1 Introduction

"Low Impact Design" *is a design approach for site development that protects and incorporates natural site features into erosion and sediment control and stormwater management plans.*

1.1 Purpose

The primary purpose of this guideline is to present an alternative approach to site design and development from a stormwater management context. It is very applicable to residential development but can also be used on commercial and even on industrial development. Its basis is founded in the recognition that the volume of stormwater discharged from a site may be of equal importance to limiting contaminant discharge. The low impact design approach is another stormwater management tool for reducing the adverse impacts of stormwater runoff.

It is not intended that the approach will become mandated by the by the Hawke's Bay Regional Council at this time. There may be development situations where it will be difficult for other approaches to provide the same level of protection for downstream receiving waters, but the decision as to the stormwater management approach rests with the site developer as long as there is an approach to stormwater management which can provide similar benefits and protection to receiving waters.

Stormwater management issues relate primarily to providing guidance for site and catchment design, which incorporates natural site features into land development. The intention is to advise land developers on the benefits of retaining and incorporating these natural features into the site development process and thereby reducing or, in very limited situations, eliminating the need for structural stormwater management controls. Other benefits are also realized through natural site feature utilisation, such as more closely approximating the predevelopment water budget, protection of habitat, and reduced overall impact to the receiving system.

Site features include:

- Wetlands,
- Watercourses,
- Floodplains,
- Forested areas with emphasis on native vegetation,
- Riparian buffers,
- Soils,
- Steep slopes, and
- Other natural features.

Design procedures are provided which allow site designers to incorporate practices, inherently known to be good, but which have not had a sound rational basis to ensure plan approval. That rational basis will be provided in this guideline for a variety of situations. The design approach will be flexible enough to allow for various low impact practices to be combined on one site and quantify the benefits of that combination.

It must be emphasized that structural controls will still be essential on many sites. A heavily vegetated site having a significant portion of the tree canopy removed will still have a significant increase in sediment yield and stormwater runoff, even with aggressive planning efforts related to erosion and sediment control and stormwater management. The practices detailed in this guideline are provided as additional tools in the erosion and sediment control and stormwater management toolbox. They may supplement structural control practices and may, in some situations, replace or reduce the need for structural practices while providing attractive site amenities.

1.2 Audience

The guideline can be used on residential, commercial or industrial sites, especially in the context of a treatment train approach when considering multiple contaminants. Clustering may be more appropriate for residential subdivisions and catchment level implementation than it would be for commercial or industrial sites but issues such as water reuse, green roofs or biofiltration are equally possible on all types of land use activities.

1.3 Background

When discussing the background of this guideline, it is beneficial to recognise the evolution of efforts related to erosion and sediment control and stormwater management and their relationship to the Resource Management Act. These programmes are continually evolving as we learn and this evolutionary process will have to continue as long as water quantity, water quality and aquatic ecosystem problems exist.

The Hawke's Bay Regional Council has its duties, powers and functions specified in the RMA, which was enacted in 1991. The purpose of the Act is defined in Section 5 of the Act.

> "Section 5. Purpose:
>
> 1. The purpose of the Act is to promote the sustainable management of natural and physical resources.
> 2. In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while.
>
>   (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
>   (b) Safeguarding the life supporting capacity of air, water, soil, and ecosystems; and
>   (c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment."

Under the RMA Regional Councils and Territorial Authorities (TA's) have different duties, powers and functions. The Hawke's Bay Regional Council has the function of "the establishment, implementation, and review of policies and methods to achieve integrated management of the natural and physical resources of the region" and "the control of discharges of contaminants into or onto land, air, water, and discharges of water into water". The RMA is enabling, rather than a prescriptive act. The Hawke's

Bay Regional Council can implement management of natural and physical resources through the adoption of policies and rules.

Under Section 32 of the RMA, the Hawke's Bay Regional Council has a duty to consider alternatives and assess the benefits and costs before adopting policies and rules. An urban runoff quality control programme must therefore consider all the tools available for reducing environmental degradation from urban runoff and establish a strategy that passes the tests provided for in Section 32 of the Act.

1.4 Problem Statement

When considering problems, there are a number of aspects that can be considered. One approach is to consider problems from a temporary (erosion and sediment control) and permanent (stormwater management) perspective. From a temporary context, there is the importance of site disturbance on sediment yields during construction. There are some basic statements that can be made.

