# CLIMATE CHANGE ADAPTATION TOOLKIT

## uMgungundlovu District Municipality

uMngeni Resilience Project

2019

The uMngeni Resilience Project is funded by the Adaptation Fund. The uMgungundlovu District Municipality (uMDM) is the Executing Entity responsible for overall project implementation, working with the University of KwaZulu-Natal's School for Agriculture, Earth and Environmental Sciences (UKZN SAEES) who are the Sub Executing Entity. The South African National Biodiversity Institute (SANBI) is the National Implementing Entity responsible for project oversight in partnership with the Department of Environmental Affairs (DEA).

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| | |
|---|---|
| CC | Climate Change |
| CEB | Compressed Earth Block |
| cm | Centimetres |
| COGTA | Department of Cooperative Governance and Traditional Affairs |
| CSIR | Council for Scientific and Industrial Research |
| DPC | Damp Proof Course |
| KZN | KwaZulu-Natal |
| LPS | Lightning Protection System |
| mm | millimetres |
| SANS | South Africa National Standard |
| SuDS | Sustainable Urban Drainage Systems |
| uMDM | uMgungundlovu District Municipality |
| WSA | Water Services Authority |
| WSUD | Water Sensitive Urban Design |

# ICON KEY


Definitions


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Useful references


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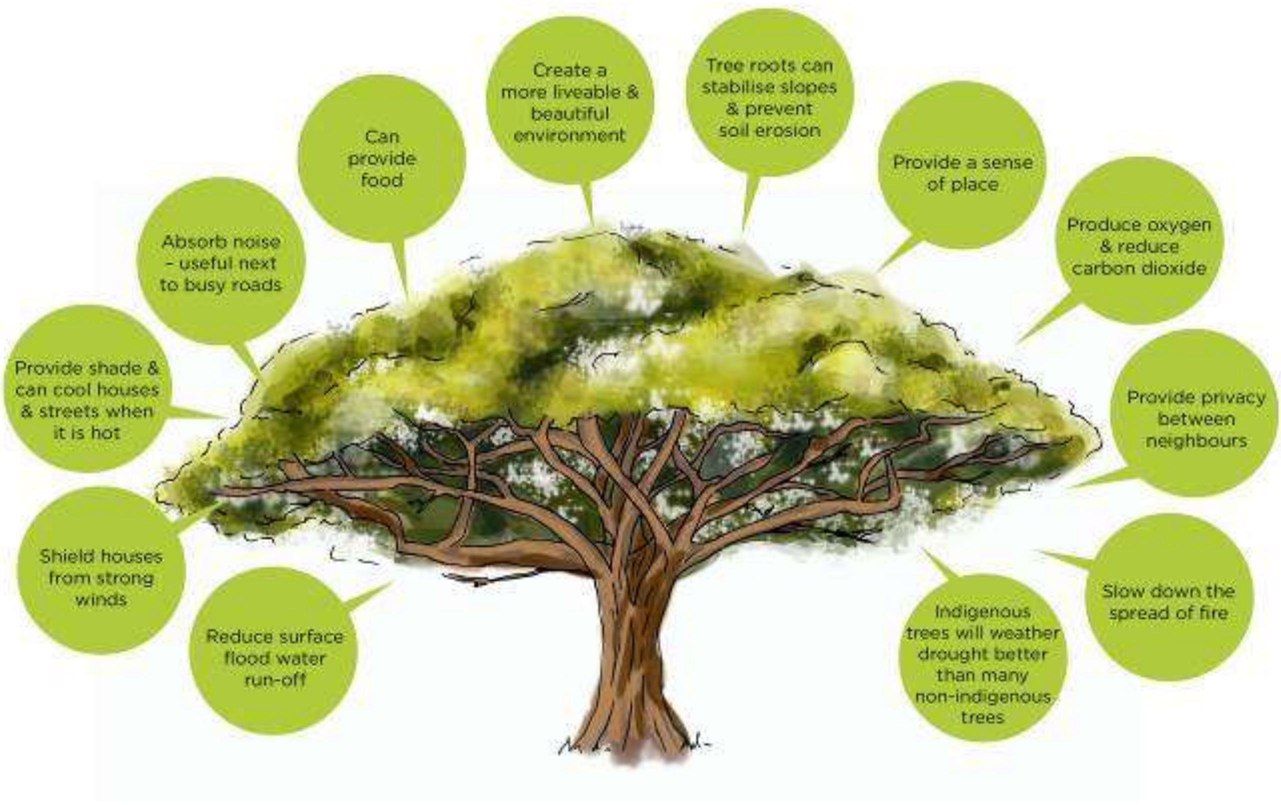
# OBJECTIVES OF THIS TOOLKIT

This toolkit exists to help decision makers be **proactive** rather than **reactive** in their responses to the impacts of climate change on communities in the uMDM. Climate change adaptation is vital to the development goals of South Africa and the uMDM. Reducing the vulnerability of communities will ultimately lead to more sustained benefits of development work and efforts to reduce poverty.

The built environment has a long lifespan – the layout and design decisions that we make now will have an impact for the next 50 years and longer. Adaptation measures need to take into account the problems of today plus those that are likely to arise in the near future. Many KZN villages and settlements do not have sufficient infrastructure to assist with climate change variability.

Changing how we plan and build our houses, villages, settlements, neighbourhoods and even cities allows us an opportunity to rethink how we want our residential areas to be. This is an opportunity to make residential areas more liveable and safer and enhance people's quality of life in them while also increasing their ability to withstand the burdens of climate change.

Many of the adaptation strategies proposed in this guideline can give multiple benefits. For example, planting indigenous plants both increases biodiversity and reduces flood risks. It also creates a more liveable neighbourhood.




BENEFITS OF PLANTING INDIGENOUS TREES


# CHAPTER 1

## General climate science and responses

uMgungundlovu Climate Change Adaptation Toolkit

# CHAPTER 1: GENERAL CLIMATE CHANGE SCIENCE AND RESPONSES

## WHAT IS CLIMATE CHANGE?

Climate change is caused by the **enhanced** **greenhouse effect**. The greenhouse effect works like this: Sunlight passes through the atmosphere and warms the earth's surface. The heat is radiated back towards space, but much of it (about 90 %!) is absorbed by greenhouse gases and radiated back towards the earth's surface. This natural process makes life on earth possible. As more greenhouse gases enter the atmosphere, this effect is enhanced, which leads to climate change. Gases contributing to the greenhouse effect (i.e. greenhouse gases) include carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane ($CH_4$), and water vapour ($H_2O$).

The **greenhouse effect** is a natural process in which heat that is radiated towards space is absorbed by greenhouse gases in the atmosphere. This effect helps maintain the earth's surface at a temperature that supports life on earth.

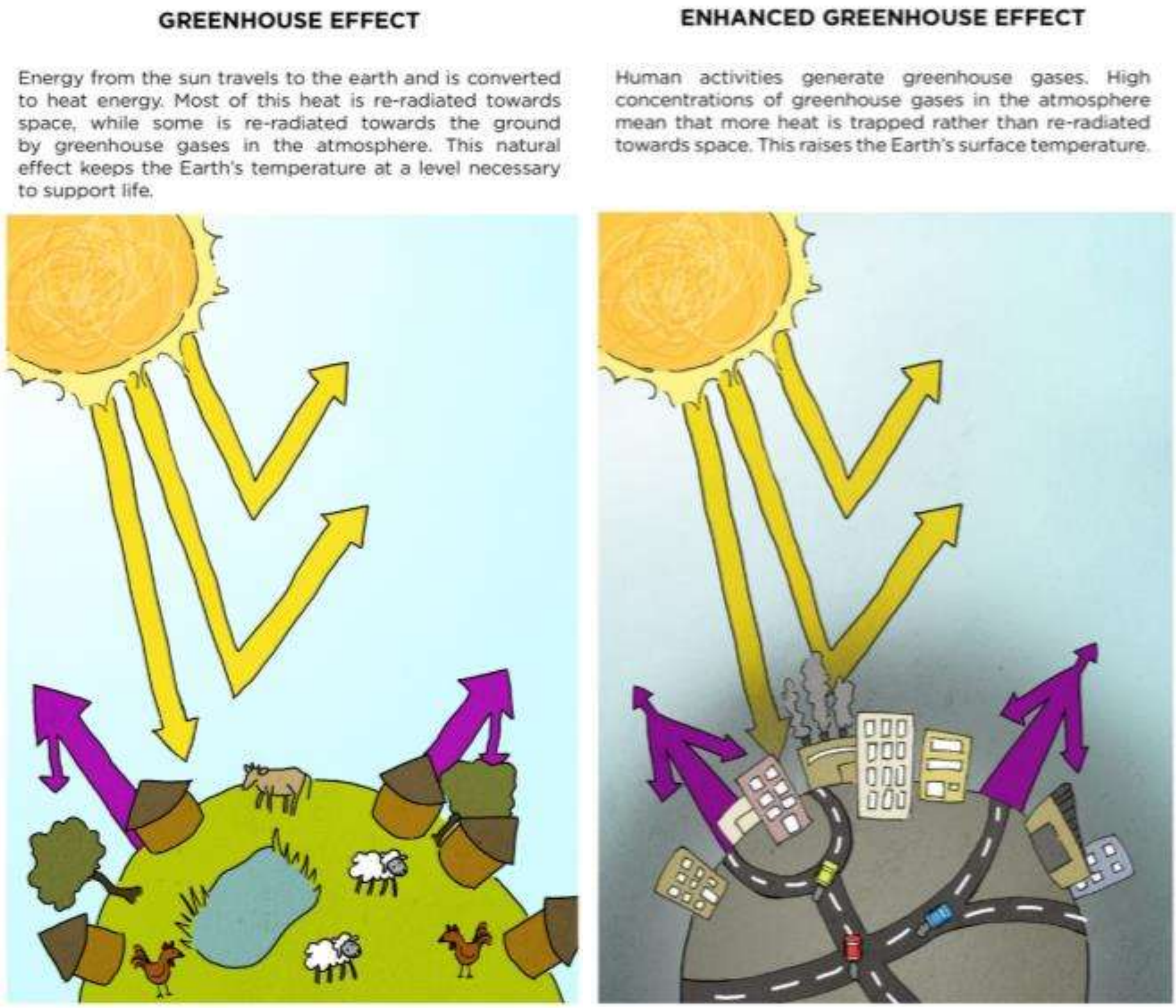



FIGURE 1-1: CLIMATE CHANGE AND THE ENHANCED GREENHOUSE EFFECT

The burning of fossil fuels like coal and oil has increased the concentration of carbon dioxide in the atmosphere. Other activities contributing to the increased concentrations of greenhouse gases in the atmosphere include deforestation to accommodate development and agriculture and unsustainable farming practices (e.g. factory farming of beef cattle). In the uMDM context, large contributors include burning of coal at power stations to generate electricity and emissions from cars, trucks, and taxis that use petrol or diesel. All of these activities are increasing the greenhouse effect which means that more heat is trapped in the earth's lower atmosphere.

According to the South African Weather Service, climate models currently predict that the average air temperature over South Africa will increase by approximately 2°C over the next century. But what does an increase in atmospheric temperature actually mean for human and animal life? The increase in atmospheric temperature impacts on global weather systems. In some areas, this will lead to extreme increases in temperatures and more extreme heat waves. Some areas will experience more rain, while others will experience extended periods of drought. Other areas will experience a combination of all these variations so these "abnormal" weather patterns will become the new normal. This will also lead to a rising sea level which will impact the villages, towns and cities along South Africa's coast. More extreme weather events (e.g. hurricanes) are to be expected.

During a 2014 Climate Change Summit in iLembe District Municipality, Mr Sibongiseni Ngema of the KZN Department of Cooperative Governance described the way in which weather-related disaster incidences will increase as a result of climate change. At the time, more than 90 percent of disaster incidences in KZN were weather-related and this would only increase in coming years. Ngema reported that the cost of dealing with disasters in KZN in 2011/2012 was R1.2 billion.

FROM 2009 TO 2014, KZN COGTA SPENT MORE THAN R7 BILLION ON CLIMATE-RELATED DISASTERS. DURING THAT PERIOD, KZN COGTA RESPONDED TO **1,241 INCIDENTS INVOLVING HEAVY RAINS AND 3,001 FIRES**, WHICH WERE EXACERBATED BY DRY AND HOT CONDITIONS.

COGTA administers the *disaster relief grant* to provide for immediate relief as and when disasters occur. Allocations to this grant have increased significantly, from R118.1 million in 2016/17 to R423.7 million in 2017/18.

These statistics show that climate change is already happening and causing significant damage. We need to take action now to slow this process down.

Read the full article here: https://www.iol.co.za/news/south-africa/kwazulu-natal/expect-more-weather-disasters-1699343

# WHAT CAN WE DO ABOUT IT?

## MITIGATION

**Mitigation** aims to reduce the rate and magnitude of climate change by reducing the emissions of greenhouse gases to the atmosphere. Mitigation can be accomplished by reducing the sources of GHGs or by enhancing natural features that can store these gases, "sinks" (such as oceans, forests, and soil). These activities might include developing public transport systems that will reduce greenhouse gas emissions from cars; developing "clean" energy options, such as solar, wind, or hydropower; establishing forests that can act as sinks; and regulating emissions from industrial operations through legislation. South Africa's National Development Plan acknowledges that alleviating poverty and protecting the environment are closely related, suggesting that environmental policies should not be framed as an either growth or climate change mitigation option.

**Mitigation** aims to reduce the rate and magnitude of climate change by reducing the emissions of greenhouse gases to the atmosphere.

*But climate change is already happening. Even if we mitigate **all** greenhouse gas emissions immediately, present and future generations will experience the effects of climate change.*

## ADAPTATION

**Adaptation** involves changing the way we do things because of the changing climate. It acknowledges that climate change impacts will happen even if we pursue the best mitigation efforts. Thus, adaptation involves taking steps to reduce vulnerability to the harmful effects of climate change. Poor rural communities have contributed the least to the climate change problem, but unfortunately, they are the most vulnerable to its effects. The overarching goal of a climate change strategy should be to: "create sustainable livelihoods that are resilient to the shocks and stresses caused by climate change and do not adversely affect the environment for present and future generations," as is stated in the *Climate Change Adaptation Sector Strategy for Rural Human Settlements* (DRDLR, 2013).

**Adaptation** acknowledges that climate change impacts will happen and therefore aim to change the way things are done to respond to the changing climate.

