in the section are considered, the weak items could be identified and removed in order to improve the overall score. If one of these items is negative, the 1-5 Likert scale should be turned around (1 becomes 5, 2 becomes 4, 4 becomes 2, and 5 becomes 1).

The results are presented and discussed in Chapter 4.

4. RESULTS AND DISCUSSION

4.1 INTRODUCTION

The aim of this chapter is to present the results obtained from the empirical study. The results and the statistical analysis will be given in order to demonstrate the validity of the data. These results will be discussed to address the research questions raised in Chapter 1.

A total of 70 fully completed surveys were returned (7% of the emails that were sent out via SAICE). Ten more respondents partially completed the questionnaire. The survey consisted of 6 parts:

- Part I - The demographic profile of the respondents.
- Part II - The influence of EIA on engineering designs.
- Part III - The role that EIA plays in ensuring environmental legal compliance.
- Part IV - The influence of EIA on the sustainability of the design.
- Part V - The influence of EIA on the time schedule of the development.
- Part VI - The environmental education acquired by civil engineers.

The purpose of Part I was to give background information about the respondents. The purpose of Parts II – VI was to address the research questions formulated in Chapter 1.

Firstly, the demographic profile of the survey respondents is shown. Then, for Parts II – VI, the level of agreement to the survey questions is graphically shown and discussed. Thereafter, the mean values from the Likert scale are shown. The mean values could be calculated as shown in section 3.3.3.1. The Likert scale means values have been adapted into a percentage value to enhance the interpretation of the results i.e. 70% high level of agreement to a question. For the purpose of this study the percentages are interpreted as follows:

- <60% Lower importance
- 60%-75% Important or satisfactory agreement

- >75% Very important or very satisfactory agreement

Subsequently, the reliability and internal consistency of the data is shown by means of the Cronbach Alpha coefficient (α). This could be determined as shown in section 3.3.3.2. An explanation of the reliability or consistency is also given in section 3.3.3.2. A low Alpha coefficient indicates that the factor is less likely to present itself if the study is to be repeated when subjected in a different application setting. Factors with a low Alpha coefficient should be interpreted bearing this limitation in mind. George and Mallery (2003:231) provide the following rules of thumb for the Cronbach Alpha coefficient:

$\alpha > 0.9$ – Excellent

$\alpha > 0.8$ – Good

$\alpha > 0.7$ – Acceptable

$\alpha > 0.6$ – Questionable

$\alpha > 0.5$ – Poor

$\alpha < 0.5$ – Unacceptable

Not all the survey respondents answered each question. In presenting the results in this chapter, for Part I, the number of respondent that selected the specific answer is given as (n) and this amount is then expressed as a percentage of the total number of responses received to that question. In Parts II – VI, the sum of respondents that agreed to a specific survey statement “strongly agree” and “agree” is given as (n) and this amount is then expressed as a percentage of the total number of responses received to that question. The total number of responses to the questions for Parts II – VI is shown in Figures 4.1 - 4.5.

4.2 DEMOGRAPHIC PROFILE (PART I)

Part I of the survey covered the demographic profile of the respondents. Responses were received from engineers from 8 of the 9 provinces of South Africa. The greatest number of responses was received from Gauteng (n=36, 45%), followed by the Western Cape (n=14, 18%) and Mpumalanga (n=11, 14%). Most of the respondents have their own firms (n=34, 43%), followed by respondents working for large companies (n=30, 38%) and the remaining (n=16, 20%) are working for small/medium enterprises. Table 4.1 shows a summary of the demographic profile of the respondents.

Table 4.1: Demographic characteristics of survey respondents

Respondents		No. (%)
Based in South Africa	Gauteng	36 (45%)
	Mpumalanga	11 (14%)
	Western Cape	14 (18%)
	KwaZulu-Natal	10 (13%)
	Eastern Cape	7 (9%)
	Limpopo	4 (5%)
	North West	3 (4%)
	Free State	3 (4%)
	Northern Cape	0 (0%)
Employment	Own firm	34 (43%)
	Large company	30 (38%)
	Small/medium enterprise	16 (20%)
Years of experience	15 years and more	67 (84%)
	5 to 15 years	13 (16%)
	Less than 5 years	0 (0%)

Only professionally registered civil engineers were invited to take part in the survey. Therefore, it is expected that none (n=0, 0%) of the respondents has less than 5 years of experience. The majority (n=67, 84%) has more than 15 years of experience and the remainder (n=13, 16%) has 5-15 years of experience. In this study, the more

experienced engineers registered with SAICE were targeted in order to learn from their experience with EIA. It must be taken into account that this could skew the stance of environmental education as it was not available when these well experienced engineers were studying. However, nothing prevented them from completing environmental short courses or post graduate studies and this is one of the aspects that was tested in the survey.

4.3 THE INFLUENCE OF EIA ON ENGINEERING DESIGN (PART II)

The results obtained for Part II of the survey is shown in Figure 4.1. The total number of respondents (n) that answered the specific question is shown in brackets in Figure 4.1.