Estuarine Sedimentation from Site Development

- The greater the area of site disturbance, the greater the sediment yields.
- The longer the area remains disturbed, the greater the sediment yields.
- The greater the slope, the greater the sediment yields.
- Disturbed land has a greater runoff potential than vegetated surfaces.
- The closer the site disturbance is to a receiving environment (watercourse, estuary, marine area), the greater the potential impact.

When considering the permanent impacts of urbanisation, there is the historic recognition that flooding can be a problem. There is also increased recognition that other water-related problems are associated with land development. The most obvious, is stream channel erosion with subsequent impacts on the stream biota. The creation of impervious surfaces increases the total volume of water running off the land during a rainfall event. This increased volume of stormwater runoff results during all storm runoff events and increases the potential for stream channels to erode. The channel capacity is increased (wider, deeper, or both) and results in the loss of private and public property and significant habitat degradation. There is documentation indicating that channel erosion in a catchment that is completely developed is the single largest source of sediment delivered downstream. Channel instability results in public expenditures to reduce property loss and necessitates channel works such as stone armouring or channel lining.

Other impacts associated with land development include the generation and discharge of contaminants carried off the landscape by stormwater runoff. These contaminants include:

- Sediment,

- Oxygen-demanding substances (decomposition of organic materials),
- Nutrients (predominantly nitrogen and phosphorus),
- Metals (many different ones but zinc, copper, lead are generally found),
- Oil and grease,
- Microorganisms (human or animal waste), and
- Organics (pesticides, herbicides, etc.)

Typical Urban Contaminants

Contaminants build up in a catchment, and are delivered to a receiving system during storm runoff and may accumulate over time. Their impacts tend to be chronic rather than acute or episodic, and increase over time. Examples of impacts associated with contaminant loadings include increased water supply treatment costs, destruction of aquatic plants and animals, beach and shellfish area closures from bacterial contamination, and bioaccumulation of chemical pollutants. More subtle impacts can include reduced harvesting or landings of fish and shellfish.

Another emerging concern is the reduction in low stream flow as catchments develop. Streams which had water flowing in them all year frequently become ephemeral as groundwater recharge is reduced. As a general comment, if a stream is flowing when it is not raining, then the flow is groundwater generated. If groundwater levels drop lower than the stream invert, baseflow ceases and the stream loses its biologic values unless aquatic organisms can exist in pools until the time when the stream flows again. All of us live in catchments that have been impacted as a result of our activities on the land.

For all of these reasons, the Hawke's Bay Regional Council requires erosion and sediment control and stormwater management to implement temporary and permanent practices and strategies for water quantity and water quality purposes. Consent requirements for erosion and sediment control are detailed in the Erosion and Sediment Control Guidelines for the Hawke's Bay Region. Existing stormwater management requirements are detailed in the Stormwater Management Guidelines for the Hawke's Bay Region.

The guidelines place heavy emphasis on structural practices such as filters and ponds to minimise, to some extent, the adverse impacts of stormwater runoff both during and post-construction. When intending land development, the land developer must consider both the quantity of water leaving the site and the quality of that water both during and post-construction. Criteria are specified in the various Hawke's Bay Regional Council Guidelines that must be followed.

1.5 Limitations of Existing Practices

Most stormwater management programmes place a heavy reliance on implementation of structural practices. These practices include ponds, both wet and dry; flow diversion systems; filtering practices; and other variations. The implementation of stormwater management practices is necessary for their water quantity and water quality benefits and is expected to remain integral to programme implementation, but there should not be an over reliance on them. These practices, in and of themselves, cannot eliminate adverse impacts that urban development has both during and post-construction. In addition, there are a number of limitations to structural facilities.

A stormwater management programme relying solely on structural practices has a number of weaknesses. The existence of these weaknesses has been recognized for some time, but there has been little information available on alternative approaches that would justify their inclusion in programmes. In addition, clear guidance must be available on alternative design approaches or practices that can be used by plan designers and approval agencies. The guidance must also lend itself to effective field implementation. The following items and their discussion present some of the weaknesses of programmes based on structural controls.