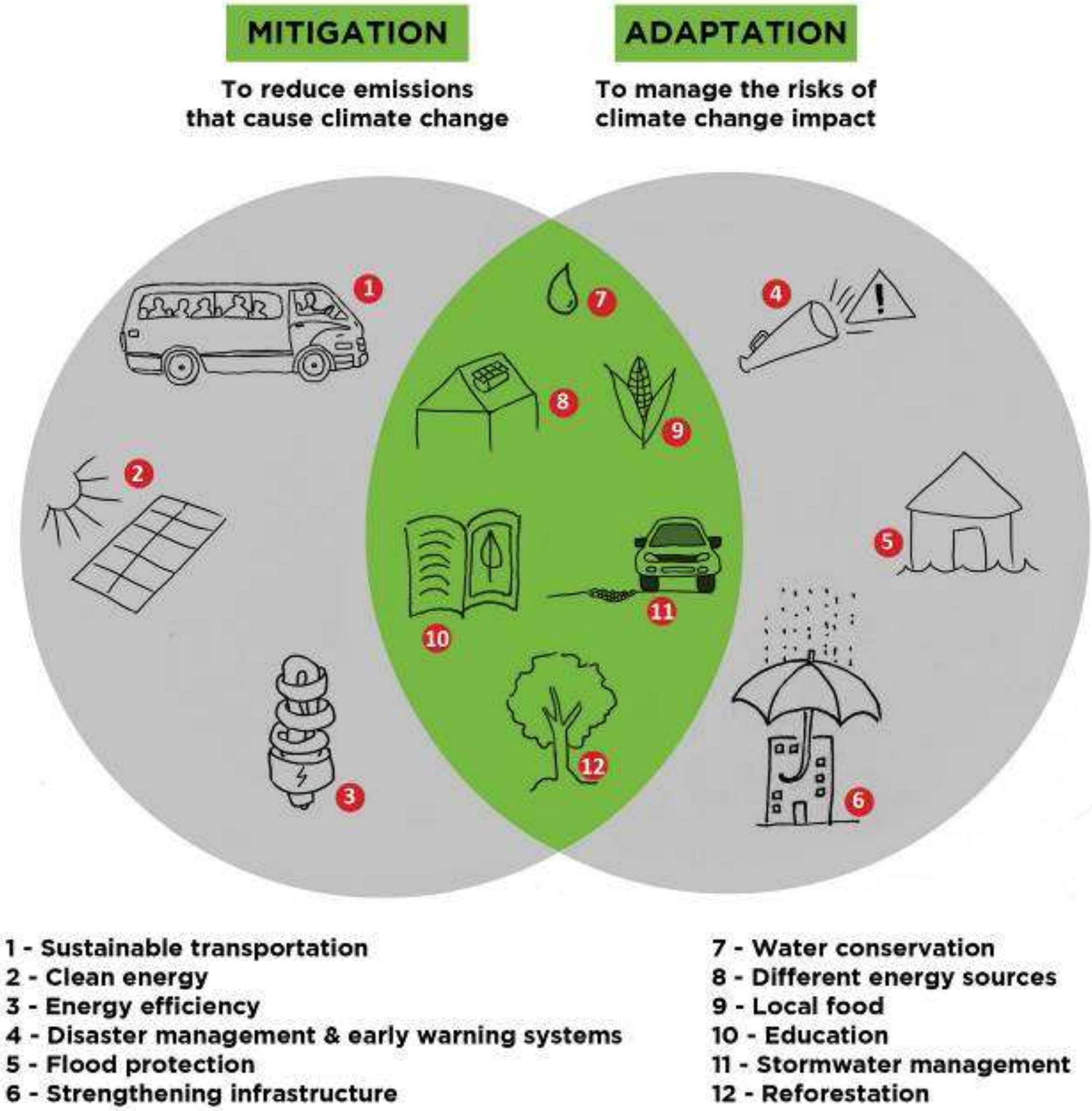
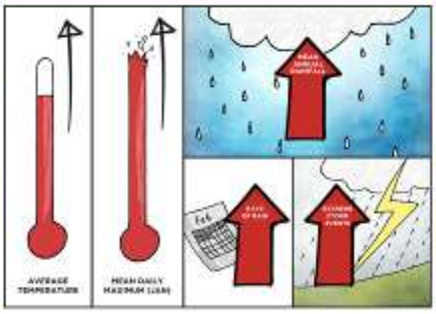



**FIGURE 1-2: WHAT CAN WE DO TO BUILD RESILIENCY IN THE FACE OF CLIMATE CHANGE?**

*CITIES ARE INCREASINGLY EXPECTED TO TAKE CONCRETE ACTIONS TO ADAPT TO RISKS ASSOCIATED WITH RISING SEA LEVELS, FLOODS, DROUGHTS AND OTHER NATURAL HAZARDS THAT ARE EXACERBATED BY CLIMATE CHANGE AND CLIMATE VARIABILITY SUCH AS DESERTIFICATION. REDUCING THE RISK OF DISASTERS HELPS TO PROTECT DEVELOPMENT INVESTMENTS AND ENABLES SOCIETIES TO ACCUMULATE WEALTH, IN SPITE OF THE HAZARDS THEY FACE.*

– Minister of COGTA, Dr Zweli Mkhize, 2018 International Day for Disaster Risk Reduction

# CHAPTER 2



# Key concerns for uMgungundlovu DM

uMgungundlovu Climate Change Adaptation Toolkit

# CHAPTER 2: KEY CONCERNS FOR uMDM

The main disaster risks that are likely to affect human health in the uMgungundlovu District Municipality are floods, severe storms, wild fires, drought and lightning (Cox et al., 2017). While the impacts of climate change cannot be precisely determined, some general trends for the District are presented in the *uMgungundlovu District Municipality Climate Change Response Strategy and Plan*, and these are shown in Figure 2-1. Overall uMDM will experience increased maximum and minimum temperatures; increased annual rainfall and daily maximum rainfall; increased extreme events; and increased lightning strikes. These will highlight existing vulnerabilities to severe storms, floods, and wildland fires. Within the District the effects of climate change will vary – some local municipalities such as Mpofana and Impendle will experience more rainfall and flash floods while others such as Mkhambathini will experience drought more frequently (Golder Associates, 2013). **All of these risks are already present in uMgungundlovu, so finding solutions to them is important! With the impacts of climate change, it just means that finding solutions is even more urgent than it may have previously seemed.**

Areas and populations that are most at risk from the predicted climate change impacts include: informal dwellings; dwellings located close to rivers and the coast; areas of high population density; traditional dwellings; areas with under-resourced fire stations and disaster management systems; and areas with poor land-use management practices (Golder Associates, 2013).

The main disaster risks that are likely to affect human health in the uMDM are **floods, severe storms, wild fires, drought and lightning**.

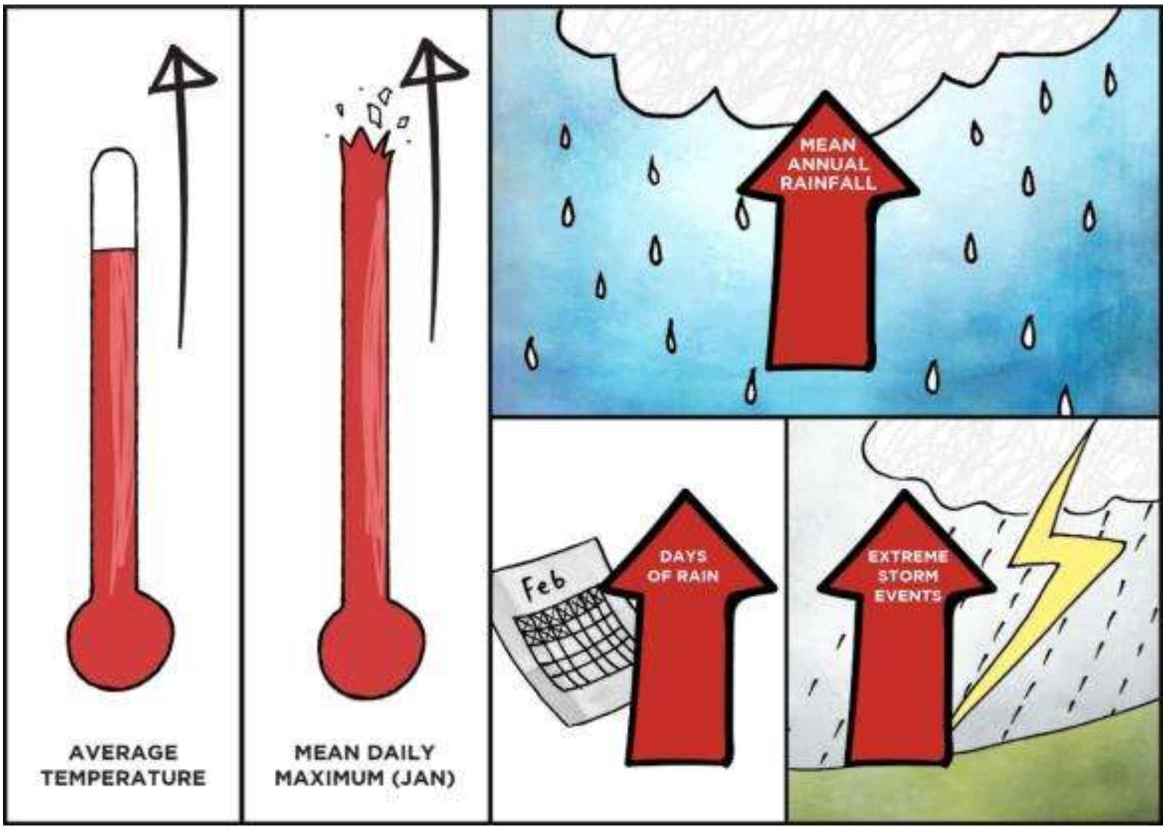



FIGURE 2-1: PROJECTED CLIMATE CHANGE IMPACTS IN uMDM (GOLDER ASSOCIATES, 2013)

**Box 2-1: Key concerns relating to climate change from uMDM officials**

*Climate change issues must be integrated in all **planning policies** and **frameworks**.*

– Planning Official

*A need to plan for **adaptation strategies** and [create] **resilient communities**.*

– Planning Official

*[Climate change] has an impact on planning for **future developments** and **land use management** in terms of deciding the **appropriate location** for developments.*

– Planning Official

*Inasmuch as we focus more on infrastructural development, the key to sustainable water services provision is our water services (surface and underground). Drought causes reduction of surface water and underground water and **the quantity of potable water** supplied to the communities. [This results] in **poor revenue collection**, affecting the **water services business**. [This can also cause] **social instability** due to water demand…**Floods transport pollutants** from the upper parts [of the catchment] downstream. [This overloads] the treatment works [with pollutants].*

– WSA Official

*I think we will need to **refurbish our infrastructure** and **review our policies**.*

– WSA Official

*Environmental health is concerned with the relationship between the environment and the health of the people. **Negative changes in the environment negatively affect the health of the people**…[issues include]: the availability of **safe and clean water**; possible **increase in disease** vectors thereby increasing risk of communicable disease; **air quality** impacted upon through dust and wildfires; **food safety** issues…; **heat stroke** from increased temperatures.*

–Environmental Health Official

Due to drought, floods… **performance of treatment plants** will be affected and **drinking water quality** will not be able to meet drinking water quality standards…there will **not be enough water supply**. Sometimes, the abstraction pumps will be submerged with water in a flood.

–Technical Services Official

## Extreme storms

In general, the number of **extreme storm events** will increase as a result of climate change. An extreme storm event can include any combination of heavy rainfall, extensive lightning, and high wind speeds. Risks associated with extreme storms include:

1. High volumes of stormwater, which, if not properly managed, can cause flooding and erosion
2. Flooding of infrastructure
3. Loss of roofs due to high wind speeds
4. Pollution of water courses due to high volumes of stormwater as well as erosion, poor solid waste management, and others
5. Damage to infrastructure as a result of lightning
6. Wildfires resulting from lightning

***What is an extreme storm event?***

An extreme storm event is an event that is rare for a given location. With climate change, the magnitude and frequency of these rare events is likely to increase. Events that would have been considered extreme in the past may become more and more normal due to climate change impacts.

## Soil erosion

**Erosion** naturally results from the impact of wind and water, and it is made worse when the soil cover is disturbed by infrastructure such as roads and buildings. By some estimates human activities can increase the rate of erosion by between **10 to 40 times** (LandCare). Climate change has the potential to accelerate erosion through an increase in the frequency and severity of storms.

Humans have already increased erosion through the reduction of vegetated areas, the introduction of hard, impermeable surfaces and over grazing (which reduces vegetative cover and creates unstable soils). When erosion takes place, the topsoil is lost, which makes land unsuitable for new vegetation. This causes desertification, decreases in agricultural productivity, sedimentation of water ways, and ecological collapse due to the loss of nutrient-rich topsoil.

***Erosion** is the process by which soil and rock are removed from the earth's surface by exogenic processes such as wind or water flow and transported and deposited in another location.*
(LandCare)

## FLOODING

Flooding of rivers and streams presents a risk in terms of loss of life, loss of property, and loss of access to essential services. The risk of floods mainly concerns people living in the vicinity of rivers and especially those living within the 1:100 year floodplain. The impact of floods is worse in the case of informal or traditional buildings, where low-grade building materials, such as mud, leave the structure vulnerable to failure in the case of a flood (Department of Environment and Natural Resources, 2010). In addition to impacting infrastructure directly in the floodplain, floods impact people's access to their homes and community services. Where river crossings are damaged by the force from a flooded river, access to services could be cut off for far longer than the duration of the flood, which could cause many more problems.

***Floods** account for two thirds of natural disaster-related deaths, with an average of 84 deaths per annum in South Africa.*
(Kahn, 2003, cited by Botes, 2014)

## STEEP SLOPES

Communities located on steep slopes are at risk for a number of reasons. On a day-to-day basis, steep slopes make access difficult, both by car and on foot. In many settlements, not enough consideration has been given to providing access to households by way of established pathways and staircases. In addition, if paths are provided without enough consideration being given to stormwater runoff, the paths can make erosion worse. During storm events, steep bare slopes result in water moving at very high speeds, and water moving at high speeds can cause damage to property and increased erosion. Access issues are also made worse by storm conditions, as any roads that do exist become muddy and difficult to travel on without a 4x4 vehicle, and paths can become slippery and muddy. Furthermore, excessively steep slopes affect the elderly and those with physical ailments disproportionately in terms of accessing their homes and services.

## Fire risk

Fire is a necessary and regular occurrence on the planet. Wildfires are started by lightning or human activities, and controlled fires are used to manage farmlands and pasture. Fires can lead to safety risks, including poor air quality and degraded **ecosystems**. However, fires are also useful in clearing away dead and dying underbrush, which can make ecosystems healthier. While controlled fires can be used as part of good ecosystem management, wildfires can easily grow out of control and lead to loss of life and property. Nearly the entire uMDM is at extreme risk of veld fire, and that risk is likely to increase with the climate change impacts of increased temperatures, drier conditions, and lightning strikes associated with intense storms. **In the uMDM, wildfires are most common after dry winters, when temperatures begin rising and summer rains have not yet arrived.** Dry conditions and high temperatures create ideal conditions for fire. Once storms begin, lightning can pose a further fire risk. Where invasive alien plants have taken over an area, they provide more fuel for fires that begin to spread, making fires more intense.

The most obvious impact of fire on humans is loss of life, injury, and loss of property. Even if some communities avoid these direct impacts of fires, wildfire can lead to entire communities being cut off from city centres and essential services. Wind can also carry wildfire smoke far beyond the boundaries of wildfires themselves, resulting in public health impacts over a wider area, particularly for those who struggle with respiratory problems, such as asthma.