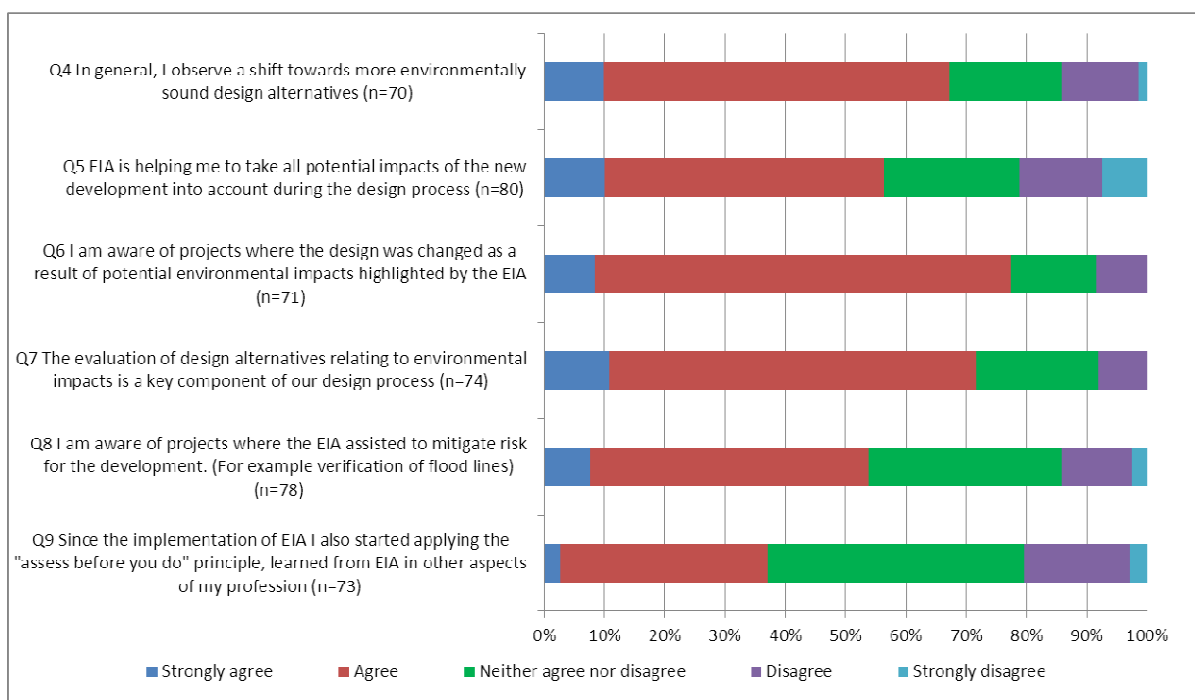


Figure 4.1: The influence of EIA on engineering design

Overall there was a high level of agreement with these statements, especially Questions 6 and 7. These two questions returned the highest level of agreement. Of all the questions in Part II, the largest percentage and the highest mean of the respondents “agreed” or “strongly agreed” that they were aware of projects where

the design had changed as a result of potential environmental impacts highlighted by the EIA for Question 6 (n=55, 78%) and that the evaluation of design alternatives relating to environmental impacts was a key component of their design process for Question 7 (n=53, 72%).

There was also a majority agreement with the content of Question 4. The respondents observed a shift towards more environmentally sound design alternatives (n=47, 67%). Questions 5 returned 56% agreement (n=45, 56%) about the EIA assisting the engineer taking all potential impacts of the new development into account. Similarly, Question 8 returned 54% agreement (n=42, 54%) that the engineers were aware that EIA assisted to mitigate risk for the development. The lowest level of agreement in Part II was with Question 9 (n=27, 37%) that since the implementation of EIA, engineers started applying principles learned from EIA in other areas of their profession.

The mean scores of each question in Part II of the survey is summarized below in Table 4.2. The mean scores are an indication of the importance of the specific question for engineers in terms of the influence of EIA on the design.

Table 4.2: Mean scores (Part II)

Question	Mean %
Q4 In general, I observe a shift towards more environmentally sound design alternatives (n=70)	72%
Q5 EIA is helping me to take all potential impacts of the new development into account during the design process (n=80)	68%
Q6 I am aware of projects where the design was changed as a result of potential environmental impacts highlighted by the EIA (n=71)	75%
Q7 The evaluation of design alternatives relating to environmental impacts is a key component of our design process (n=74)	75%
Q8 I am aware of projects where the EIA assisted to mitigate risk for the development. (For example verification of flood lines) (n=78)	69%
Q9 Since the implementation of EIA I also started applying the "assess	63%

before you do" principle, learned from EIA in other aspects of my profession (n=73)

The mean scores of all the questions shown in Table 4.2 are above the 60% threshold, and Questions 6 and 7 are equal to the 75% threshold. This means that, according to the respondents, EIA has a significant influence on the design outcomes (Question 6) and that the evaluation of alternatives (as prescribed by EIA) is a key component of design (Question 7). The other components of engineering design shown in Table 4.2 returned satisfactory agreement among the respondents, but could be further developed.

The reliability of data for Part II of the survey is summarized in Table 4.3 below.

Table 4.3: Reliability data (Part II)

Summary for scale: Mean = 21.129 Standard deviation = 3.615	
Cronbach alpha: 0.774 Standardised alpha: 0.766	
Average inter-item correlation: 0.366	
Question	Cronbach alpha
Q4 In general, I observe a shift towards more environmentally sound design alternatives (n=70)	0.716
Q5 EIA is helping me to take all potential impacts of the new development into account during the design process (n=80)	0.705
Q6 I am aware of projects where the design was changed as a result of potential environmental impacts highlighted by the EIA (n=71)	0.749
Q7 The evaluation of design alternatives relating to environmental impacts is a key component of our design process (n=74)	0.809
Q8 I am aware of projects where the EIA assisted to mitigate risk for the development. (For example verification of flood lines) (n=78)	0.693
Q9 Since the implementation of EIA I also started applying the "assess before you do" principle, learned from EIA in other aspects of my profession (n=73)	0.744

As shown in Table 4.3, the average Cronbach Alpha for Part II of the survey is 0.766. This places it in the $\alpha > 0.7$ “acceptable” bracket. It could therefore be concluded that:

- Civil engineers are observing a shift towards more environmentally sound design alternatives. This could be as a result of EIA influencing engineers and developers to consider design alternatives and to choose the more environmentally sound option.
- EIA is assisting civil engineers in taking all potential impacts of a new development into account during the design process. This is one of the primary objectives of EIA, as discussed in Section 3.2.1 and is one of the objectives of EIA according to the IAIA (1999) to “*anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals*”. In helping engineers take these potential impacts into account, EIA creates the opportunity for the engineers to avoid and to design out the most severe adverse impacts. According to civil engineers, EIA is successful in this respect.
- According to civil engineers, EIA has a real influence on their designs because they are aware of projects where the design was changed as a result of potential impacts highlighted by the EIA. This shows that, in spite of criticism, EIA has some benefit to the biophysical environment.
- The evaluation of design alternatives relating to environmental impacts is a key component of the design process of civil engineers. This could be a result of EIA influencing engineers to take environmental impacts into account and to incorporate these considerations into their design process. If the evaluation of design alternatives relating to environmental impacts is a key component of their design process, it should be part of the design process even when no EIA is required.
- According to civil engineers, EIA has benefits in terms of risks to the development because they are aware of projects where EIA highlighted certain risks for the development and potentially prevented a disaster.
- Civil engineers are applying principles learned from EIA to other areas of their profession.

4.4 THE ROLE THAT EIA PLAYS IN ENSURING ENVIRONMENTAL LEGAL COMPLIANCE (PART III)

The results obtained for Part III of the survey is shown in Figure 4.2. The total number of respondents (n) that answered the specific question is shown in brackets after the question in Figure 4.2.