1.5.1 **Lack of Flexibility in Site Design**

A lack of flexibility in what a site developer can do for stormwater management will have an impact on how the site is developed. The requirement to construct ponds will necessitate that site drainage be routed to the ponds. This would mean that runoff which can travel through sheet flow across vegetated areas must be conveyed to the pond. This will normally entail conversion of the water from sheet flow into concentrated flow through a reticulation system.

The existing approach detailed in the Stormwater Management Guidelines for the Hawke’s Bay Region is presented as a “cookbook” of practices. The approach does not mandate one practice over another, but rather provides a framework by which one practice is used over or in conjunction with another one. Practices and approaches have limitations to their use and those limitations will determine, to a large extent, which ones are used. Some flexibility does exist but that flexibility is only as broad as the interpretation of the individuals designing or approving the stormwater management plan. In reality, there is a perception, for the most part valid, that the preference for ponds is too often a mandate. In addition, design consultants must deliver an approvable plan to the site developer. The expense associated with that plan is dependent on the consultant being reasonably comfortable that their cost estimate for design will provide for their time and expense in doing the site design. An innovative site design may receive a poor reception from the consenting agency and necessitate a redesign with a more traditional approach to site control. Innovation is very difficult to budget for when monetary resources are limited.

1.5.2 **Altered Site Hydrology**

The only structural practices that attempt to mimic predevelopment site hydrology are practices that take stormwater out of the runoff stream. Infiltration, water reuse and evapotranspiration practices reduce the total volume of stormwater runoff. Unfortunately, these practices are not appropriate everywhere, Other practices, such as stormwater management ponds, only reduce, to an extent, the adverse impacts of land development. The volumes of stormwater runoff are increased immediately upon site clearance, and consequently the duration of storm flows from these ponds is considerably longer than that which would have occurred prior to site development. From a water quantity standpoint, the intention is to hold the site's stormwater long enough to allow the catchment's storm flows to pass the site, and thus reduce downstream flooding. They also provide water quality treatment primarily through settling processes that are designed into the practice. However, it needs to be recognised that flows can also modify ambient water quality so as to make it unsuitable for downstream biota.

The use of ponds is a recognition and acceptance that site hydrology has drastically been modified, and an increase in the volume of stormwater runoff is inevitable. In the same regard, groundwater levels will drop and base stream flow will be reduced. The pond's purpose is to reduce, to the extent possible, the adverse impacts of contaminant discharge and altered site hydrology. If the site hydrology were not altered to the degree that is normally accomplished, downstream impacts would be reduced.

1.5.3 Expense

In addition to design costs, there is the greater expense associated with the construction of ponds and filtering practices. These practices can be expensive. Too often in stormwater design the sizing of stormwater management practices is based on the generic land use draining to the practice and does not consider that portions of the site, if left undisturbed, would not generate the amount of runoff that results from the developed portion of the site.

Ponds, as generally implemented, are structural practices. They must have properly designed structural components such as a core trench, anti-seep collars, a riser assembly with a trash rack, a barrel, and structural fill. These components are expensive and require care in their proper installation and performance.

For the most part discussion in this guideline will address ponds as the current primary means for stormwater management in site development. Ponds have been preferred historically as a result of their applicability for water quantity use in addition to their proven water quality performance values. There are a number of other practices and these other practices are also structural practices. Other practices include infiltration trenches and dry wells, biofiltration practices such as swales or filter strips and filtration practices that rely on the movement of water through a filter media, usually sand, to provide a water quality benefit.

1.5.4 Loss of site area

Stormwater management practices take up site area. When a land developer decides to develop a given piece of property, an initial consideration is how many housing units can be placed on that property, and their potential sale prices. A factor in this determination includes how much of the site must be devoted to the stormwater management practice, maintenance access to the practice and drainage components that convey water to it. All of these features limit what the land developer can do on the remainder of the property. Low impact design practices will also utilize site area, but they can more easily be blended into the overall site development and required open space plan than can stormwater management ponds, for example.

1.5.5 Potential increased impacts to site and catchment natural resources

Generally, the lowest elevation of the site will be where the stormwater management pond is to be located. This will ensure gravity flow throughout the site to the pond. If this portion of the site is bush or a wetland, construction in this area could adversely impact on those resources.