An **ecosystem** is made up of living things and the environment, interacting and depending on one another.

**Nearly the entire uMDM is at extreme risk of veld fire.** (Department of Agriculture, Forestry, and Fisheries, 2010 as cited in uMgungundlovu District Municipality Climate Change Adaptation Summary Report, 2017)

Wildfires are most common in the uMDM after dry winters, when temperatures begin rising and summer rains have not yet arrived.

## High winds

High winds associated with extreme storms can impact household and community infrastructure and environments. Winds in dry areas can create the perfect environment for wildfires to start and spread. High winds can also contribute to the transport of smoke from wildfires. High winds can lead to other public health issues related to allergies and transport of air pollutants from urban centres to peri-urban or rural areas. At the household level, particularly where homes have been inadequately constructed, winds can lead to damage. This is especially true when roofs are improperly secured. Where roofs are not attached to the structure properly, households resort to setting heavy objects on top of roofs to hold them down. This presents a safety risk, should those items be dislodged from the roof.

Figure 2-2: A roof in Nhlazuka held down by blocks

## WATER QUALITY AND QUANTITY

*Water is the primary medium through which the impact of climate change will be felt by people in South Africa*

(National Water Resource Strategy, "Chapter 10: Managing water resources for Climate Change," 2013).

Through drought, reduced runoff, increased evaporation, and an increase in flood events, climate change will affect both the **quantity** and **quality** of water resources in the area of the uMgungundlovu District Municipality (*uMgungundlovu District Municipality Climate Change Adaptation Summary Report*, 2017).

The impact of drier conditions will be felt both in the household and in the agriculture sector. Given the increased temperatures, greater volumes of water will be lost to evaporation, and given the relative increase in extreme storm events as opposed to consistent rains, storage of runoff will become more difficult. Coping with the impacts of drought requires strategies for managing water effectively and diversifying water supplies.

**Silt** is comprised of clay and soil particles which are eroded from the surface of the land during storms and transported by streams and rivers. Where the stream or rivers slow down due to a change in the slope of the water course, the silt is deposited. This process of deposition is called siltation. While erosion and siltation are natural processes that happen in even pristine catchments, if a catchment is badly degraded due to human impacts the rate of erosion can be accelerated by 10 or even a 100 times.

Increased erosion associated with larger storms will result in increased **silt** loads in rivers and siltation of dams. In the same way, the impacts of poor solid waste management will be felt in terms of water quality, as more rubbish and/or organic waste can be washed into surface water resources. This will have a direct impact on the treatment requirements for surface water that is intended for potable use. Because South Africa is already a water-scarce country, pollution of freshwater sources should be avoided as much as possible.

## UNDER-PROVISION OF INFRASTRUCTURE

Areas that do not have sufficient infrastructure, such as well-surfaced roads, stormwater drainage systems, water supply and electricity are more vulnerable to the risks of climate change. This is often the case in lower income areas, which themselves are also more vulnerable.

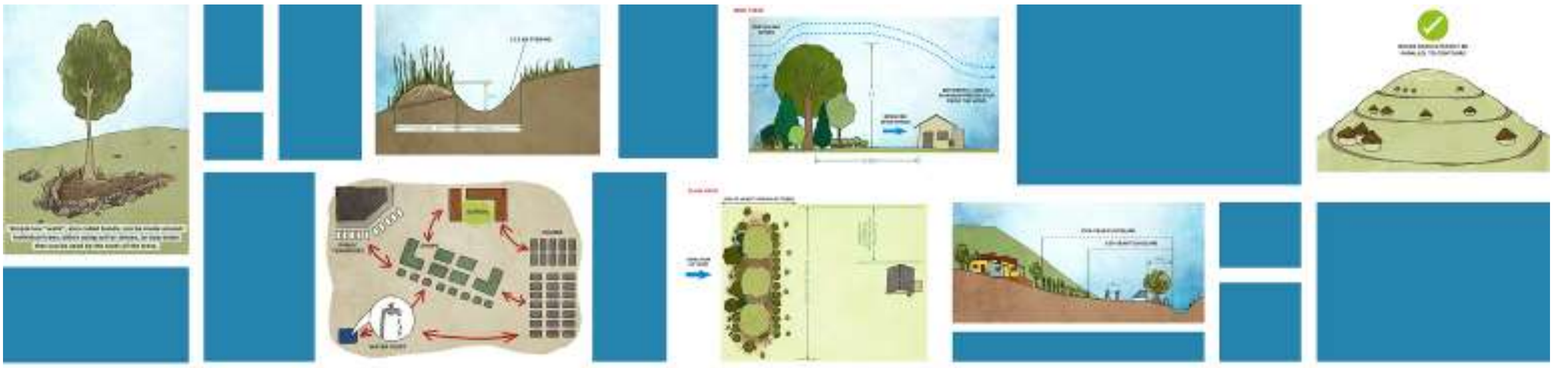
## POOR LAND USE MANAGEMENT AND OVERGRAZING

Poor land use management can lead to houses and other structures being built in areas that are vulnerable to the effects of climate change. Houses built on unstable soils or in low-lying areas are more vulnerable to the extreme weather associated with climate change. Areas that are vulnerable to flooding, such as within the floodplain, are often not developed and simply left alone. While development should not take place in these areas, leaving them unmanaged often leads to the growth of informal settlements. With poorly constructed houses, these settlements are extremely vulnerable to climate change impacts.

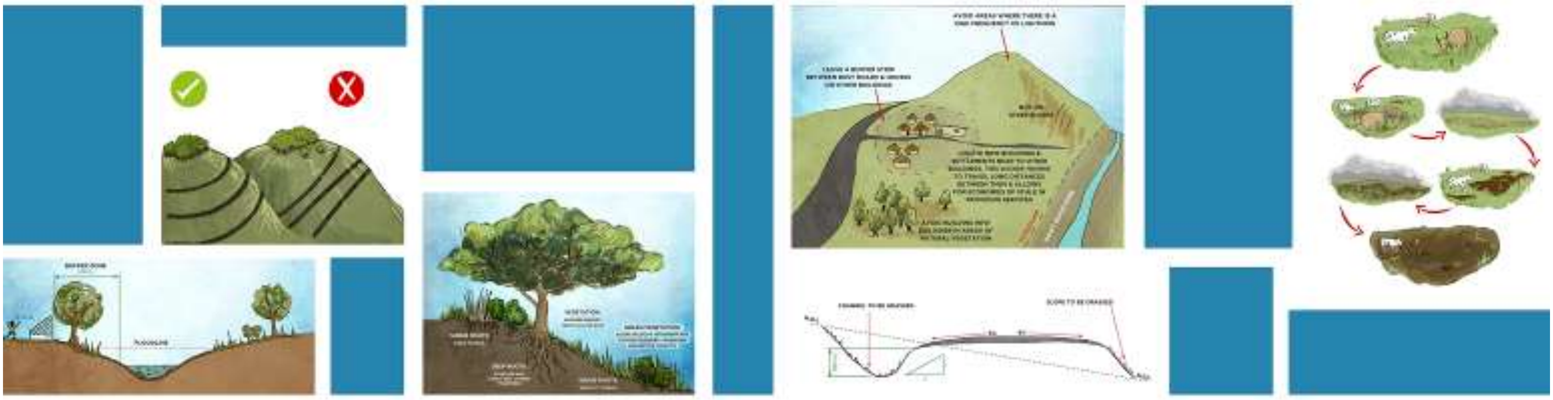
Overgrazing can lead to infertile and unstable soils, which can jeopardise infrastructure integrity and agricultural productivity. Overgrazing leads to barren soils, which are vulnerable to erosion by wind and/or runoff. Once fertile topsoil is removed, it is near impossible for new vegetation to grow. This makes erosion more likely and can lead to hungry livestock. When houses are located in these areas, their foundations can be weakened due to weakened soil structure.

**BOX 2-2: EDUCATE AND INFORM**

- ✓ People and communities who are better educated and have secure tenure are able to deal more effectively with a wide range of shocks and stresses.
- ✓ There is a need for greater sharing of information for extreme weather events – early warnings, disaster preparedness and information about evacuation strategies.
- ✓ Identify areas that are not suitable for housing and consider zoning these for no housing. Educate the community about the risks of locating housing in these areas.
- ✓ Help people to understand and know the risks through assessing existing areas and structures and ensuring that those responsible for them are aware of the risks and how to mitigate them
- ✓ Provide information on the possible impacts of extreme events
- ✓ When educating, try to understand the main motivating factors for community members and identify risks to their motivators. For instance, in farming communities, a sustained food supply for cattle might be a greater motivator against overgrazing than simply preventing erosion and siltation of surface water.



# CHAPTER 3



# Village Resilience

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# CHAPTER 3: VILLAGE RESILIENCE

In an ideal world, human settlements should be pro-actively planned and located. However, there are some instances where this does not happen. Many informal settlements are established on pieces of land that are the only remaining open land in already developed areas. Some of this land may be on steep slopes, in river flood zones or on land with geological problems. Shack settlements can also grow on land that is far from urban opportunities as it is more easily occupied than more central land. These factors mean that informal dwellers are often located on the most poorly situated land, not out of choice, but necessity.

Together with the temporary nature of construction of many newer informal settlements, this makes informal dwellers highly vulnerable to the impacts of climate change. Shacks are often not strong enough to withstand strong storms or flooding water. Flammable building materials and the high density of many shack settlements make them more vulnerable to fire.

This vulnerability means that planners and traditional authorities, Amakhosi and Izinduna, responsible for identifying or allocating land for residential purposes must be aware of these risks and must take them into consideration. Training for adapting to the impacts of climate change must therefore be focussed on traditional authorities, land use planners and housing officials.

# Overview of village-level risks and vulnerabilities

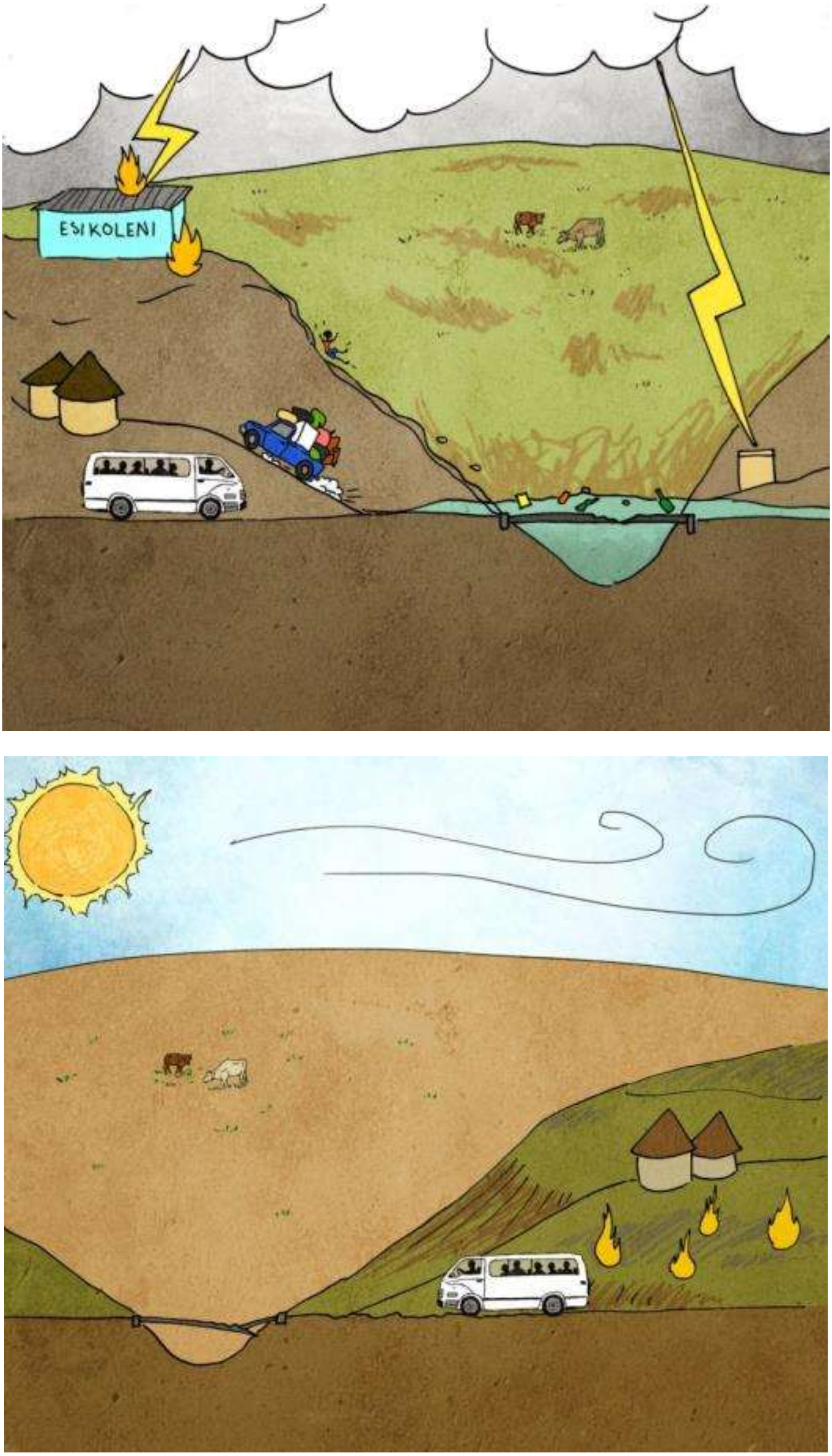



**Figure 3-1: Community level risks and vulnerabilities during the rainy season (top) and the dry season (bottom)**

> "Human activities have increased erosion by **10 to 40 times** the rate at which erosion is occurring globally."
>
> (LandCare, DAFF)