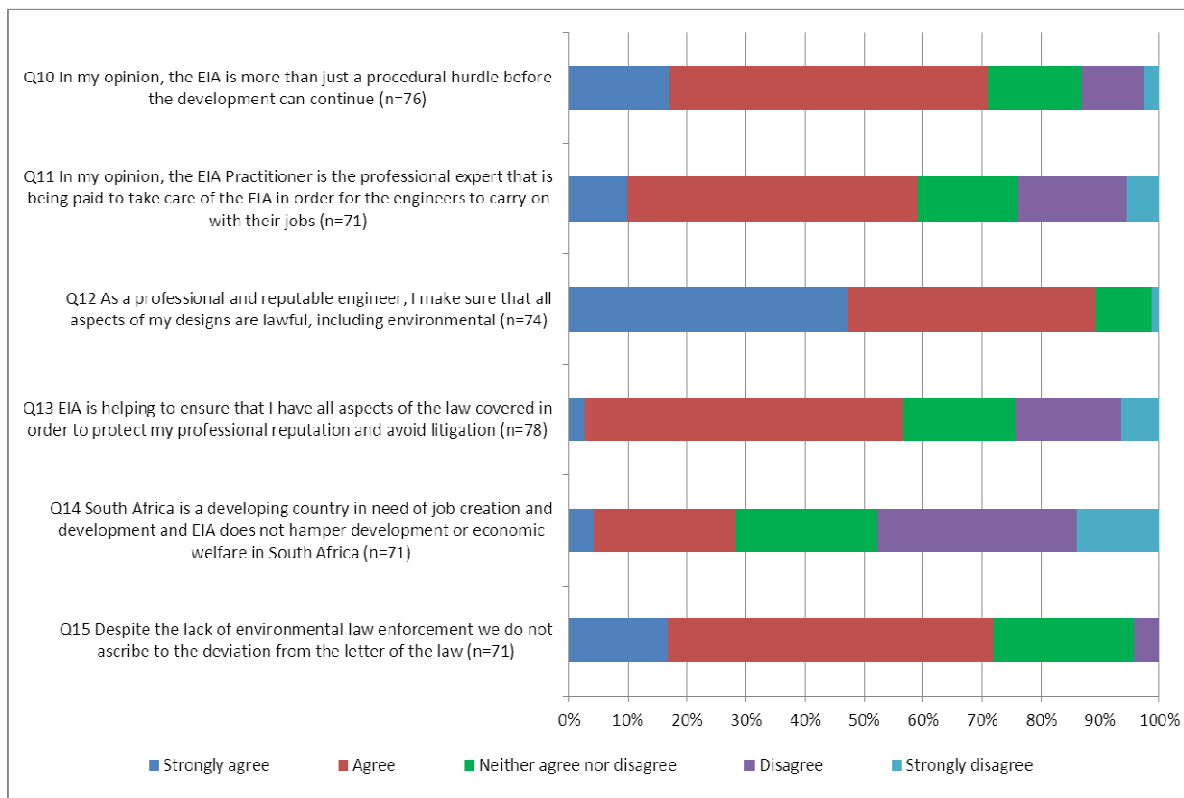


Figure 4.2: The role that EIA plays in ensuring environmental legal compliance

The respondents were in agreement with the questions of Part III of the survey, except for Question 14 where the responses varied significantly. The respondents showed the highest level of agreement with Question 12 that as professional engineers, they ensure that all aspects of their designs are lawful, including to environmental legislation (n=66, 89%). Question 12 is followed by Question 15 that despite the lack of law enforcement, they do not ascribe to deviation from the letter

of the law (n=51, 72%). Similarly, Question 10 returned 71% agreement that EIA is more than just a procedural hurdle before development can continue (n=52, 71%). Question 11 achieved 59% agreement that, in their opinion, the EIA Practitioner is the professional that is being paid to take care of the EIA in order for them to carry on with their jobs (n=42, 59%). Question 13 achieved 56% agreement that EIA is helping them to ensure that they have all legal aspects covered in order to protect their professional reputations and avoid litigation (n=44, 56%). The lowest level of agreement was with Question 14 that EIA does not hamper development (n=20, 28%).

The mean scores of each question in Part III of the survey is summarized below in Table 4.4. The mean scores are an indication of the importance of the specific question for engineers in terms of the role that EIA plays in ensuring environmental legal compliance.

Table 4.4: Mean scores (Part III)

Question	Mean %
Q10 In my opinion, the EIA is more than just a procedural hurdle before the development can continue (n=76)	74%
Q11 In my opinion, the EIA Practitioner is the professional expert that is paid to take care of the EIA in order for the engineers to carry on with their jobs (n=71)	68%
Q12 As a professional and reputable engineer, I make sure that all aspects of my designs are lawful, including environmental (n=74)	87%
Q13 EIA is helping to ensure that I have all aspects of the law covered in order to protect my professional reputation and avoid litigation (n=78)	66%
Q14 South Africa is a developing country in need of job creation and development and EIA does not hamper development or economic welfare in South Africa (n=71)	54%
Q15 Despite the lack of environmental law enforcement we do not ascribe to the deviation from the letter of the law (n=71)	77%

The mean scores of all the questions shown in Table 4.4 are above the 60% threshold, except for Question 14 below the 60% threshold at 54%. This means that Question 14 could be improved and further developed. Questions 10, 11 and 13 are below the 75% threshold, and Question 12 and 15 are above the 75% threshold. This shows that the respondents take the legal compliance of their designs very seriously.

The reliability data for Part III of the survey is summarized in Table 4.5.

Table 4.5: Reliability data (Part III)

Summary for scale: Mean = 21.239 Standard deviation = 2.880	
Cronbach alpha: 0.394 Standardised alpha: 0.386	
Average inter-item correlation: 0.100	
Question	Cronbach alpha
Q10 In my opinion, the EIA is more than just a procedural hurdle before the development can continue (n=76)	0.396
Q11 In my opinion, the EIA Practitioner is the professional expert that is paid to take care of the EIA in order for the engineers to carry on with their jobs (n=71)	0.384
Q12 As a professional and reputable engineer, I make sure that all aspects of my designs are lawful, including environmental (n=74)	0.475
Q13 EIA is helping to ensure that I have all aspects of the law covered in order to protect my professional reputation and avoid litigation (n=78)	0.380
Q14 South Africa is a developing country in need of job creation and development and EIA does not hamper development or economic welfare in South Africa (n=71)	0.170
Q15 Despite the lack of environmental law enforcement we do not ascribe to the deviation from the letter of the law (n=71)	0.218

The Cronbach Alpha of this group of items is below 0.700 at 0.394. This places it in the $\alpha < 0.5$ (“unacceptable”) bracket. The correlations of each of the items were

reviewed to identify weak items. Weak items are items with poor reliability. When these items are removed, the Cronbach alpha score of the group subsequently improves. Questions 10 and 11 were subsequently removed and the revised summary is shown in Table 4.6.