Even if wetlands or other natural features are avoided by the stormwater management practice, getting a reasonable financial return on the project may necessitate disturbance in those areas for another aspect of site development. This could occur because housing densities may necessitate filling wetlands or cutting down more trees to get the minimum number of lots needed.

Increased disruption of natural site features can have impacts off-site. Downstream wetlands or estuarine areas may have greater sedimentation as a result of increased site disturbance or increased disturbance of steep slopes, or erodible soils, etc. New Zealand has lost approximately 90 percent of its nontidal wetlands. Those wetlands were not lost overnight or as the result of one activity. Adverse sediment and stormwater impacts are cumulative in nature and result from numerous activities, each having a minor catchment-wide individual impact.

1.5.6 Configuration of Development

Typical Form of Urban Development

The traditional approach to stormwater management seems to also fit with the traditional approach to site development. The site design approach allocates a portion of the site to sediment control and stormwater management in conjunction with a “cookie cutter” approach to site layout. Site development is configured in a traditional pattern that easily goes through the territorial authority approval process. Traditional structural stormwater management requirements are now well understood and are just incorporated in an overall site plan with little consideration of the need to protect existing site resources.

1.5.7 Connection of Impervious Areas

Conventional storm drains usually link impervious areas on most sites. Storm drains are efficient water conveyance systems that collect and quickly pass runoff into a structural stormwater management practice. Rapid travel through an enclosed storm drain system eliminates any potential for contaminants to be removed from the stormwater conveyance system prior to its entry into the stormwater management practice. This results in the stormwater management practice being the only means of treating the runoff water quality and providing for water quantity control.

1.5.8 Disregards Site Resource Conservation Benefits

There is little incentive, under the existing approach to site development, to leave trees in a given location, to establish native vegetation in open space, or to maintain low areas as wetlands. All of these practices reduce the total volume of runoff and provide water quality benefits. There is no incentive if structural stormwater management is still required for the land development and the volume and areal extent of the practice cannot be reduced.

Protecting and preserving natural site features requires a greater effort during the land development process. At present, there is little incentive for the land developer to take additional natural feature protection efforts, especially if public perception indicates that site buyers might prefer a more manicured site. The land developer must receive an economic benefit by leaving natural features if that individual is to "sell" eventual property owners on the rationale for leaving natural features.

1.5.9 Maintenance Obligations

Operation and maintenance of structural stormwater management practices is a significant responsibility if ongoing adequate performance of the practices is to occur. Structural practices require routine and periodic inspections to ensure proper function and all system components need to be checked. Individuals conducting these inspections need to be trained to recognize when a problem exists and what steps need to be taken to rectify them. Inspection report forms need to be completed and given to those individuals responsible for maintenance of the practice.

Actual maintenance of the structural practice is generally divided into two categories: routine and non-routine. Routine maintenance needs to be ongoing, such as mowing or maintenance of terrestrial vegetation, debris removal, lubrication of any moving parts to the practice, etc. Non-routine maintenance is done on an "as-needed" basis and can include sediment removal, aquatic weed removal, replacement of worn parts, needed structural repairs, and other activities associated with a particular structural practice. Maintenance activities represent a significant commitment of time and resources to ensure long-term function of the sediment control and stormwater management practices.

Also, the issue of who is responsible for operation and maintenance can be a problem. This can exist where stormwater practices such as ponds have been installed in new subdivisions. Local authorities or maintenance organizations may not have the expertise, awareness, or inclination to address operation and maintenance obligations or problems. There may also be a potential safety or liability problem in the event of stormwater practice failure.

When maintenance is not accomplished, the results can range from increased downstream flooding and increased contaminant discharge to potential loss of life and property. Maintenance is a major expense associated with structural stormwater management practices.

1.6 Low Impact Design (LID) Approach

Low impact design (LID) approaches reflect a totally different philosophy towards site design that integrates stormwater management into the very core of site design, as opposed to being considered an afterthought to site design with a conventional approach. These approaches can include an almost endless universe of practices, strategies, planning and common sense. This guideline cannot include all potential components but will provide guidance and information on many that are currently recognized where data exists or can be generated to substantiate their benefits from a water budget perspective.