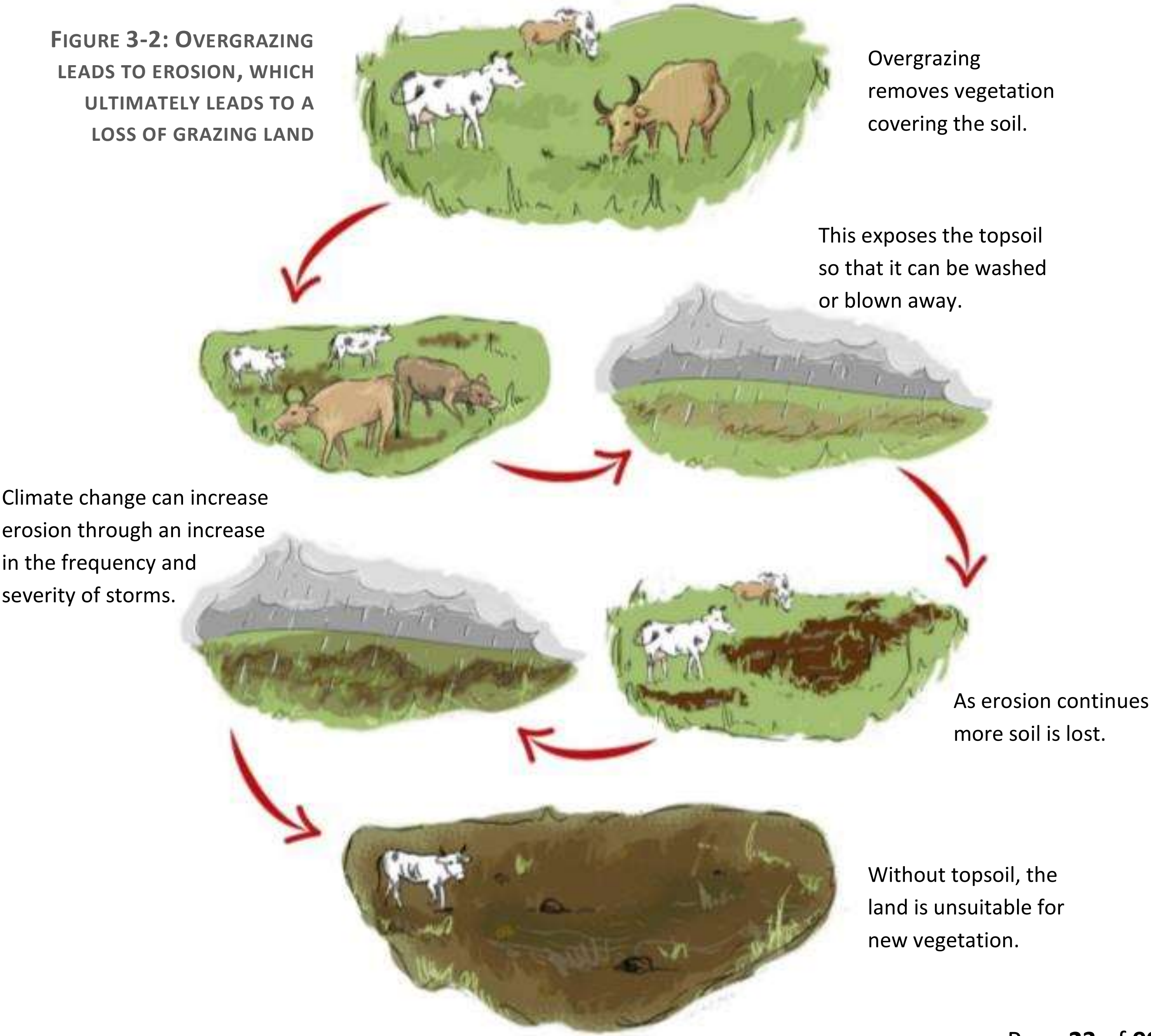
## Storm Damage

Increased storm intensity has the potential to cause excessive damage to community infrastructure. This is particularly true with the densification of settlements, which increases the number of hard surfaces like roads, pavement, and roofs. Hard surfaces do not allow for rainwater to seep into the ground, leading to higher volumes and rates of water running off and along surfaces. In addition to direct impacts of storms, such as heavy winds and heavy rainfall, uncontrolled runoff can cause damage to roads and property and endanger people through erosion and flooding.

## Erosion

Erosion is caused by a mix of unmanaged stormwater runoff, poor protection of banks formed by cut and fill, and overgrazing. Excessive erosion can cause desertification, decreases in agricultural productivity due to land degradation, sedimentation of water ways, and ecological collapse due to the loss of nutrient-rich topsoil. Thus, erosion can ultimately lead to a loss of grazing land.

**Figure 3-2: Overgrazing leads to erosion, which ultimately leads to a loss of grazing land**



## FLOODS

Flooding often cuts off access. In poor communities it can also lead to unhealthy living conditions, as people are left without shelter, waterborne sewage systems become flooded, and standing water becomes a breeding area for mosquitoes and other insects, which can result in **vector-borne diseases**. In times of heavy rain or rain that persists over a number of days, if drainage systems are not able to cope with the amount of water, water will build up and cause flood damage to houses and other infrastructure. Flood water can also overload sewerage systems, causing sewage to seep out. This presents a health danger. If drinking water becomes polluted due to stagnant water remaining in settlements, it can result in **waterborne diseases** such as cholera, dysentery and other diarrhoeal disease.

**Vector-borne diseases** are illnesses caused by parasites, viruses and bacteria that are transmitted by vectors, such as mosquitoes, ticks, blackflies, tsetse flies, and others.

**Waterborne diseases** are illnesses caused by microorganisms in untreated or contaminated water, such as cholera, dysentery, or other diarrhoeal diseases.

## FIRE

Increased dry spells and strong winds mean that fires can spread rapidly through a settlement, endangering life and property. The spread of alien invasive plants provides more fuel for fires, which can lead to wildfires that burn longer and more intensely. Particularly in rural, isolated areas, access to communities in the case of fire can be limited, which will increase the extent of destruction due to the inability of firefighting teams to reach the area timeously.

## SLOPES

Settlements built on steep slopes are more difficult to access, for both vehicles and pedestrians. In the case of emergencies as well as day-to-day life, steep slopes can make it difficult for people to access their houses and basic services. Steep slopes also increase the cost of building houses, and increase the potential for soil erosion.

## WIND

Strong wind can destroy buildings and is especially dangerous where there are informal structures, where building materials can fly off and cause other damage and injuries. Strong winds can also increase risk of wildfires during hot and dry periods. Once wildfires start, wind can be a catalyst in spreading the fire far from its starting point.

## LIGHTNING

Lighting associated with extreme storms poses a fire risk. In traditional communities where thatch roofing is common, there is potential for building fires following lightning strikes. Lightning can also pose a risk to essential community infrastructure, such as water pumps. In the event of lightning strike, the entire pump will need to be replaced, which can be a very long process due to cost implications. This experience was shared by one representative of the Water Services Authority.

# TECHNICAL CONSIDERATIONS FOR BUILDING RESILIENCE AT THE VILLAGE LEVEL

## GENERAL GUIDANCE ON WHERE TO SITE SETTLEMENTS

Generally, it is better to locate residential areas closer to:

- ✓ Access roads and transport
- ✓ Existing facilities – schools, police stations, health facilities
- ✓ Existing settlements. It is better to have clusters of settlements, rather than have settlements spread out – as this makes it easier to provide services

This should be done whilst avoiding risk areas such as:

- × Areas that could become flooded in times of heavy rain
- × Slopes that are too steep
- × Areas which are known to have a lot of lightning
- × Areas with shallow rainwater

When situating new housing, protect the following types of areas:

- ∗ Wetlands and areas of natural indigenous vegetation
- ∗ Areas for farming and hunting
- ∗ Areas for communal use and recreation, such as central play areas, meeting spaces

The National Water Act (No 36 of 1998) specifies that "no person may establish a township unless the layout plan shows, in a form acceptable to the local authority concerned, lines indicating the maximum level likely to be reached by floodwaters on average once in every 100 years" (NWA, Section 144).

Houses, small buildings, and local access roads should ideally not be developed on slopes steeper than 1:10. Larger developments (such as administrative complexes and community halls) should be developed on land where the slope is flatter than 1:10 (ideally 1:20). If areas steeper than 1:10 must be developed, terracing is required (requiring extensive earthworks), as well as retaining walls to reduce erosion potential. These areas will also require extensive provision of drainage.

**Slope** is defined as the rise or fall of the land surface. It is often described by the change in elevation over a specified horizontal distance. In other words, slope is rise:run. So, describing a slope as 1:10 means that over a 10-metre horizontal distance, the elevation of the site changes by 1 metre.

### FLATTER THAN 1:20

Suitable for large developments (shopping centres, offices, flats), parking areas, and sports fields. Remember that ground that is too flat may not drain well.

### SLOPE BETWEEN 1:20 AND 1:10

Suitable for buildings and roads that don't require major earthworks.

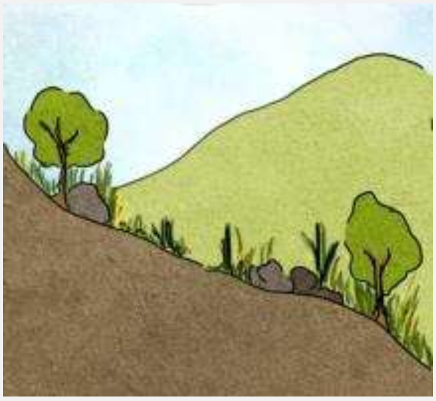
### SLOPE BETWEEN 1:10 AND 1:6

Suitable for smaller buildings, houses, and local access roads. Some terracing and earthworks may be needed, which will increase costs.

### SLOPE BETWEEN 1:6 AND 1:4

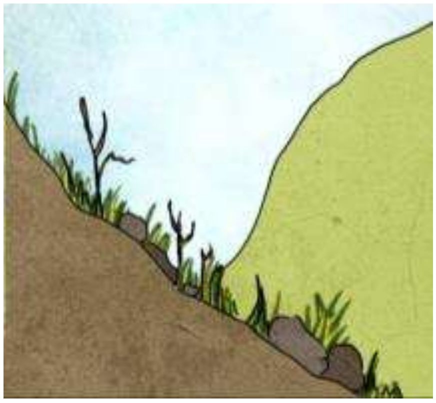
Terracing and retaining structures will be needed for development here. This makes is costly to develop, and road access can be especially difficult. Special attention needs to be paid to drainage from developed sites.

### SLOPE BETWEEN 1:4 AND 1:2



Expensive and difficult to develop and install services. Ideally, these areas should be conserved with natural vegetation and foot paths should be added to avoid damage to natural vegetation from human traffic.

### STEEPER THAN 1:2



Not suitable for development and potentially unstable, even difficult to walk on. It will be difficult to re-establish vegetation, so rather leave natural vegetation undisturbed.

**3-3: Guidelines for development on slopes**
**(adapted from *A Place Called Home* by Sowman and Urquhart, 1998)**

## SITE PLANNING

Site planning must be taken into consideration when choosing or allocating land for residential purposes. Engagements should be held with Amakhosi and Izinduna to ensure that they are aware of climate resilience factors so that they can take them into consideration when allocating land and advising on development. Various factors impacting site planning are described below.

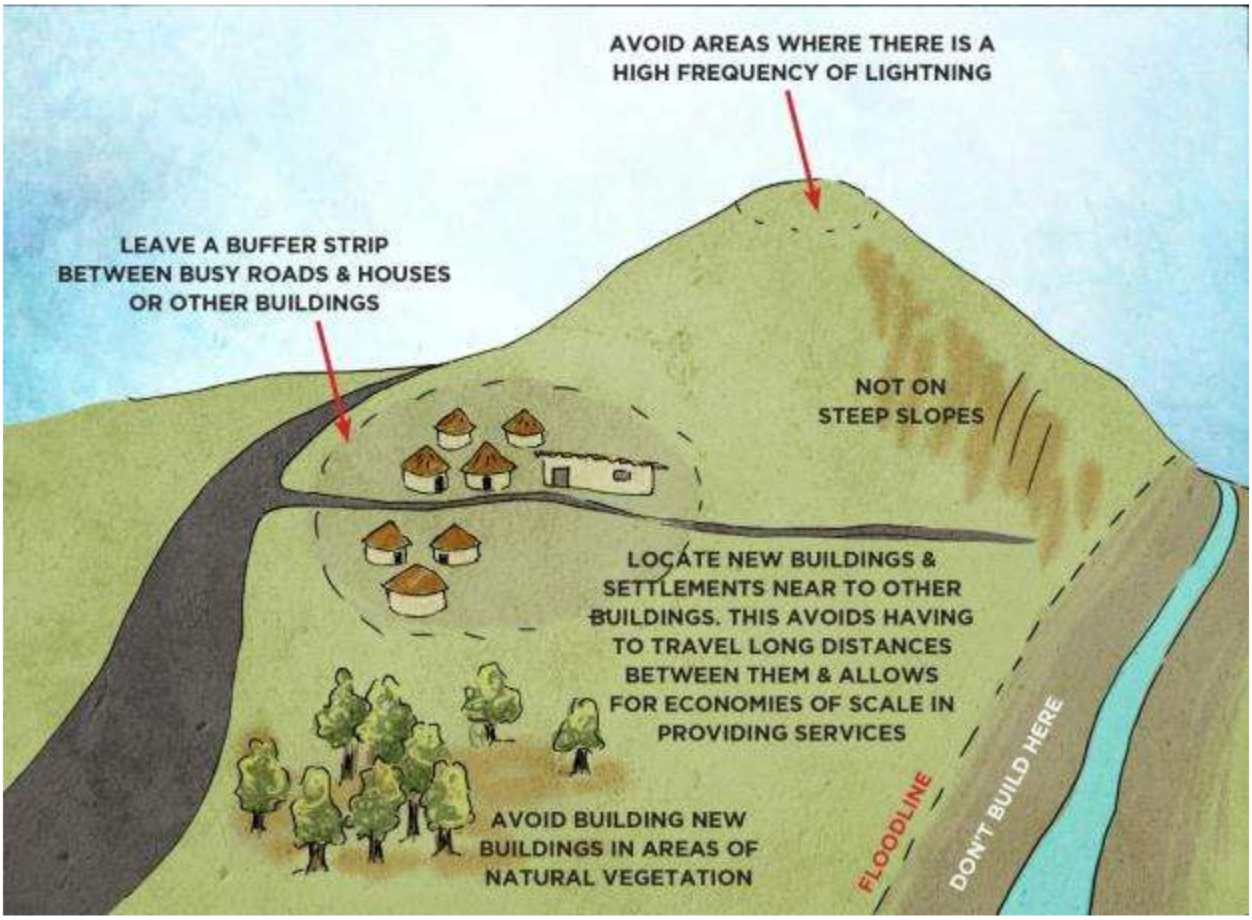



FIGURE 3-4: SETTLEMENT POSITIONING AND LAYOUT CONSIDERATIONS

### *Slopes and contours*

- ✓ Avoid developing or allowing new housing on steep slopes.
- ✓ Keep the majority of roads and footpaths parallel to the slope contours. Where roads and footpaths run at right angles to the contour, they will become channels for water in times of heavy rain.

### *Site Layout and Transport routes*

- ✓ The location of pedestrian and vehicle routes throughout the development project should align with existing movement patterns.
- ✓ Priority should be given to pedestrian movement, not vehicles. Aim to create a strongly pedestrian-friendly design layout in the first place, and for private vehicles in the last place.
- ✓ Ensure that there is space for pedestrians and cycles to move safely along all roads.
- ✓ Consider where the main destinations are within the village, such as water points, schools, public transport pick up points and shops and ensure that access to these are prioritised. Direct connections between these facilities must be prioritised.