Table 4.6: Reliability data (Part III) – revised

Summary for scale: Mean = 14.1268 Standard deviation = 2.437	
Cronbach alpha: 0.560 Standardised alpha: 0.543	
Average inter-item correlation: 0.239	
Question	Cronbach alpha
Q12 As a professional and reputable engineer, I make sure that all aspects of my designs are lawful, including environmental (n=74)	0.591
Q13 EIA is helping to ensure that I have all aspects of the law covered in order to protect my professional reputation and avoid litigation (n=78)	0.356
Q14 South Africa is a developing country in need of job creation and development and EIA does not hamper development or economic welfare in South Africa (n=71)	0.361
Q15 Despite the lack of environmental law enforcement we do not ascribe to the deviation from the letter of the law (n=71)	0.555

As shown in Table 4.6, the Cronbach Alpha increased to 0.560 with the omission of Questions 10 and 11. However, this still only places it in the $\alpha > 0.5$ (“poor”) bracket, which means that it is questionable whether the factor will present itself if the study is to be repeated when subjected to a different application setting. The average score of this section should therefore not be applied to a representative conclusion. However, the following conclusions may be drawn:

- The respondents to this survey make sure that all the aspects of their designs are lawful. This includes environmental aspects.

- The respondents are of the opinion that EIA assists them in ensuring environmental legal compliance and thereby protecting their professional reputation.
- According to only 28% of the respondents EIA does not significantly hamper development in South Africa.
- The respondents do not deviate from the letter of the law in spite of the lack of enforcement in South Africa. This speaks of good ethics.

4.5 THE INFLUENCE OF EIA ON THE SUSTAINABILITY OF THE DESIGN (PART IV)

As shown in Figure 4.3, there was good agreement on Questions 16, 18, 19 and 21. The highest level of agreement on the questions in this section was obtained for Question 18, that the life cycle and sustainability of the design plays a key role in any project in which they are involved (n=63, 81%). Question 16 obtained 59% agreement that they are aware of projects where the EIA leads to the adjustment of the initial design, construction materials or any other aspect of the project in order to improve the sustainability of the design (n=44, 59%). According to the respondents, 57% agreed with Question 19 that they became more aware of the life cycle and sustainability of the development since the implementation of EIA (n=40, 57%). The respondents agreed that they personally experience EIA as a useful tool to improve the sustainability of the design according to 50% (n=37, 50%) in Question 21. At some of the companies only 48% of the respondents agreed the environmental review of the design is a compulsory step in any project that they do (regardless of the EIA) as shown by Question 20 (n=35, 48%).

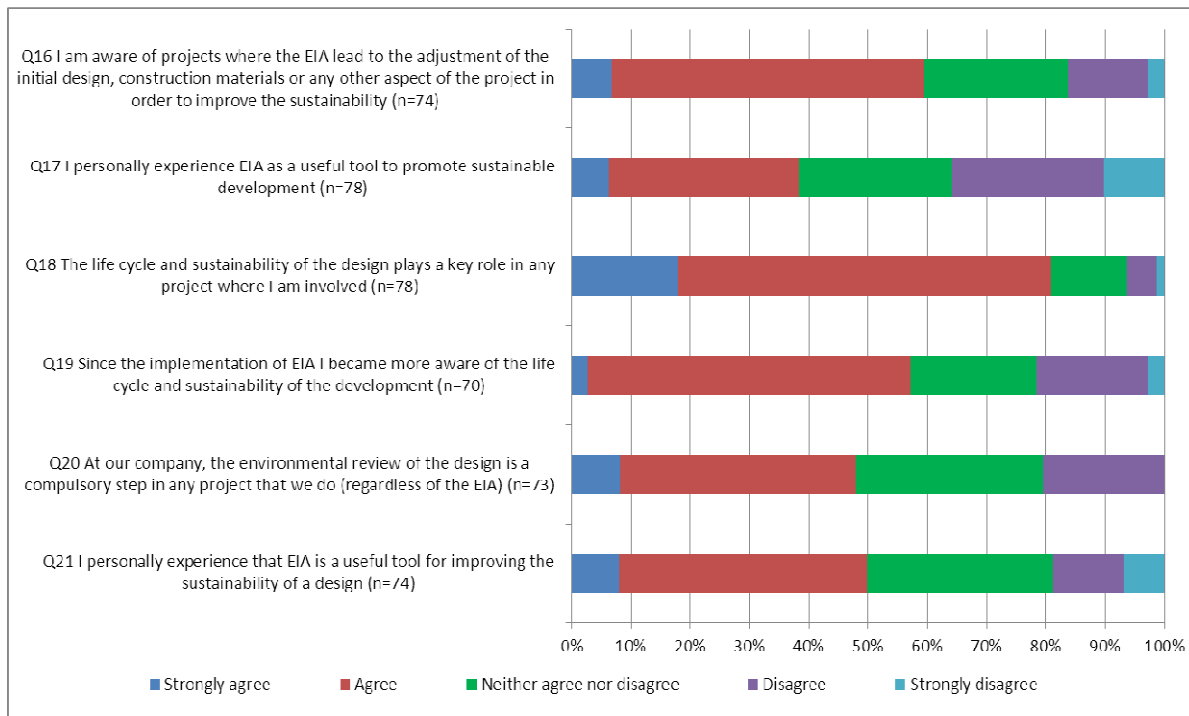


Figure 4.3: The influence of EIA on the sustainability of the design

The lowest level of agreement was with Question 17 where they personally experience EIA as a useful tool to promote sustainable development (n=30, 38%).

The mean scores of each question in Part IV of the survey is summarized below in Table 4.7. The mean scores are an indication of the importance of the specific question for engineers in terms of the influence of EIA on the sustainability of the design.

Table 4.7: Mean scores (Part IV)

Question	Mean %
Q16 I am aware of projects where the EIA lead to the adjustment of the initial design, construction materials or any other aspect of the project in order to improve the sustainability (n=74)	69%
Q17 I personally experience EIA as a useful tool to promote sustainable development (n=78)	60%
Q18 The life cycle and sustainability of the design plays a key role in	79%

any project where I am involved (n=78)

Q19 Since the implementation of EIA I became more aware of the life cycle and sustainability of the development (n=70) 67%

Q20 At our company, the environmental review of the design is a compulsory step in any project that we do (regardless of the EIA) (n=73) 66%

Q21 I personally experience that EIA is a useful tool for improving the sustainability of a design (n=74) 66%

The means scores of all the questions shown in Table 4.7 are above the 60% threshold, and Question 18 is above the 75% threshold. This means that, according to the respondents, the sustainability of the design plays a key role in the projects where they are involved. The other questions, shown in Table 4.7, indicate that EIA has a satisfactory influence on the sustainability of the design, but it could still be further developed.