It is important to develop an ethic that treats stormwater runoff as a “resource” rather than a “waste-product” of development. As such, there are a number of key site design components to consider:

- Reducing site disturbances,
- Reducing impervious surfaces,
- Constructing biofiltration practices,
- Water reuse,
- Creating natural areas, and
- Clustering development

Low impact approaches will be discussed through the guideline but some are briefly discussed here to provide an initial awareness of the range of options that will be discussed later in greater detail.

1.6.1 **Reducing site disturbances**

Many sites have existing resources that, in addition to other values, have soil retention and stormwater management benefits. These natural systems include forested areas, wetlands, and other areas of natural value and are discussed in greater detail in Section 3.

Forested areas provide for rainfall interception by leaf canopy. In addition, an organic forest litter develops on the forest floor that acts very much as a sponge to capture the water and prevent overland flow. Trees provide for uptake and storage of nutrients. They also moderate temperatures during the summer and provide wildlife habitat, thus providing other environmental benefits.

Wetlands are valuable resources and provide numerous benefits including flood control, low stream flow augmentation, erosion control, water quality and habitat. They are very productive ecosystems whose maintenance would have significant water quantity and quality benefits. Where they exist on a development site, they could become an important element in site design.

From a construction standpoint, leaving areas in natural ground cover can have a significant benefit by reducing downstream sediment delivery. Sediment yield from disturbed soils can be 2000 times greater than yields from forested areas. Leaving site areas undisturbed is an important low impact approach component.

1.6.2 Reducing impervious surfaces

Impervious surfaces (roads, roofs, footpaths) prevent the passage of water through their surface into the ground. Water must then be transported across the surface to a point of discharge. Residential subdivisions can reduce the width of roadways, or design the roadways to limit the total length needed to service individual properties. In conjunction with imperviousness, roof down drains may be directly connected to streets or reticulation systems when providing splash blocks and discharging the water across grass and away from impervious surfaces (footpaths, streets) will allow for a greater amount of water to infiltrate into the ground.

An important factor in limiting impervious surfaces and separating roof drains from direct connection to streets is the need for education of home owners regarding their awareness and responsibility to ensure continued function of these practices. Homeowners often change or otherwise redirect lot drainage to impervious surfaces, which undoes a lot of low impact design, benefits. Community education and involvement is integral if implementation of LID is to be effective.

1.6.3 Constructing biofiltration practices

The use of vegetative swales, buffer strips and rain gardens can provide a significant water quality benefit in addition to reducing the total volume of stormwater runoff. The primary processes involved in their performance are filtering of pollutants contained in stormwater runoff, evapotranspiration and infiltration of runoff into the ground.

Even with kerbs being needed to prevent traffic movement off of paved surfaces, kerb cuts or openings can be placed in the kerb to allow water to pass off the paved surface into a biofiltration practice. This would allow for both objectives (traffic control and stormwater) to be attained.

1.6.4 Water reuse

Using stormwater generated from roof areas or even from impervious surfaces for domestic or industrial purposes can reduce the total volume of stormwater being discharged, as water being reused will be separated from catchment stormwater delivery. Water reuse is potentially a very valuable tool in reducing stormwater runoff volumes and would have other beneficial effects such as reduced use of groundwater and reduced potable water needs.

Water Reuse at a Hospital Site

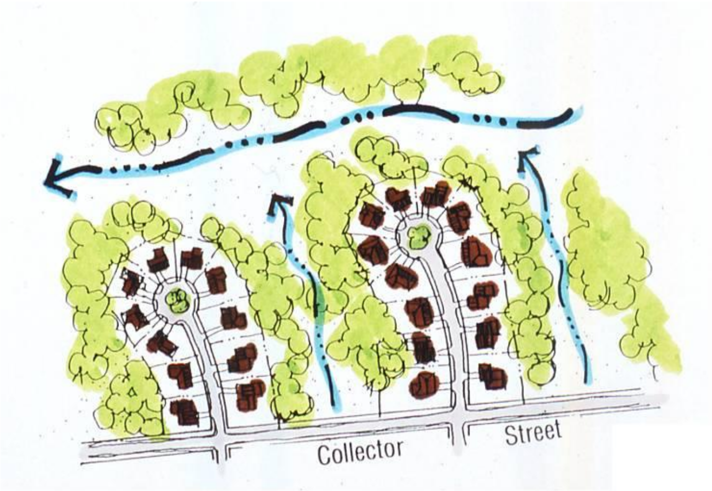
1.6.5 Creating natural areas

In many site development situations, the predevelopment condition may be pasture or other highly modified hydrological condition. Re-establishment of native bush as riparian cover, steep slope protection or general site revegetation as open space would have significant stormwater management benefits for both water quantity and water quality. The area, if well designed and constructed, could become an attractive amenity to a community and enhance the value of the properties.