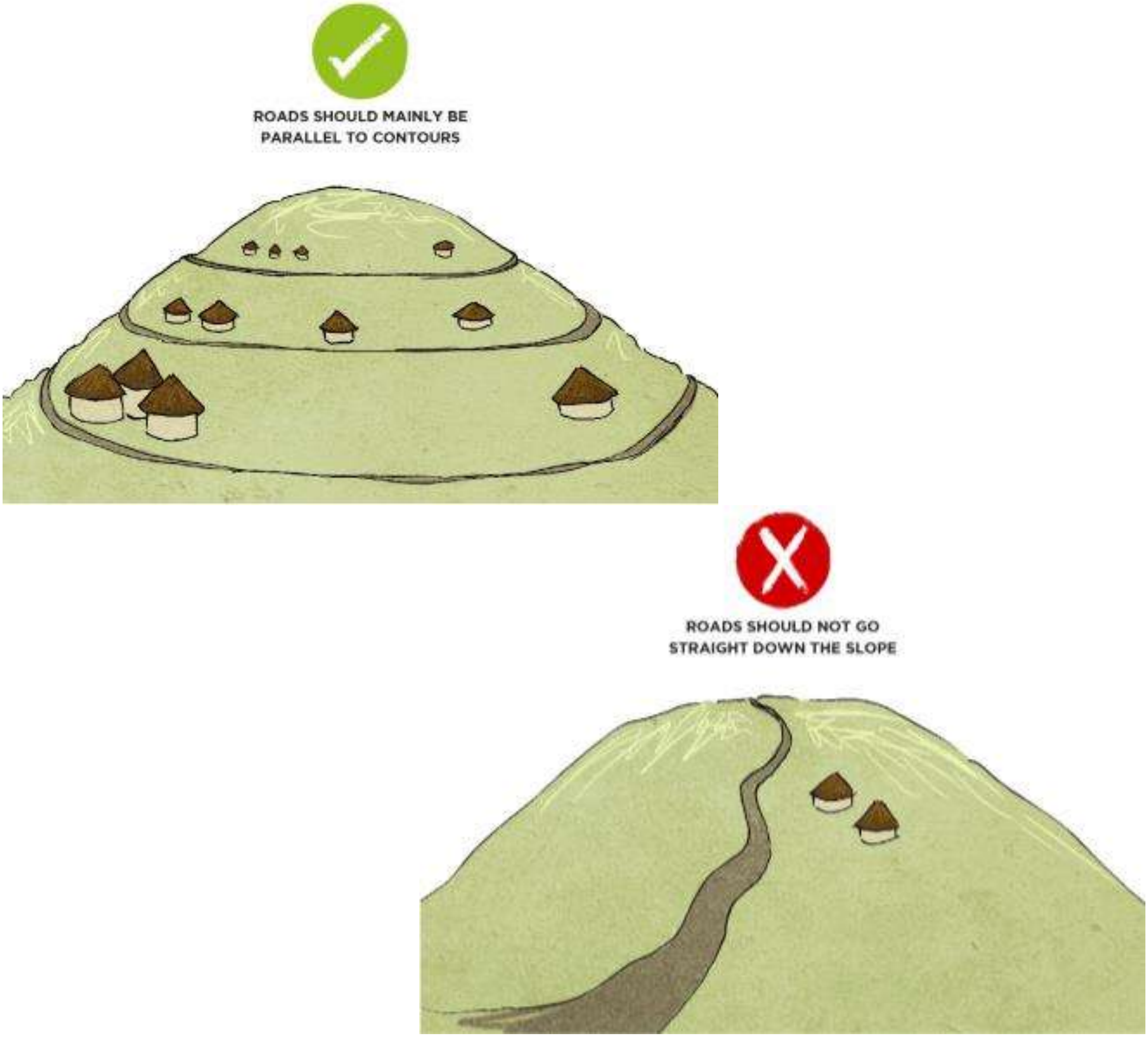



**FIGURE 3-5: WORKING WITH SLOPE CONTOURS**

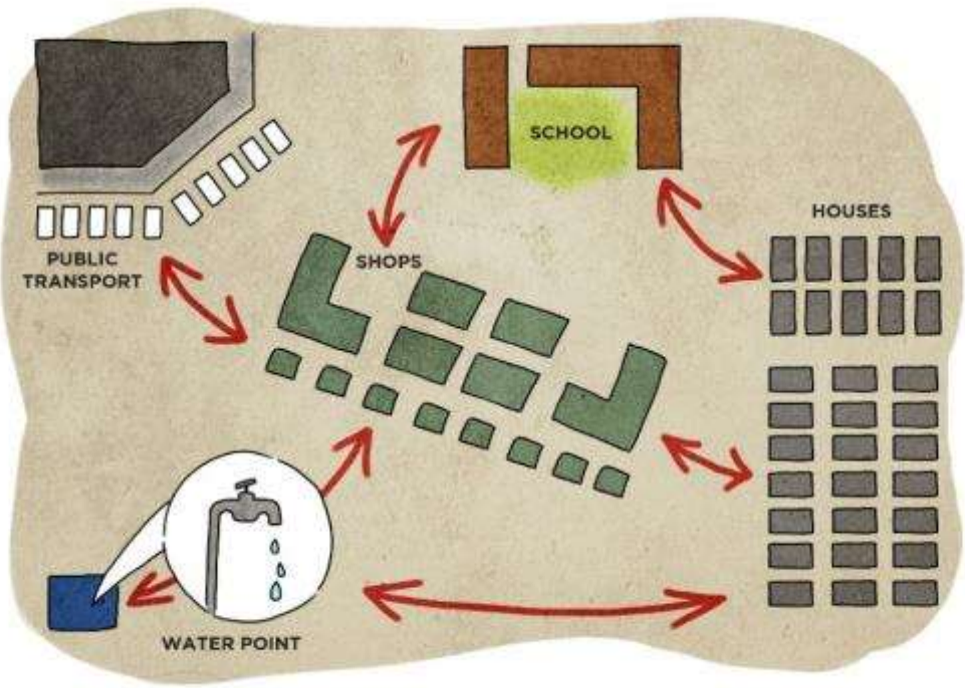



**FIGURE 3-6: PRIORITISING ACCESS AND LINKAGES BETWEEN MAIN DESTINATION POINTS**

## MORE SITE PLANNING CONSIDERATIONS

*Roads must be provided to suit land use and not the other way around.*

- ✓ Where there is no piped water into the yard or house, the routes to collect water must be kept open and accessible.

- ✓ Create as many access points into the residential area as possible. A permeable layout increases accessibility of different amenities and makes it easier for pedestrians or cyclists to get around. It also spreads vehicular traffic out through the area, rather than concentrating it on one particular road.

- ✓ Where pedestrian routes go alongside main roads, ensure that a sidewalk is available alongside the road – preferably separated by a barrier where it is a high-speed road.

- ✓ Footpaths and sidewalks should cater for a variety of needs. The width of footpaths and sidewalks should be reflective of the volume of people and its use. The busier a footpath is, the wider and sturdier its construction should be.

- ✓ In the design of pathways and routes, always consider surveillance. Avoid routes through areas that are not visible, avoid routes along high walls, avoid paths through dense bush. This is particularly important for routes that are used by the young and old who are more vulnerable.

- ✓ Develop a hierarchy of roads: "Roads must be provided to suit land use and not the other way around." Main distributor roads should be routed around residential areas and not through them wherever possible.

- ✓ Layout patterns should ensure that buildings, pathways and roads follow the slope of contours. This reduces the need for expensive earthworks. The size of blocks should be adapted to the topography where possible. Where possible the layout should allow the long side of buildings to face north. Street blocks and properties should be designed to allow drainage towards the street.

- ✓ The layout of a village should allow buildings to face north if possible. The northern side of a home will be lighter and warmer than the southern side. Consideration should also be given to the prevailing direction of inclement weather when siting a house/homestead so that it is protected from bad weather. In uMDM, rain usually comes from a south-western direction and berg winds from a north-westerly direction.

**In low lying areas and floodplains, anticipate flooding or high water and keep housing away from it.** Do not locate any new dwellings in areas within the 100-year flood plain.

**In mountainous or hilly areas, only build on slopes where it is not too steep; make sure that houses are not too shaded due to their position against the mountain.** Homes built in shaded areas can become cold and very damp. Avoid this by building in areas where winter sun is not blocked out by the mountain.

**In sensitive natural environments, aim to maintain and protect:**

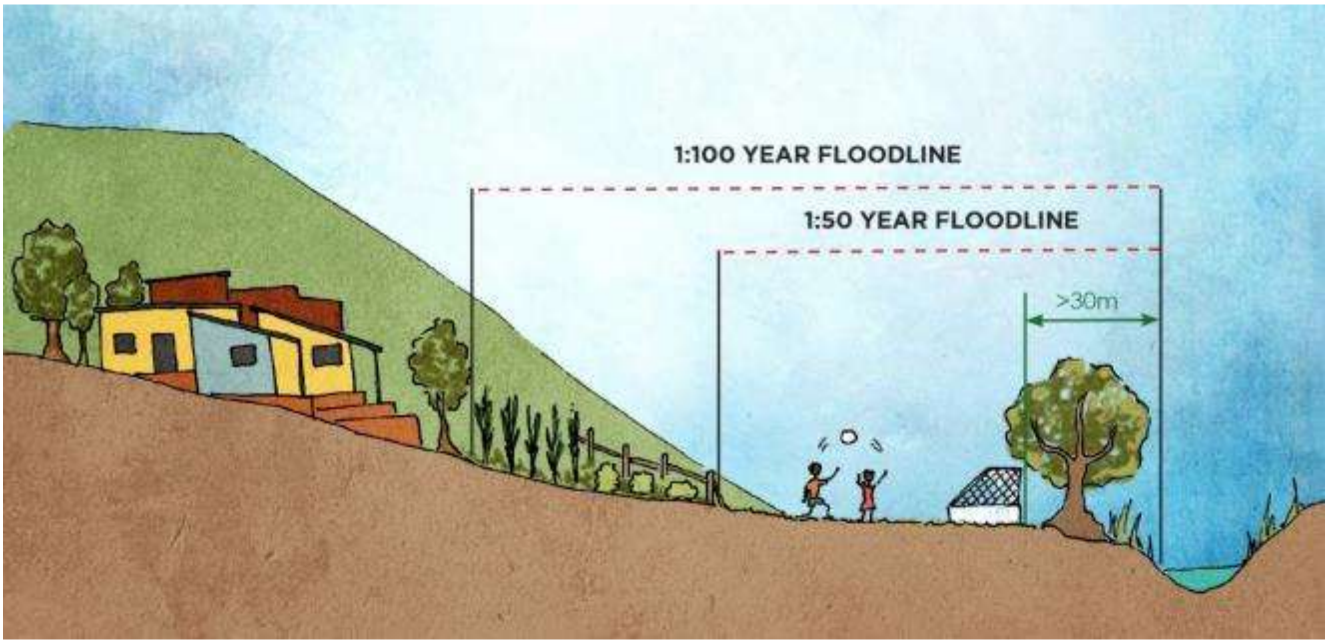
- ✓ Identify and demarcate areas of high conservation value
- ✓ Identify areas which should and can be revegetated
- ✓ Consider access to natural resources

## UNDERSTANDING THE FLOODPLAIN

The **floodplain** is an area of low-lying ground near a river or stream that is vulnerable to flooding. Especially given the inevitable impacts of climate change, no development should occur within the **1:100 year floodplain**. In addition to climate change, development in urban areas will lead to higher flood volumes due to less area available to absorb runoff. Any development within the 1:100 year floodplain is in danger of being flooded, which may put people and infrastructure in danger. Development in the floodplain can also put the river/stream ecosystem at risk.

Avoiding the 1:100 year floodplain may be difficult in the more densely populated areas, where informal settlements often develop on any open land. If necessary environmental approval is obtained for development in the 1:100 year floodplain, **no buildings should be situated below the 1:50 year floodline**. A buffer zone on either side of a river or stream which incorporates the river banks and a margin of approximately 30 metres should be left undisturbed (or if disturbed should be revegetated with suitable riparian vegetation). The area between that buffer zone and the 1:50 year floodline can be used for open space development, recreational areas, sports fields, or small vegetable gardens (Sowman and Urquhart, 1998). Establishing some use of this zone is important for discouraging informal residents from settling there.

**The floodplain** is an area of low-lying ground near a stream of river which is subject to flooding. The 1:100 year floodplain represents an area which will be flooded during a 1:100 year storm. The 1:100 year floodplain is an area that will be flooded on average every 100 years, over a very long period (see definition of “flood recurrence intervals” on page 32). With climate change, this marker is changing due to the increased frequency of floods.



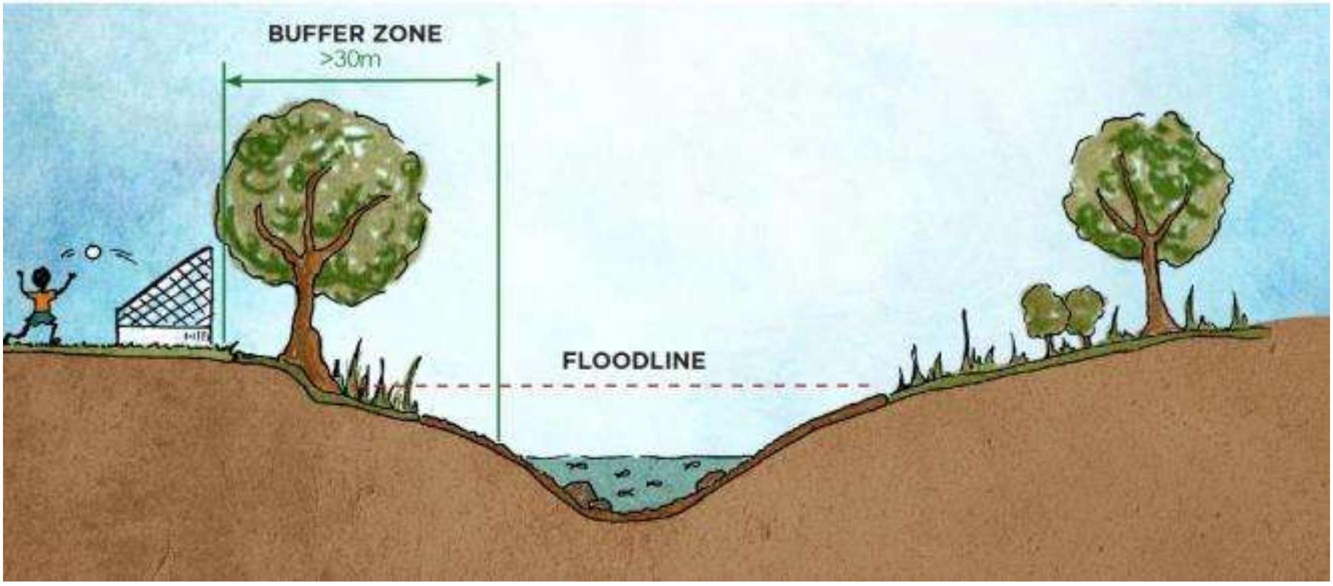




FIGURE 3-7: UNDERSTANDING THE FLOODPLAIN – ABSOLUTELY NO BUILDINGS OR STRUCTURES SHOULD BE BUILT WITHIN THE 1:50 FLOODPLAIN, AND DEVELOPMENT SHOULD BE AVOIDED WITHIN THE 1:100 YEAR FLOODPLAIN

**BOX 3-1: HOW CAN YOU DETERMINE THE LIMITS OF THE 1:50 YEAR FLOODPLAIN?**

On a site by site basis, the floodplain can be defined by suitably experienced hydrologists and engineers.