The reliability data for Part IV of the survey is summarized in Table 4.8

Table 4.8: Reliability data (Part IV)

Summary for scale: Mean = 20.400 Standard deviation = 3.457

Cronbach alpha: 0.656 Standardised alpha: 0.631

Average inter-item correlation: 0.246

Question	Cronbach alpha
Q16 I am aware of projects where the EIA lead to the adjustment of the initial design, construction materials or any other aspect of the project in order to improve the sustainability (n=74)	0.592
Q17 I personally experience EIA as a useful tool to promote sustainable development (n=78)	0.487
Q18 The life cycle and sustainability of the design plays a key role in any project where I am involved (n=78)	0.713
Q19 Since the implementation of EIA I became more aware of the life cycle and sustainability of the development (n=70)	0.573

Q20 At our company, the environmental review of the design is a compulsory step in any project that we do (regardless of the EIA) (n=73)	0.714
Q21 I personally experience that EIA is a useful tool for improving the sustainability of a design (n=74)	0.508

The Cronbach Alpha of this group of items is below 0.700 at 0.631. This places it in the $\alpha > 0.6$ “questionable” bracket. The correlations of each of the items were reviewed to identify weak items. Questions 18 and 20 were subsequently removed and the revised summary is shown in Table 4.9.

Table 4.9: Reliability data (Part IV) - revised

Summary for scale: Mean = 13.143 Standard deviation = 3.200	
Cronbach alpha: 0.821 Standardised alpha: 0.821	
Average inter-item correlation: 0.542	
Question	Cronbach alpha
Q16 I am aware of projects where the EIA lead to the adjustment of the initial design, construction materials or any other aspect of the project in order to improve the sustainability (n=74)	0.592
Q17 I personally experience EIA as a useful tool to promote sustainable development (n=78)	0.487
Q19 Since the implementation of EIA I became more aware of the life cycle and sustainability of the development (n=70)	0.573
Q21 I personally experience that EIA is a useful tool for improving the sustainability of a design (n=74)	0.508

As shown in Table 4.9, the Cronbach Alpha increased to 0.821 with the omission of Questions 18 and 20. This places it in the $\alpha > 0.8$ “good” bracket. It could therefore be concluded that:

- The civil engineers are aware of projects where the EIA led to the adjustment of the initial design, construction materials or any other aspect of the project in order to improve the sustainability.
- The respondents have become more aware of the life cycle and sustainability of the development since the implementation of EIA. This means that EIA is successful in terms of creating awareness.
- The civil engineers personally experience that EIA is a useful tool for improving the sustainability of a design. As discussed in Section 3.2.4, promoting sustainable development is another objective of EIA. According to the IAIA (1999) the objective is to, *“promote development that is sustainable and optimizes resource use and management opportunities”*. Improving the sustainability of the design is a step in the right direction towards sustainable development. EIA is therefore successful in this regard.

4.6 THE INFLUENCE OF EIA ON THE TIME SCHEDULE OF THE DEVELOPMENT (PART V)

Figure 4.4 shows that there was agreement among the respondents with the questions of Part V of the survey, except for Question 26 where the responses varied significantly. The respondents showed high levels of agreement with Questions 22, 24 and 25. In Question 24, 86% of the respondents agreed that project delays are normally caused by slow decision making by the competent authority (n=65, 86%). In Question 25, 79% of the respondents agreed that project delays are normally caused by the cumbersome nature of the EIA process (n=60, 79%). In Question 22, 79% also agreed that the EIA caused a significant delay in the majority of the projects where they were involved (n=60, 79%). In Question 27, 52% agreed that EIA is causing more good to the environment than harm to the economy (n=38, 52%). In Question 23, 51% agreed that they are aware of projects where the delay was so severe that the economic feasibility of the project was jeopardized (n=37, 51%). 49% of the respondents agreed that the competent authority can often be blamed for engineers who start with projects before authorisation (n=39, 49%).

The lowest level of only 34% agreement was with Question 26 that project delays are normally caused by the inefficiencies of EIA practitioners (n=25, 34%).

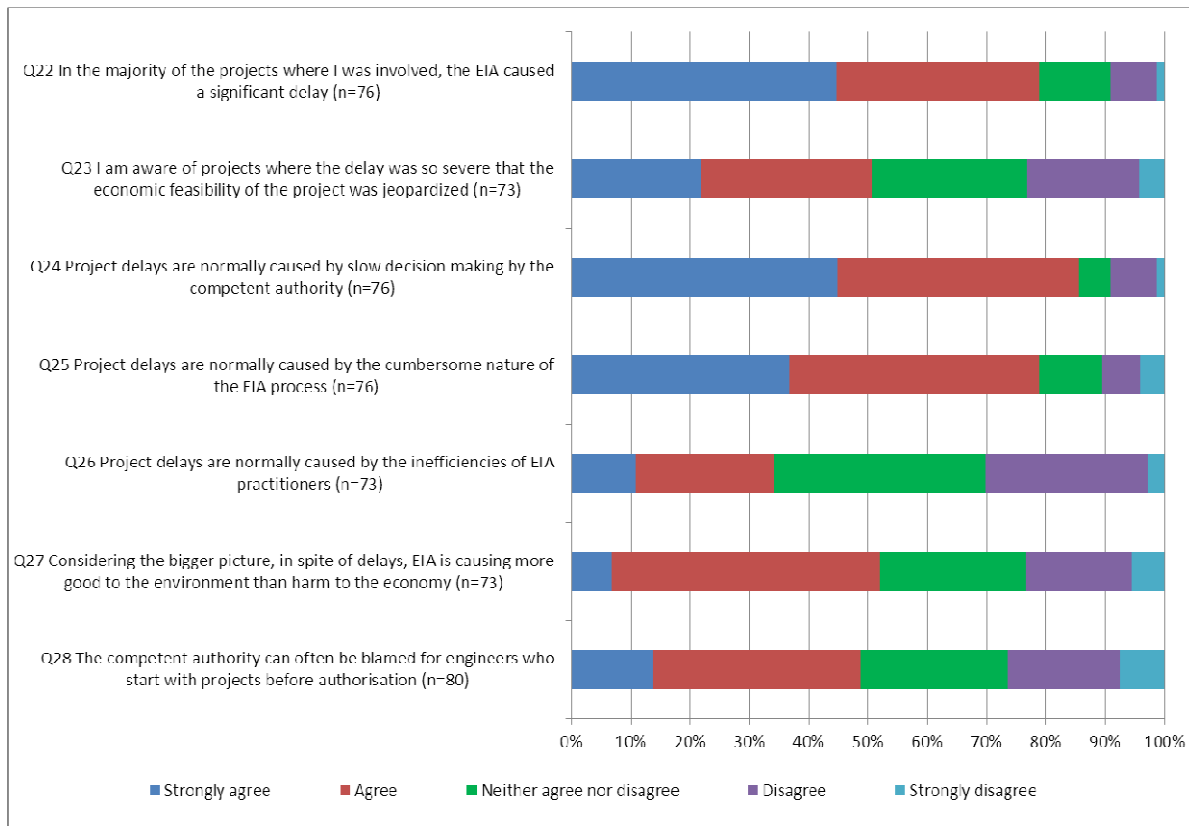


Figure 4.4: The influence of EIA on the time schedule of the development

The mean scores of each question in Part V of the survey is summarized below in Table 4.10. The mean scores are an indication of the importance of the specific question of engineers in terms of the influence of EIA on the time schedule of the development.