1.6.6 Clustering development

How a site is developed and to what degree the entire site must be utilized will have a significant impact on sediments and stormwater runoff from the site. Conventional land development encourages sprawl, while other approaches to land development can provide significant sediment reduction during construction and post-construction stormwater benefits. Cluster development encourages smaller lots on a portion of a site, allowing the same site density, but leaving more site area in open space and disturbing less of the natural ground cover. Clustering entails designing residential neighbourhoods more compactly, with smaller lots for narrower single-family homes, as are found in traditional villages and small towns. Cluster development can provide for protection of site natural areas, while at the same time reducing total site imperviousness by reducing the areal extent of roads.

House Clustering Schematic for a Residential Subdivision



1.7 Catchment Wide Approaches

Catchment-wide considerations, from a broad perspective, are important and should be the context from which many resource-based land development decisions are made. This Guideline strongly supports catchment-based approaches to land use decisions and Section 6 focuses entirely on catchment-wide implementation of LID. This context is important from a number of perspectives.

- Catchment approaches allow for a recognition and consideration of where growth distribution should occur.
- Consideration of land use from a catchment perspective allows for a greater awareness of the cumulative impacts of catchment development. Impervious surfaces are important to consider if downstream areas are to be protected.
- A comprehensive approach to resource protection can be developed and implemented based on consideration of catchment specific issues such as steep slopes, erodible soils, existing bush retention, high water table, the need for aquifer recharge, etc.
- A catchment approach allows for developers and the general public to understand the basis by which land use decisions were made in a rational format that can be easily understood.

- Land use decisions based on catchment wide analyses provide the local authority a basis for making decisions that can be defended.

As desirable as catchment-wide approaches are, it must be recognized that significant "up front" resources and costs may be needed to accomplish these efforts. Depending on the goals of the effort, significant data needs may exist. From a long-term perspective, catchment approaches represent the most economical approach if resource protection is to be considered in conjunction with land development.

1.8 Organisation of Guidelines

The guideline is organised along the following chapters.

Section 1 - Introduction to LID

The context of LID is presented here along with a discussion of problems that occur from implementation of conventional development and conventional approaches to stormwater management. LID concepts are briefly discussed to familiarise the reader with information presented in later sections.

Section 2 - Importance of Water Cycle in Stormwater Management

Various aspects of the water budget are discussed. Rainfall and its relationship to site stormwater runoff are components of the water cycle. Data that relates to ecological response to urbanisation and that relationship to water quantity and quality are also presented. A final element mentioned is natural mechanisms for stormwater pollution removal.

Section 3 - Site Resources

Site resources will be discussed in terms of their inclusion as components of overall site design. This will include a discussion of ecology and landscape form, wetlands, floodplains, riparian buffers, forests, soils, steep slopes, and other natural features. Consideration of these site components may have a significant impact on reducing adverse stormwater related impacts.

Section 4 - Low Impact Design Approach

A low impact design approach will be presented that considers an array of nonstructural low impact techniques. These techniques include: reduction of site imperviousness, use of swales appropriately, reduction in use of kerbing, clustering to reduce site disturbance and imperviousness, lengthening stormwater flow paths, preservation and enhancement of native bush, and other concepts.

Section 5 - Detailed Design Procedures

A design procedure is provided for minimising adverse impacts related to earthworks during construction and minimising impacts on a long-term basis relating to permanent stormwater management. Checklists are provided to assist in site design.

Section 6 - Catchment -wide considerations

The concept of approaching LID from a catchment-wide perspective is presented in this Section to demonstrate that approaching resource protection from a catchment perspective is the most effective way to consider it. Issues such as fitting development to the land, avoidance of development on steep slopes or in wetlands, setting target densities and consideration of stormwater impacts on receiving systems are integral elements in consideration of development potential in a sustainable context.