Another form of "expert advice" is to interview long-term residents of the area, particularly older residents. Asking residents about the largest storm they can remember in their lifetime can provide an idea of the extent of a 1:50 year storm. You can ask them which areas were flooded during that storm to get an idea of what level the water reached.

In the absence of expert input, one rough rule of thumb is to maintain a buffer zone of 50 metres on either side of a river (Sowman and Urquhart, 1998), although this buffer should be doubled or tripled in the case of flat flood plains and halved where the valley sides are steep.

## Stormwater Management

Stormwater management must protect human life, property, and the environment. Spending some money now on proper stormwater management can save large amounts of money that would be required to repair facilities that would otherwise be damaged during heavy storms.

### KEY DEFINITIONS, adapted from the Revised Red Book (2018)

**Stormwater** is rainwater that runs off the land. When stormwater is absorbed into soil, in natural systems, most of it returns to the atmosphere by evapotranspiration and the remainder is filtered and ultimately replenishes aquifers or flows into streams and rivers.

**Flood recurrence intervals** represent the average interval between events exceeding a stated benchmark. The recurrence interval is expressed in years and is the reciprocal of the annual probability. As an example, the event with an annual probability of occurrence of 2% (0.02) has a recurrence interval of 50 years. This does not imply that such an event will occur after every 50 years, or even that there will necessarily be one such event in every 50 years, but rather that over a very long period (e.g. 1000 years), **assuming no climate change**, there will be approximately 20 events of greater magnitude (1000/20 = 50 years). Flood recurrence intervals are based on historical data. **Given that climate change is occurring, flood events are likely to occur more regularly in the future than historical data would suggest.**

**Major stormwater systems** are trunk systems (e.g. large diameter stormwater pipes) that receive discharge from minor stormwater systems. Their main function is to ensure public safety and protection of the built and natural environment during unusually intense hydrologic events. Large attenuation ponds can also be used to attenuate flood peaks while reducing the need for excessively large culverts and channels.

**Minor stormwater systems** are used to retain and store runoff by storms of relatively frequent occurrence via source controls (green roofs, rain tanks, permeable pavements, etc.) or drainage elements. The purpose of minor systems is to convey runoff from frequent rainfall events to locations where it can be conveniently stored and treated before release into the drainage system.

### TECHNICAL GUIDELINE 3-1: GUIDANCE FOR STORMWATER SYSTEMS

The *Revised Red Book* provides **guidelines** for design of major and minor stormwater systems, but the final decision must always be made based on the best judgement of the engineer involved.

- ✓ The stormwater management system for all new townships will be designed to safely contain floods up to the 1:20 year flood within road reserve boundaries, avoiding the flooding of properties.
- ✓ MAJOR stormwater systems should be designed for the 1:100 flood recurrence interval. Based on the Revised Red Book, this applies to all land uses, including residential, institutional, general commercial/industrial, and high value CBDs.
- ✓ Stormwater pipe diameters should be at least 600mm in a servitude and 450mm in a road reserve.
- ✓ MINOR systems should be designed for flood recurrence intervals between 1 and 10 years.
- ✓ In dense, informal areas, design flood recurrence intervals should be higher than the norm, to ensure the protection of vulnerable structures.
- ✓ Where large stormwater pipes or culverts end, adequate consideration must be given to reinforcing the area beneath the pipe outlet, to ensure that further erosion does not take place (see photo below).


FIGURE 3-8: WHERE A STORMWATER PIPE DISCHARGES, THE LAND MUST BE ADEQUATELY PROTECTED/REINFORCED TO AVOID EROSION FROM FAST-MOVING WATER

The South African Constitution, Schedule 4 – Part B advises that stormwater services in urban areas are to be provided by the local municipality (RSA, 1996). In many municipalities, stormwater management is separated from water and sanitation provision and is typically assigned to the roads department. This means that stormwater is often treated as a hazard that must be disposed of as rapidly as possible to prevent road damage. While preventing damage of infrastructure is important, this approach fails to recognize more environmentally responsible methods of dealing with stormwater. **Effective stormwater management provides a number of necessary benefits for public safety, infrastructure protection, environmental health, and in some cases, water security.** Guidelines for stormwater management are discussed in the Red Book, where specific emphasis is placed **on Water Sensitive Urban Design (WSUD)** and **Sustainable Urban Drainage Systems (SuDS)**.

SuDS should be used extensively in stormwater management. The traditional approach to stormwater management focuses on managing the quantity (flow) of runoff by collecting it and channelling it to the nearest watercourse. This approach, while effective at protecting public safety and infrastructure, does not consider the environmental impacts of channelling large volumes of stormwater and is also very vulnerable to increased storm intensity. SuDS manages surface water drainage in a more holistic way, considering water quantity, water quality, enhanced amenity, and maintenance of biodiversity. The goal in SuDS is to create a series of processes that will enhance all four of these aspects.

**Water Sensitive Urban Design (WSUD)** is an approach to land use planning and engineering design that attempts to integrate the urban water cycle. The urban water cycle includes stormwater, groundwater and wastewater management and water supply. Designing urban areas in this way aims to minimise environmental degradation, improve aesthetics and recreational opportunities, and increase resilience.

**Sustainable urban drainage systems (SuDS)** incorporate management practices and/or control structures for draining surface water in a more sustainable manner than conventional techniques.

SuDS manages surface water drainage in a more holistic way, considering water quantity, water quality, enhanced amenity, and maintenance of biodiversity.

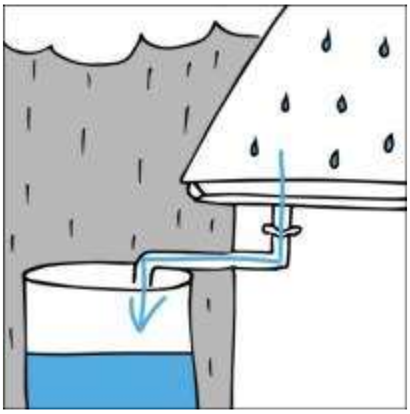
The goal of ***quantity management*** is to deal safely and sustainably with large quantities of stormwater. This is the main concern in traditional stormwater management and is one of four main concerns in SuDS.

The goal of ***quality management*** is to ensure that the stormwater entering watercourses is of acceptable quality to minimise pollution and public health risks.

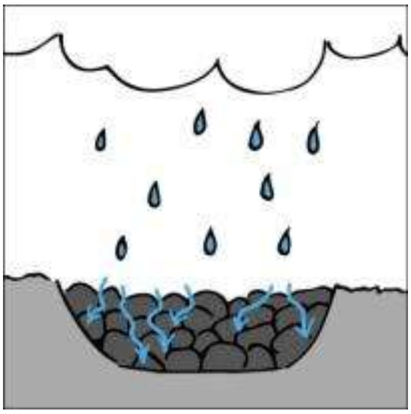
The goal of ***amenity management*** is to ensure that stormwater management is carried out in a way which protects the public and enhances their experience with the environment. While traditional methods see stormwater only as a hazard to be handled, amenity management recognises the potential benefits to human activities (assuming that public health and safety is protected!).

The goal of ***biodiversity management*** is to ensure that biodiversity is protected and enhanced in the process of stormwater management. Stormwater management should not be at odds with biodiversity.

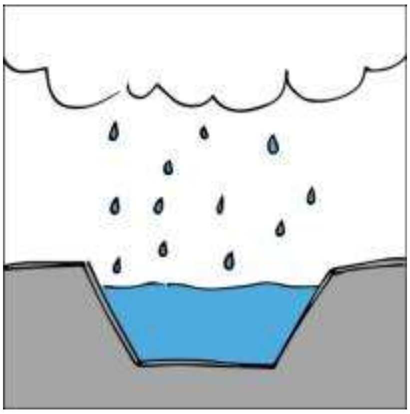
### *Processes for achieving quantity management include:*



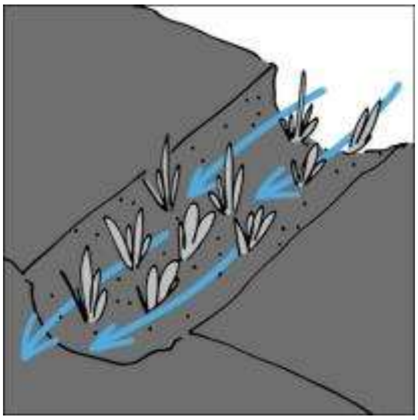
**Rainwater harvesting**



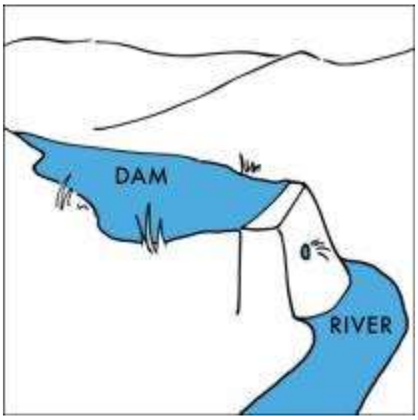
**Infiltration**



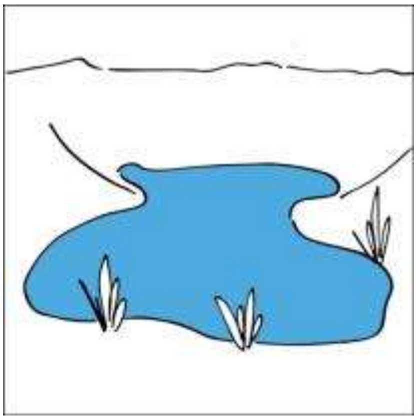
**Detention**



**Conveyance**

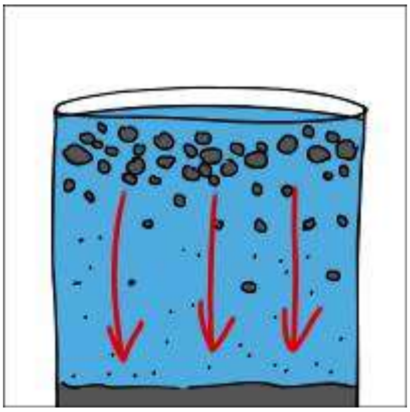



**Long-term storage**

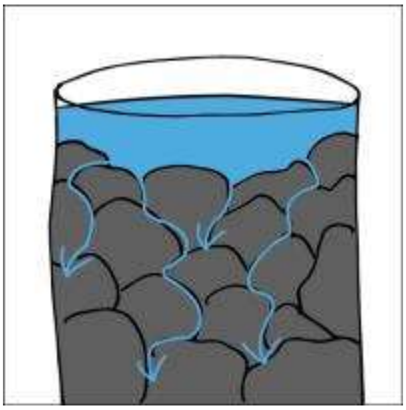


**Extended attenuation storage**

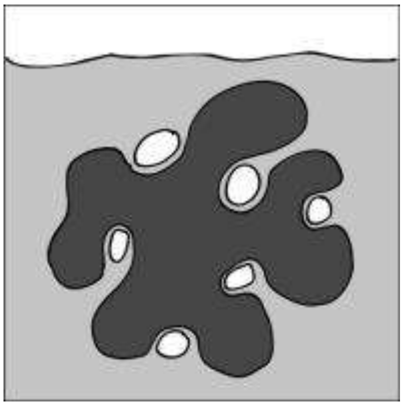
## *Processes for achieving quality management include:*



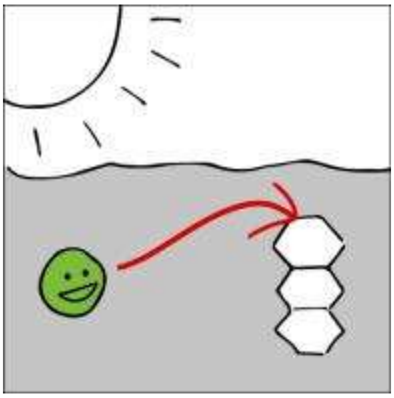
**Sedimentation**



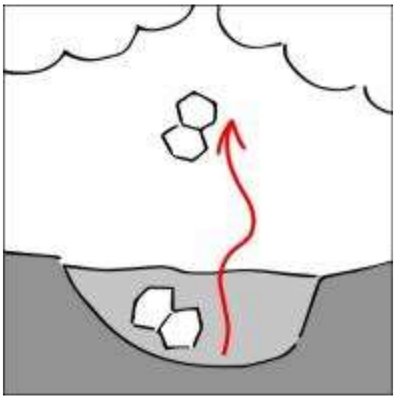
**Filtration and biofiltration**



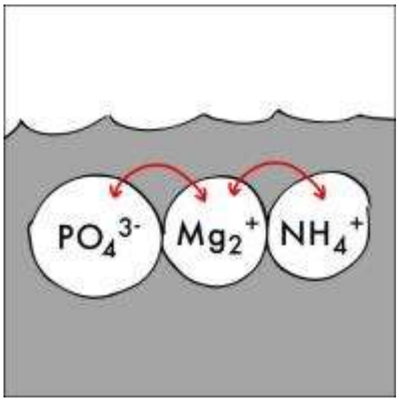
**Adsorption**



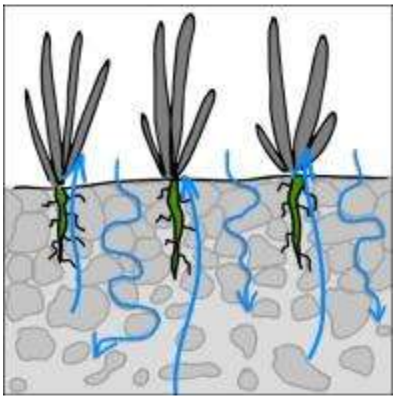
**Biodegradation**



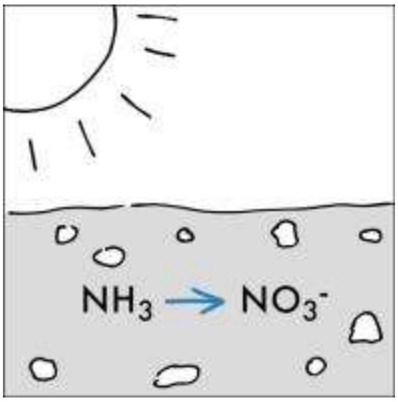
**Volatilisation**



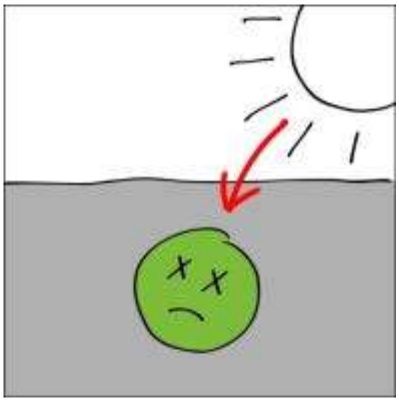

**Precipitation**



**Plant uptake**




**Nitrification**



**Photosynthesis**

### *Processes for achieving amenity management include:*

- ✓ Health and safety measures to prevent injury or death
- ✓ Environmental risk assessment and management
- ✓ Recreation and aesthetics enhancement by protecting, shaping, and creating open spaces
- ✓ Education and awareness


### *Processes to achieve biodiversity management include:*

- ✓ Protection of indigenous flora and fauna
- ✓ Maintenance of habitat through removal of invasive species
- ✓ Monitoring of fauna and flora

## So, how does one design a community stormwater system using SuDS?

Between the area of rainfall and the receiving watercourse, the four main points of intervention are: **good housekeeping**, **source controls**, **local** (site) **controls**, and **regional controls**. The most effective solution is to control and treat stormwater runoff as close to its source as possible (Armitage et al., 2013). While one must implement regional controls for stormwater (like bulk stormwater pipes or large stormwater storage units), it makes sense in the long term to also implement source and local controls.