Table 4.10: Mean scores (Part V)

Question	Mean %
Q22 In the majority of the projects where I was involved, the EIA caused a significant delay (n=76)	83%
Q23 I am aware of projects where the delay was so severe that the economic feasibility of the project was jeopardized (n=73)	69%

Q24 Project delays are normally caused by slow decision making by the competent authority (n=76)	84%
Q25 Project delays are normally caused by the cumbersome nature of the EIA process (n=76)	80%
Q26 Project delays are normally caused by the inefficiencies of EIA practitioners (n=73)	62%
Q27 Considering the bigger picture, in spite of delays, EIA is causing more good to the environment than harm to the economy (n=73)	66%
Q28 The competent authority can often be blamed for engineers who start with projects before authorisation (n=80)	66%

The mean scores of all the questions, shown in Table 4.10, are above the 60% threshold and Questions 22, 24 and 25 are above the 75% threshold. This means that, according to the respondents, delays caused by EIA are normally a result of slow decision making by the competent authority (Question 24), EIA has a significant influence on the time schedule of the development (Question 22), and that delays are also often caused by the cumbersome nature of the EIA process (Question 25).

The reliability data for Part V of the survey is summarized below in Table 4.11.

Table 4.11: Reliability data (Part V)

Summary for scale: Mean = 25.534 Standard deviation = 3.962

Cronbach alpha: 0.582 Standardised alpha: 0.585

Average inter-item correlation: 0.184

Question	Cronbach alpha
Q22 In the majority of the projects where I was involved, the EIA caused a significant delay (n=76)	0.442
Q23 I am aware of projects where the delay was so severe that the economic feasibility of the project was jeopardized (n=73)	0.518
Q24 Project delays are normally caused by slow decision making by the competent authority (n=76)	0.457

Q25 Project delays are normally caused by the cumbersome nature of the EIA process (n=76)	0.432
Q26 Project delays are normally caused by the inefficiencies of EIA practitioners (n=73)	0.526
Q27 Considering the bigger picture, in spite of delays, EIA is causing more good to the environment than harm to the economy (n=73)	0.747
Q28 The competent authority can often be blamed for engineers who start with projects before authorisation (n=80)	0.555

As shown in Table 4-11, the average Cronbach Alpha for Part V of the survey is 0.582. This places it in the $\alpha > 0.5$ “poor” bracket. The correlations of each of the items were reviewed to identify weak items. The correlation of Question 27 was found to be negative and was turned around. The revised summary is shown in Table 4.12.

Table 4.12: Reliability data (Part V) - revised

Summary for scale: Mean = 24.932 Standard deviation = 4.741	
Cronbach alpha: 0.759 Standardised alpha: 0.766	
Average inter-item correlation: 0.328	
Question	Cronbach alpha
Q22 In the majority of the projects where I was involved, the EIA caused a significant delay (n=76)	0.699
Q23 I am aware of projects where the delay was so severe that the economic feasibility of the project was jeopardized (n=73)	0.719
Q24 Project delays are normally caused by slow decision making by the competent authority (n=76)	0.726
Q25 Project delays are normally caused by the cumbersome nature of the EIA process (n=76)	0.684
Q26 Project delays are normally caused by the inefficiencies of EIA practitioners (n=73)	0.739

Q27 Considering the bigger picture, in spite of delays, EIA is causing more good to the environment than harm to the economy (n=73) (REVERSE)	0.747
Q28 The competent authority can often be blamed for engineers who start with projects before authorisation (n=80)	0.780

As shown in Table 4.12, the Cronbach Alpha increased to 0.759 with the reverse of Question 27. This places it in the $\alpha > 0.7$ “acceptable” bracket, which means that it could be concluded that:

- EIA cause a significant delay in the majority of the projects of the civil engineers.
- The engineers are aware of examples of projects where the delay was so severe that it placed the economic feasibility in jeopardy.
- According to the respondents, project delays are caused by slow decision making by the competent authority, the cumbersome nature of the EIA process and inefficiencies of EIA practitioners.
- The civil engineers are of the opinion that EIA is causing more good to the environment than harm to the economy in spite of delays caused by the EIA.
- In Part III of the survey, 87% of the respondents indicated that they make sure that every aspect of their design is lawful, including environmental. It is unlawful to start with the development before authorisation. However, it is evident that the engineers are of the opinion that, due to the slow decision making, the competent authority should be blamed if they start with the development before authorisation.

4.7 ENVIRONMENTAL EDUCATION ACQUIRED BY CIVIL ENGINEERS (PART VI)

The results obtained for Part VI of the survey is shown in Figure 4.5. The total number of respondents (n) that answered the specific question is shown in brackets in Figure 4.5.