THE KEY PRIORITIES IN DESIGNING A SUDS TREATMENT TRAIN SHOULD BE:

1) Water quality management for low flows

2) Attenuation and volume control during high flows.

**TRY TO MAINTAIN PRE-DEVELOPMENT CONDITIONS AS MUCH AS POSSIBLE, CONTROLLING AND TREATING STORMWATER RUNOFF AS CLOSE TO THE SOURCE AS POSSIBLE.**

**Good housekeeping** refers to efforts to minimise release of pollutants into the environment where it can be transported by stormwater. This would include, for instance, good solid waste and litter management.

**Source controls** manage stormwater runoff as close to the source as possible (i.e. on site). These are the first choice when it comes to SuDS controls, as it reduces the potential for excessive runoff and the negative impacts of that. Typical options include green roofs, rainwater harvesting, permeable pavements, and soakaways.

**Local controls** manage stormwater runoff within the local area. Typical options include bioretention areas, filter strips, infiltration trenches, sand filters, and swales.

**Regional controls** manage stormwater runoff from multiple developments. Typical options for regional controls include constructed wetlands, detention ponds, and retention ponds.

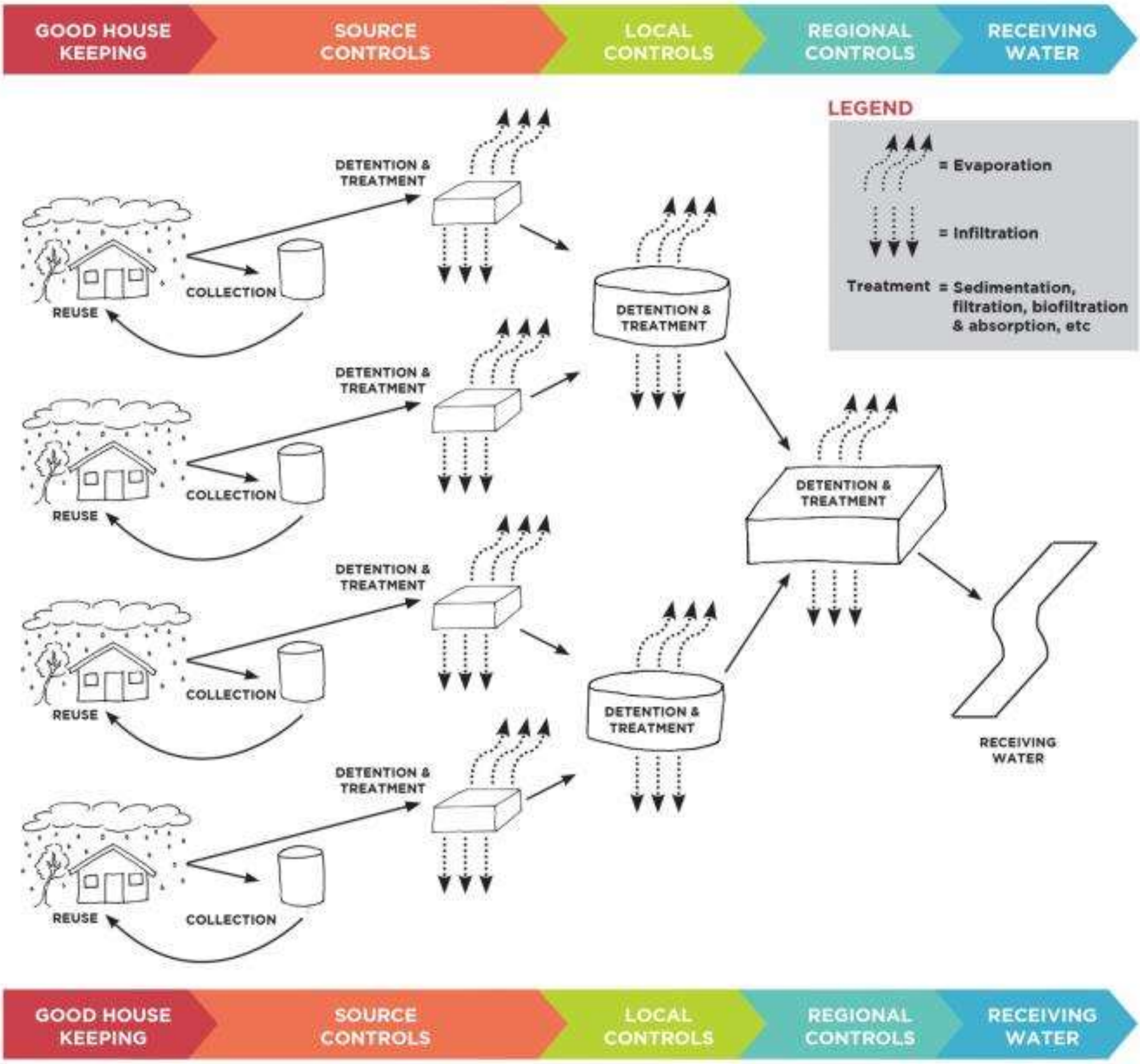



**FIGURE 3-9: SUDS TREATMENT TRAIN SCHEMATIC (ADAPTED FROM ARMITAGE ET AL., 2013)**

When designing a stormwater management system, one should deal with the stormwater as close to the source as possible. Use source SuDS controls to mimic natural drainage. If it can't all be handled on site, utilise local controls. Regional controls should only be used if local controls are limited due to space or other factors. When transporting stormwater, try to avoid concrete channels or pipes, which speed up the flow of stormwater and provide no treatment benefits. Filter strips or swales will transport stormwater while slowing the flow, increasing infiltration of water into the soil, and providing some level of treatment.

Chapter 2 of the *South African Guidelines for Sustainable Drainage Systems* provides design criteria and methods for SuDS systems, and the remainder of the guideline provides details on specific SuDS solutions that can be utilised at the source, local, and regional level.

## *Roads*

*The traffic and stormwater functions of roads should not be in conflict.*

The *Revised Red Book* suggests that the median between dual carriageways should be lowered to allow it to receive drainage from both paved roads. It can be designed as a swale, providing both retention and water quality improvements.

When it comes to unsurfaced roads, the integration between roads and stormwater drainage is even more critical. If an unsurfaced road also provides drainage, the velocity of the runoff must be limited so that the erosion potential is minimized. The slope of these roads must be kept to a minimum and roads with steep gradients should not be used as drainage ways wherever possible. Side drains must be designed with proper erosion protection: e.g. drop structures and lined channels. Roads should be planned so that the greatest length of road closely follows ground contours – this will maximise the storage function of roads. (CSIR, 2018)

Roads designed without a side drain will still transport stormwater, and that stormwater will flow downhill. In Figure 3-10, a small gully has formed due to high volumes of runoff eroding the shoulder of the road. Simply providing an earth drain lined with grass on the side of this road would ensure that the erosion would not compromise the road stability or the stability of the bank adjacent to the road.

Side drains like these also require regular barriers to slow the stormwater and limit erosion.

FIGURE 3-10: STORMWATER RUNOFF HAS FOUND ITS WAY TO FLOW ALONGSIDE THIS ROAD IN NHLAZUKA, LEADING TO EROSION (LEFT)

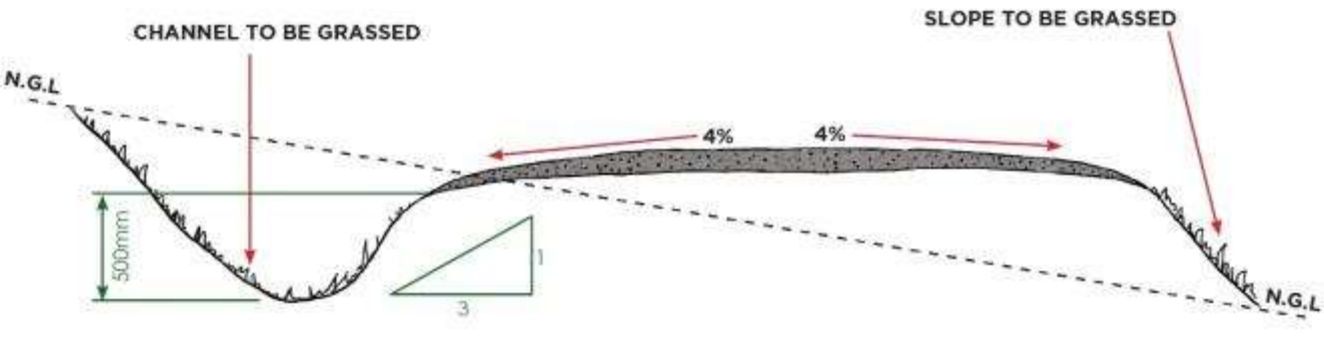



FIGURE 3-11: DESIGN OF A ROAD ON A SLOPE WITH A GRASSED DRAINAGE CHANNEL

## Erosion Control

Erosion is a cycle – the more eroded a landscape is, the greater potential there is for more erosion. Consider the photo below. On the areas which are bare on the hillside, water will flow at a higher velocity than on the areas that are vegetated. The higher velocity water will lead to more erosion and can ultimately result in formation of a donga.

FIGURE 3-12: ERODED LANDSCAPE

*Soil erosion occurs when soil is removed through the action of wind and water at a greater rate than it is formed* ("Soil Erosion," 1999).

So, to build resilience in communities vulnerable to erosion, bare areas need to be **rehabilitated** and areas susceptible to high winds and excessive runoff need to be **protected**.

*Vegetation plays an important role in slowing down erosion, as the roots bind the topsoil and hold it in place… Most soil erosion control methods are based on two simple principles. The first principle is to* ***stop soil movement by covering the soil****, and the second principle is to* ***slow down the wind or water flowing over the soil****.*

– A Place Called Home (Sowman and Urquhart, 1998)

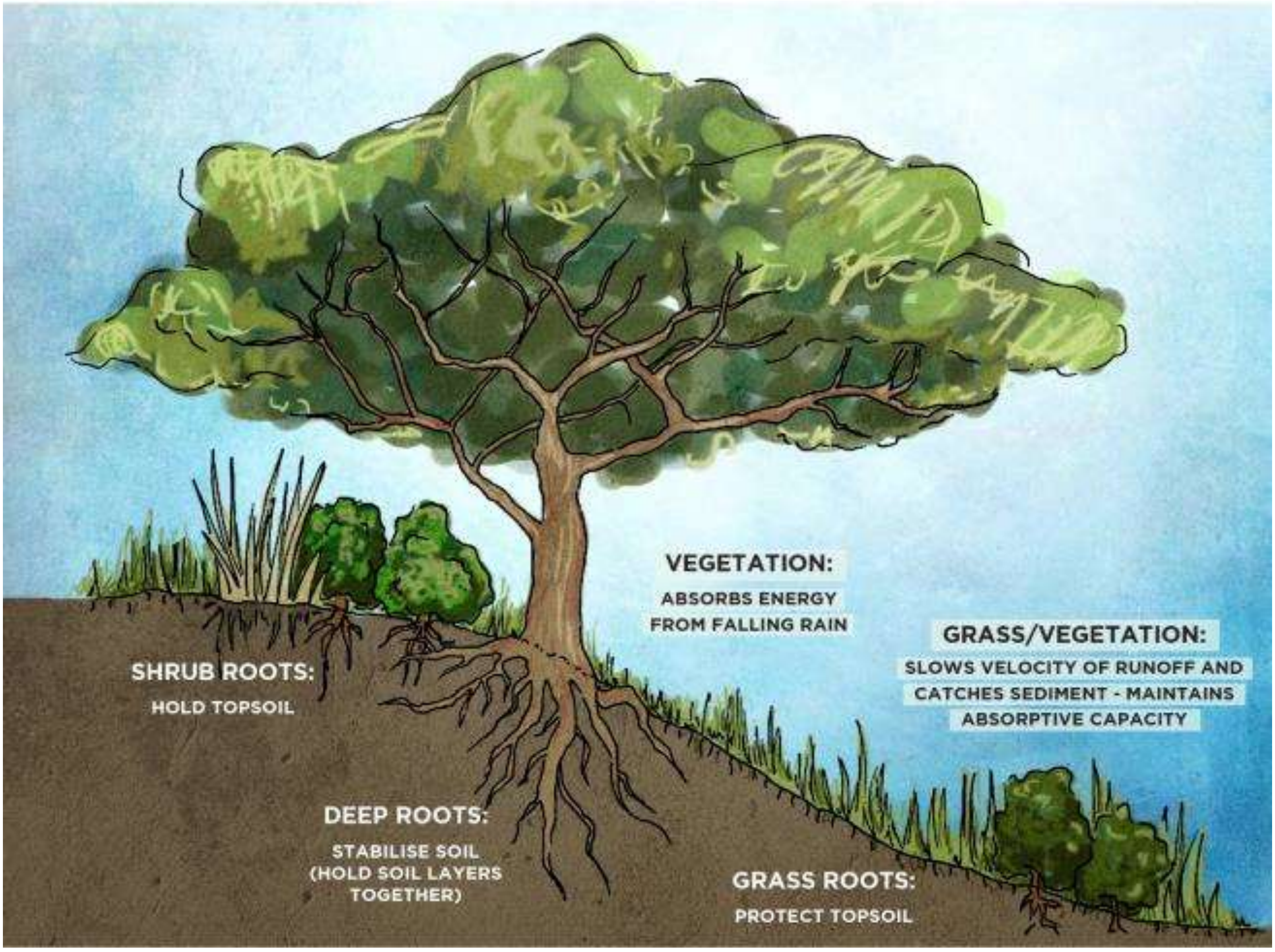



FIGURE 3-13: THE ROLE OF VEGETATION IN REHABILITATING ERODED LANDSCAPES AND PROTECTING VULNERABLE LANDSCAPES

Simple, replicable techniques should be pursued. While large-scale erosion control efforts can be carried out where funds allow, there are a number of approaches with minimal capital costs that can be done using labour-intensive methods and as much (or as little) funding is available. Some of these approaches are described below and adapted from a pilot Community Based Natural Resource Management project carried out in Okhombe in the Drakensberg over a long period (Everson et al., 2007).

### KEY CONCEPT: ON CONTOUR

In the following guidelines, you will sometimes see the phrase **on contour**. This phrase simply means that something is done at an equal elevation throughout. If something is **on contour**, it means that it follows all changes in slope in order to remain on a line of equal elevation around a sloped area. This is an important concept, because water will flow downhill. If interventions are done in a simple straight line rather than **on contour**, they won't be as effective at slowing the flow of water.