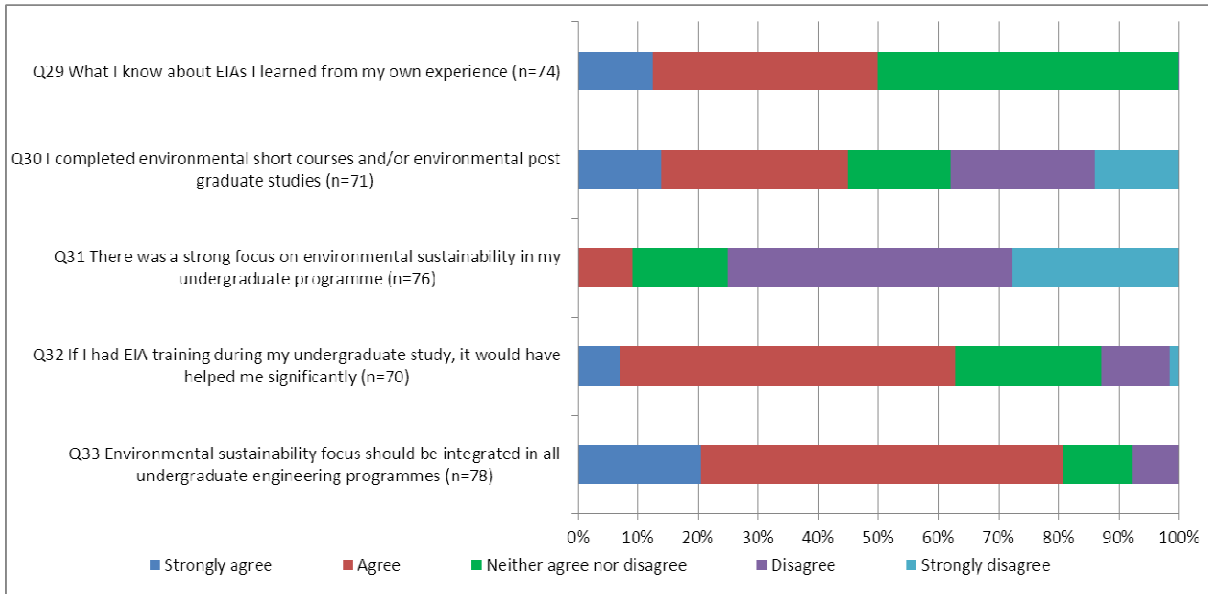


Figure 4.5: Environmental education acquired by civil engineers

As shown in Figure 4.5 there was good agreement only on Questions 32 and 33. There was some agreement on Questions 29 and 30, but there was strong disagreement with Question 31. The majority (81%) of the respondents agreed with Question 33 that environmental sustainability focus should be integrated in all undergraduate engineering programmes (n=60, 81%). Whereas 63% of the respondents to Question 32 agreed that if they had EIA training during their undergraduate studies it would have helped them significantly (n=45, 63%). In response to Question 29, 50% agreed that what they know about EIA, they learned from their own practical experience (n=39, 50%). Question 30 showed that 45% of the respondents completed environmental short courses and/or environmental post graduate studies (n=32, 45%). The majority was in disagreement with Question 31 that there was strong focus on environmental sustainability in their undergraduate programmes (n=7, 9%).

The mean scores of each question in Part VI of the survey is summarized below in Table 4.13. The mean scores are an indication of the importance of the specific question for engineers in terms of the environmental education that they have acquired.

Table 4.13: Mean scores (part VI)

Question	Mean %
Q29 What I know about EIAs I learned from my own experience (n=74)	75%
Q30 I completed environmental short courses and/or environmental post graduate studies (n=71)	59%
Q31 There was a strong focus on environmental sustainability in my undergraduate programme (n=76)	41%
Q32 If I had EIA training during my undergraduate study, it would have helped me significantly (n=70)	71%
Q33 Environmental sustainability focus should be integrated in all undergraduate engineering programmes (n=78)	79%

The mean scores of Questions 30 and 31, shown in Table 4.13, are below the 60% threshold. The low mean score of Question 31 shows that historically there was not much focus on environmental sustainability in undergraduate engineering study programmes. Also, only 45% of the respondents completed environmental short courses or post graduate studies. Questions 32 are above the 60% threshold and below the 75% threshold. Questions 29 and 33 are on and above the 75% threshold respectively.

The reliability data for Part VI of the survey is summarized in Table 4.14.

Table 4.14: Reliability data (part VI)

Summary for scale: Mean = 14.786 Standard deviation = 2.659
Cronbach alpha: 0.447 Standardised alpha: 0.475
Average inter-item correlation: 0.157

Question	Cronbach alpha
Q29 What I know about EIAs I learned from my own experience (n=74)	0.389
Q30 I completed environmental short courses and/or environmental post graduate studies (n=71)	0.431
Q31 There was a strong focus on environmental sustainability in my undergraduate programme (n=76)	0.466
Q32 If I had EIA training during my undergraduate study, it would have helped me significantly (n=70)	0.321
Q33 Environmental sustainability focus should be integrated in all undergraduate engineering programmes (n=78)	0.351

As shown in Table 4.14, the average Cronbach Alpha for Part VI of the survey is 0.447. This places it in the $\alpha < 0.5$ “unacceptable” bracket. Weak items in this section could not be singled out. The average score of this section should therefore not be applied to a representative conclusion. However, the following conclusions may be drawn:

- The respondents agreed that what they know about EIA they learned from their own experience.
- 45% of the respondents completed environmental short courses or post graduate studies.
- According to the majority of the respondents, there was not a strong focus on environmental sustainability in their undergraduate programmes.
- The majority of the respondents agreed that it would have helped them significantly if they had EIA training during their undergraduate programmes.

- The majority of the respondents agree that environmental sustainability should be integrated in all undergraduate engineering programmes.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

In this research, an assessment was done of the merit of EIA for civil engineers. The consideration of the results that were presented and discussed in Chapter 4 refers back to the main research questions:

- 5.1 To what extent do the EIA requirements and processes influence the designs of civil engineers to be more acceptable from an environmental point of view?
- 5.2 To what extent does EIA assist in creating a climate to ensuring environmental legal compliance by civil engineers?
- 5.3 To what extent does EIA lead to more sustainable designs from a life cycle point of view?
- 5.4 How does the EIA process influence the time schedule of the development?
- 5.5 To what extent is the environmental education acquired by civil engineers adequate?

With reference to research questions, engineers experienced that EIA helps to ensure that they have all the legal aspects of the development in place before development starts. They experience EIA as a catalyst for the integration of environmental considerations in the planning stages of a project. They consider South African environmental assessment to be more than a financial and administrative burden. EIA therefore creates the opportunity for the engineers to eliminate the most significant adverse environmental impacts in the design.

If the EIA is a useful tool for civil engineers to integrate environmental considerations into the planning stages of their projects, these considerations will be reflected in their designs. Since the implementation of EIA, engineers are observing a shift towards more environmentally sound design alternatives. Therefore, EIA is

influencing engineers to review their designs from an environmental point of view and this practice could significantly minimise environmental impacts.

According to engineers, EIA is assisting them to take all potential impacts of a new development into account during the design process. The engineering design normally determines the true environmental impact of a development. According to the respondents, the majority were aware of projects where the design was changed as a result of potential impacts highlighted by the EIA. Many of the respondents indicated that the environmental review of the design is a compulsory component of the design process for any project regardless of whether an EIA is required or not. This shows that the companies, where the respondents are working, have internal standards of environmental review even when a project does not require an EIA. This shows that EIA has influenced the design process in order to consider environmental impacts regardless of the environmental authorisations required by law.

The engineers have become more aware of the life cycle and sustainability of the development since the implementation of EIA and EIA is therefore creating awareness about sustainability. The engineers experience EIA as a useful tool to improve the sustainability of the design.

It was, however, found that EIA did cause a significant delay in most of the projects where the respondents were involved. The majority agreed that they are aware of cases where the delay was so severe that the economic feasibility of the project was jeopardized. According to the respondents, the delays are mainly due to slow decision making by the competent authority. Due to this slow decision making by the competent authority, the engineers blame the competent authority if they start with the project before authorisation. From their point of view it is not unlawful to start with a project when the competent authority is causing a delay. Yet in spite of these delays, the engineers are still of the opinion that EIA is doing more good to the environment than harm to the economy.

The knowledge that the majority of the engineers have about EIA, was acquired from their own experience. They agreed that EIA training during their undergraduate study would have been useful, and that there was very little focus on environmental sustainability during their undergraduate studies. In spite of this lack of training, the majority have, to date, not yet completed any environmental short courses or post graduate studies.

It seems that, in the South African context, the benefits of environmental assessment are in fact being experienced at project level, similar to the findings of international scholars mentioned in Chapter 1 (Bartik, 1988; Porter & van der Linde, 1995; Annandale and Taplin, 2003). The response of the engineers was found to be positive. They also experienced the EIA as incrementally positively influencing the work that they do from an environmental point of view. It is evident that EIA has significant merit for civil engineers and plays a positive role in the work that they do. The attitudes of the engineers towards EIA were also found to be positive. However, the majority of the respondents are of the opinion that EIA hampers development in South Africa. The engineers do not really consider EIA as a useful tool to promote sustainable development. This could be due to the costs involved or the delays caused by the EIA process. This might be focus areas for future research.

The objectives of EIA that are not aligned with the objectives of civil engineering, as shown in Figure 2.2, contribute to the project of the engineers instead of creating conflict. EIA helps engineers to consider environmental impacts, protect the biophysical environment and consider alternatives. This is where EIA processes contribute or influence the civil engineering profession. EIA compels engineers to think about the environmental impacts, how their designs will influence decision making, how to protect the biophysical environment and the possibility of alternative designs even though these factors are not identified as key objectives for the civil engineering profession.

5.2 RECOMMENDATIONS

Guidelines should be developed for engineers on how environmental issues should be incorporated into the project EIAs and should also provide the framework for environmental practitioners to participate as team members during the planning and design phase of the development. This highlights the importance of, or might even help to ensure the involvement of EIAs in the early phases of the project.

Environmental courses that are designed specifically to equip engineers with the relevant information and the knowledge about environmental design, and the EIA, could be made a pre-requisite before professional registration with ECSA. This could save many professional engineers from learning about environmental authorisations the hard way.

5.3 FUTURE RESEARCH

Due to the nature of the distribution of the survey by means of e-mail via SAICE, the number of e-mails that reached the intended recipients and the number of e-mails that were opened could not be determined. It is recommended that the number of emails that did not reach the intended recipients be determined. It is also recommended that in future studies, software should be used to determine the number of emails that were left unopened. These numbers could be subtracted from the total number of e-mails that was initially sent out.

The questions of Part III and Part VI should be developed in order to return results with a higher internal consistency.

According to the respondents to this study, the majority are of the opinion that EIA hampers development. Engineers do not really consider EIA as a useful tool to promote sustainable development. These may be investigated in greater detail in future research. If the root causes of this could be determined and eliminated it could be to the advantage of the economy as well as to the engineers and the environmental practitioners.

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APPENDIX A. QUESTIONNAIRE

THE MERIT OF EIA FOR CIVIL ENGINEERS

Part I – The demographic profile of the respondents

1. I work for:
 - My own company
 - Small/Medium Enterprise
 - Large company

2. My office is based in:
 - Gauteng
 - Limpopo
 - Mpumalanga
 - North West
 - Free State
 - Eastern Cape
 - Western Cape
 - Northern Cape
 - KwaZulu-Natal

3. My years of experience as a civil engineer:
 - Less than 5 years
 - 5 to 15 years
 - 15 years and more

4. In general, I observe a shift towards more environmentally sound design alternatives.
 - Strongly disagree
 - Disagree

- Neither agree nor disagree
- Agree
- Strongly Agree

Part II – The influence of EIA on engineering designs

5. EIA is helping me to take all potential impacts of the new development into account during the design process.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
6. I am aware of projects where the design was changed as a result of potential environmental impacts highlighted by the EIA.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
7. The evaluation of design alternatives relating to environmental impacts is a key component of our design process.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
8. I am aware of projects where the EIA assisted to mitigate risk for the development. (For example verification of flood lines, etc.).

- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
9. Since the implementation of EIA I also started applying the "assess before you do" principle, learned from EIA, in other aspects of my profession.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

Part III – The role that EIA plays in ensuring environmental legal compliance

10. In my opinion, the EIA is more than just a procedural hurdle before the development can continue.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
11. In my opinion, the EIA Practitioner is the professional expert that is being paid to take care of the EIA in order for the engineers to carry on with their jobs.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

12. As a professional and reputable engineer, I make sure that all aspects of my designs are lawful, including environmental.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
13. EIA is helping to ensure that I have all aspects of the law covered in order to protect my professional reputation and to avoid litigation.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
14. South Africa is a developing country in need of job creation and development; EIA does not hamper development or economic welfare of South Africa.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
15. Despite the lack of environmental law enforcement we do not ascribe to the deviation from the letter of the law.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

Part IV – The influence of EIA on the sustainability of the design

16. I am aware of projects where the EIA lead to the adjustment of the initial design, construction materials or any other aspect of the project in order to improve the sustainability.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
17. I personally experience EIA as a useful tool to promote sustainable development.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
18. The life cycle and sustainability of the design plays a key role in any project where I am involved.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
19. Since the implementation of EIA I became more aware of the life cycle and sustainability of the development.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree

- Strongly Agree
20. At our company, the environmental review of the design is a compulsory step in any project that we do (regardless of the EIA).
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
21. I personally experience that EIA is a useful tool for improving the sustainability of a design.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

Part V – The influence of EIA on the time schedule of the development

22. In the majority of the projects where I was involved, the EIA caused a significant delay.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
23. I am aware of projects where the delay was so severe that the economic feasibility of the project was jeopardized.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree

- Agree
 - Strongly Agree
24. Project delays are normally caused by slow decision making by the competent authority.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
25. Project delays are normally caused by the cumbersome nature of the EIA process.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
26. Project delays are normally caused by the inefficiencies of EIA practitioners.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
27. Considering the bigger picture, in spite of delays, EIA is causing more good to the environment than harm to the economy.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

28. The competent authority can often be blamed for engineers who start with projects before authorisation.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

Part VI – Environmental education acquired by civil engineers

29. What I know about EIAs I learned from my own experience.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
30. I completed environmental short courses and/or environmental post graduate studies.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
31. There was a strong focus on environmental sustainability in my undergraduate programme.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree

32. If I had EIA training during my undergraduate study, it would have helped me significantly.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree
33. Environmental sustainability focus should be integrated in all undergraduate engineering programmes.
- Strongly disagree
 - Disagree
 - Neither agree nor disagree
 - Agree
 - Strongly Agree