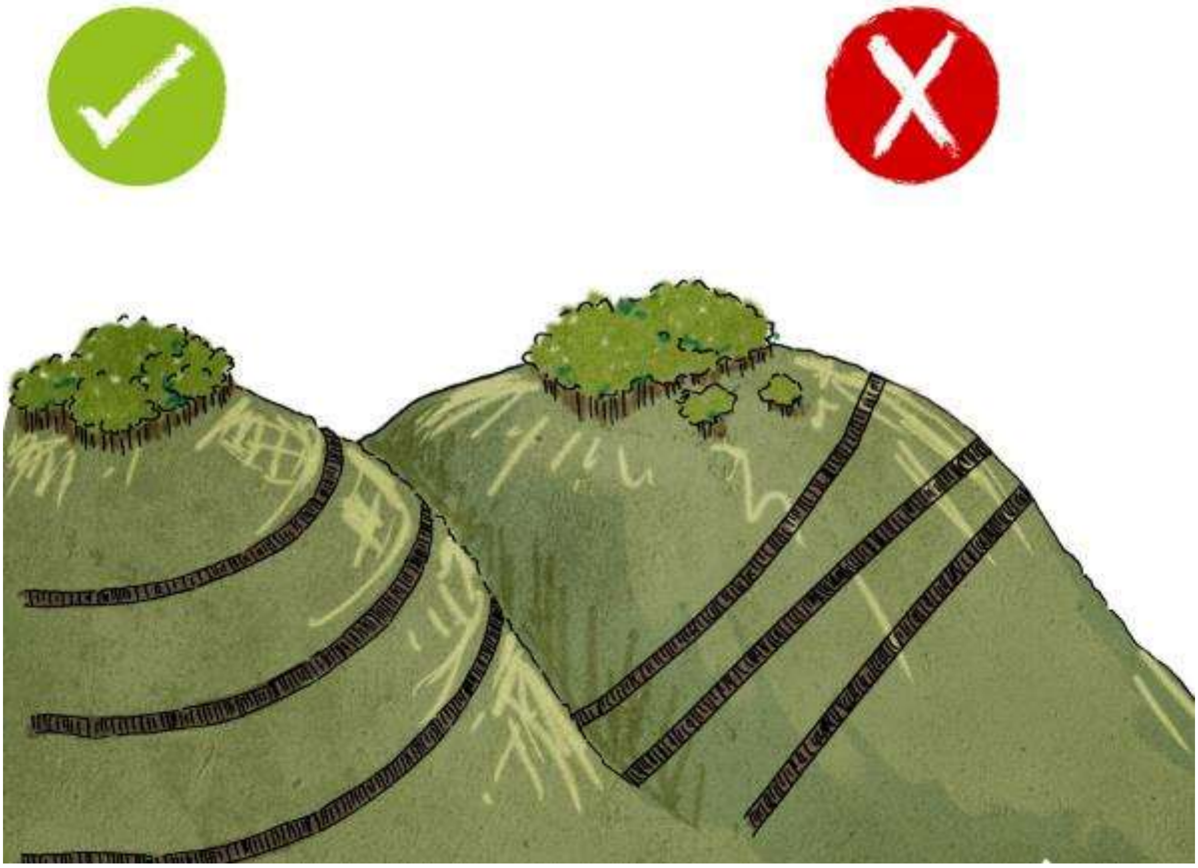


**FIGURE 3-14: WHAT DOES "ON CONTOUR" MEAN?**

## *Swales*

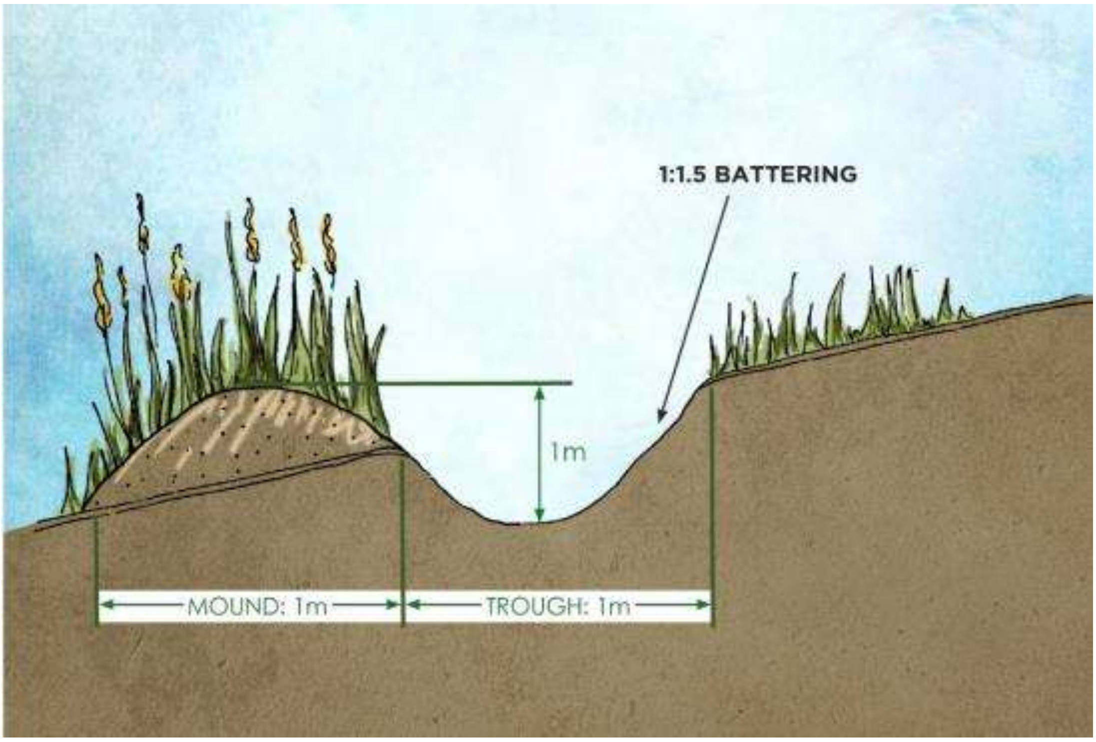
A swale is made up of a ditch and a bank dug **on contour**. Swales slow down the flow of runoff and allow for infiltration of water flowing down slopes. Swales can also capture soil, which reduces siltation of watercourses. Swales can also be used for water harvesting, providing water for trees planted on the downhill side of the swale.

**TECHNICAL GUIDELINE 3-2: CONSTRUCTING SWALES**

"The ditch and bank (berm) should be approximately 1 metre wide and have a height of 1 metre from the floor of the ditch to the top of the bank." In order to stabilise the bank, vegetation should be planted. In addition, overflows should be designed and constructed in the swales (Everson et al., 2007). The berm provides an ideal location for planting trees and foods with deep roots, since it is made up of nutrient-rich and moist topsoil.

FIGURE 3-15 (LEFT): SWALE IN OKHOMBE FILLED WITH WATER (PHOTO COURTESY OF DR TERRY EVERSON, UKZN)

FIGURE 3-16 (BELOW): DESIGN OF A SWALE FOR CONTROLLING EROSION



### Technical guideline 3-3: Planting vetiver grass for erosion control

Plant vetiver early in the wet season. Trim the roots of the plants to about 5-10 cm in length and the shoots to about 10 cm high. One slip is formed using 2-3 shoots of vetiver grass. Plant slips 10-15cm apart in a furrow treated with fertiliser and lime. The crown of the plant is buried 6-7 cm below the soil surface. Trimmed leaves can be used to cover the base of the plants to form mulch. Vertical rows should be planted approximately every 2 meters **on contour**. The slips should be watered for the first two weeks after establishment.

## *Vetiver grass*

Vetiver grass is effective in erosion control due to its extensive and dense root system, which holds soil together. Thus, runoff that flows over ground planted with vetiver will be better held in place than bare ground or soil planted with grass with shallower roots. Although vetiver is not native to South Africa, it is also not invasive, since it has sterile seeds (Everson et al., 2007). Vetiver is very resilient, able to thrive in most soils and withstand fire, drought, wind and grazing animals. It is only unsuitable in areas where rainfall is below 200mm per year (Sowman and Urquhart, 1998). Vetiver plants are often planted **on contour** to form anti-erosion hedges that trap sediment and slow the flow of water.

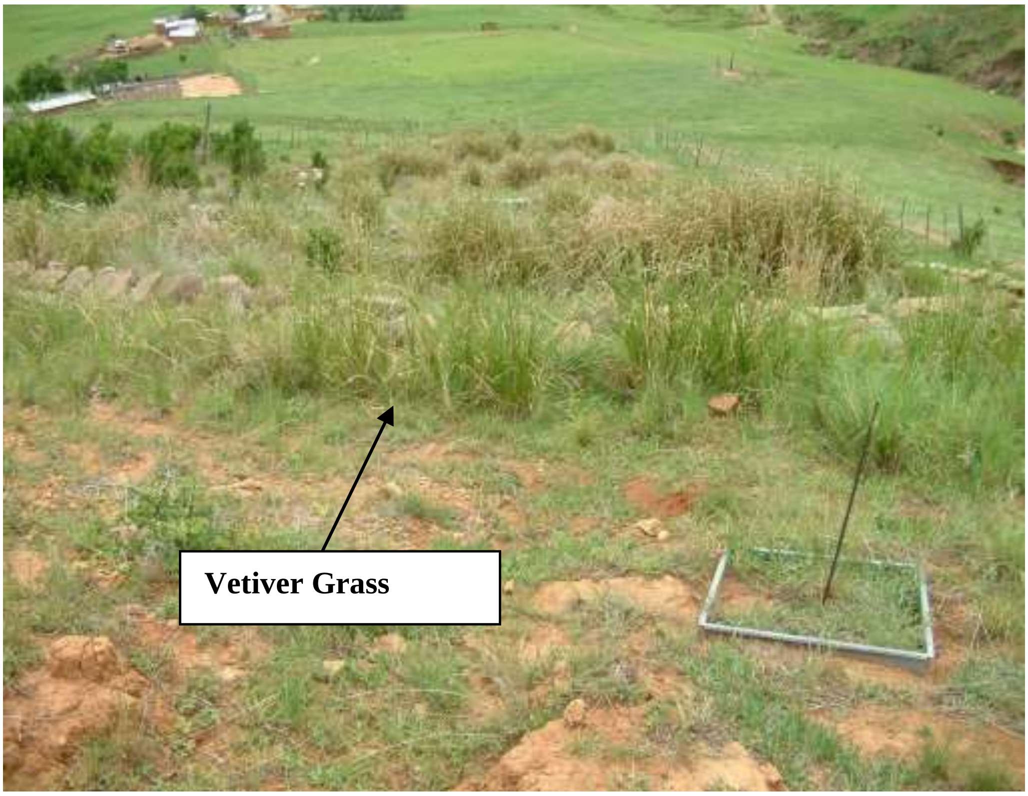



Figure 3-17: Vetiver grass planted on contour (photo courtesy of Dr Terry Everson, UKZN)

***Extra Perks:*** Vetiver grass has other uses, which make it an attractive option in terms of sustainable development. Vetiver can be used to make ropes, hats, brushes, thatch, and for mulch and animal bedding. Oil from the roots of vetiver grass has also been extracted for use in perfumes.

**Sheet flow** is water, usually stormwater runoff, which flows in a thin layer over the ground surface, rather than being channelled along a specific route created through drainage and stormwater management.

## *Tree planting and micro-catchments*

Trees planted within micro-catchments can form a barrier against **sheet flow**. A micro-catchment is formed by placing a 'wall' or bund around trees using soil or stones. Bunds should be built on the downhill side of a tree, trapping water which can be used by the tree. The soil surface around the tree should be covered with grass to provide mulch that retains more moisture for the tree.

FIGURE 3-18 (PHOTOS): TREES PLANTED WITH A MICRO-CATCHMENT IN OKHOMBE (PHOTOS COURTESY OF DR TERRY EVERSON, UKZN)

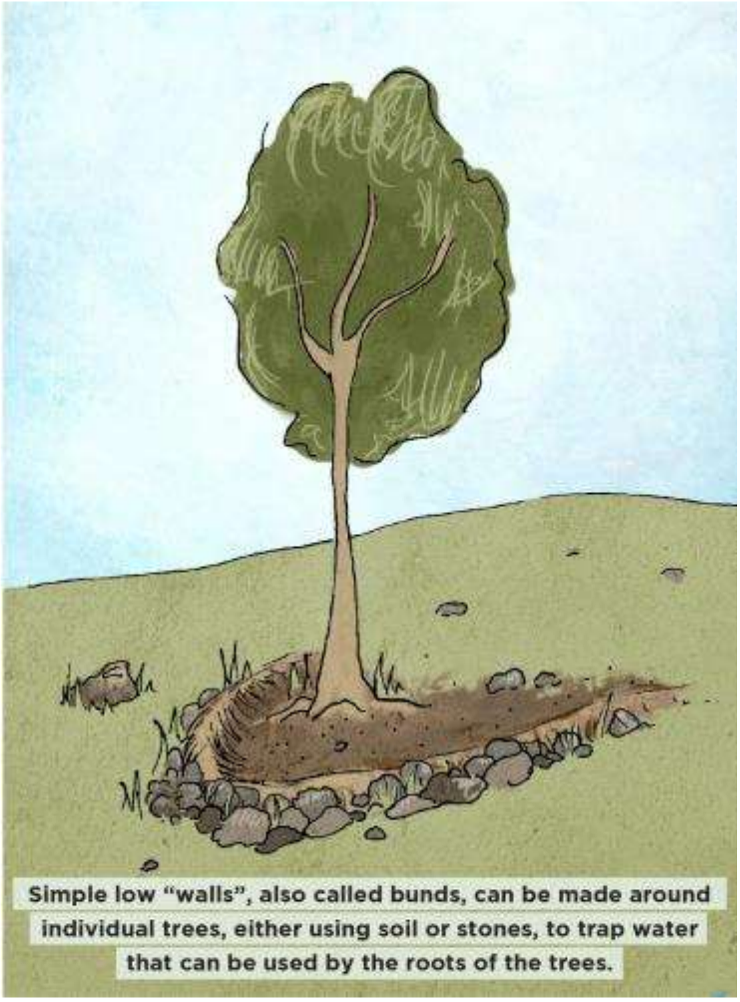



FIGURE 3-19: PLANTING TREES WITH MICRO-CATCHMENTS WHICH WILL TRAP RUNOFF

## *Low stone lines*

Low stone lines or walls are used **on contour** to prevent erosion on slopes by holding up sediment that would otherwise wash away. Stone lines can be used to effectively rehabilitate bare areas by trapping topsoil and improving water retention. Topsoil which retains water provides a good environment for vegetation to be established.

**TECHNICAL GUIDELINE 3-4: LOW STONE LINES FOR EROSION CONTROL**

Dig a trench **on contour** 30 cm wide by 10 cm deep. Place large stones on the lower side of the slope and smaller stones to fill in the spaces. Water will then be able to seep through the stones and soil will deposit above the trench (Everson et al., 2007).

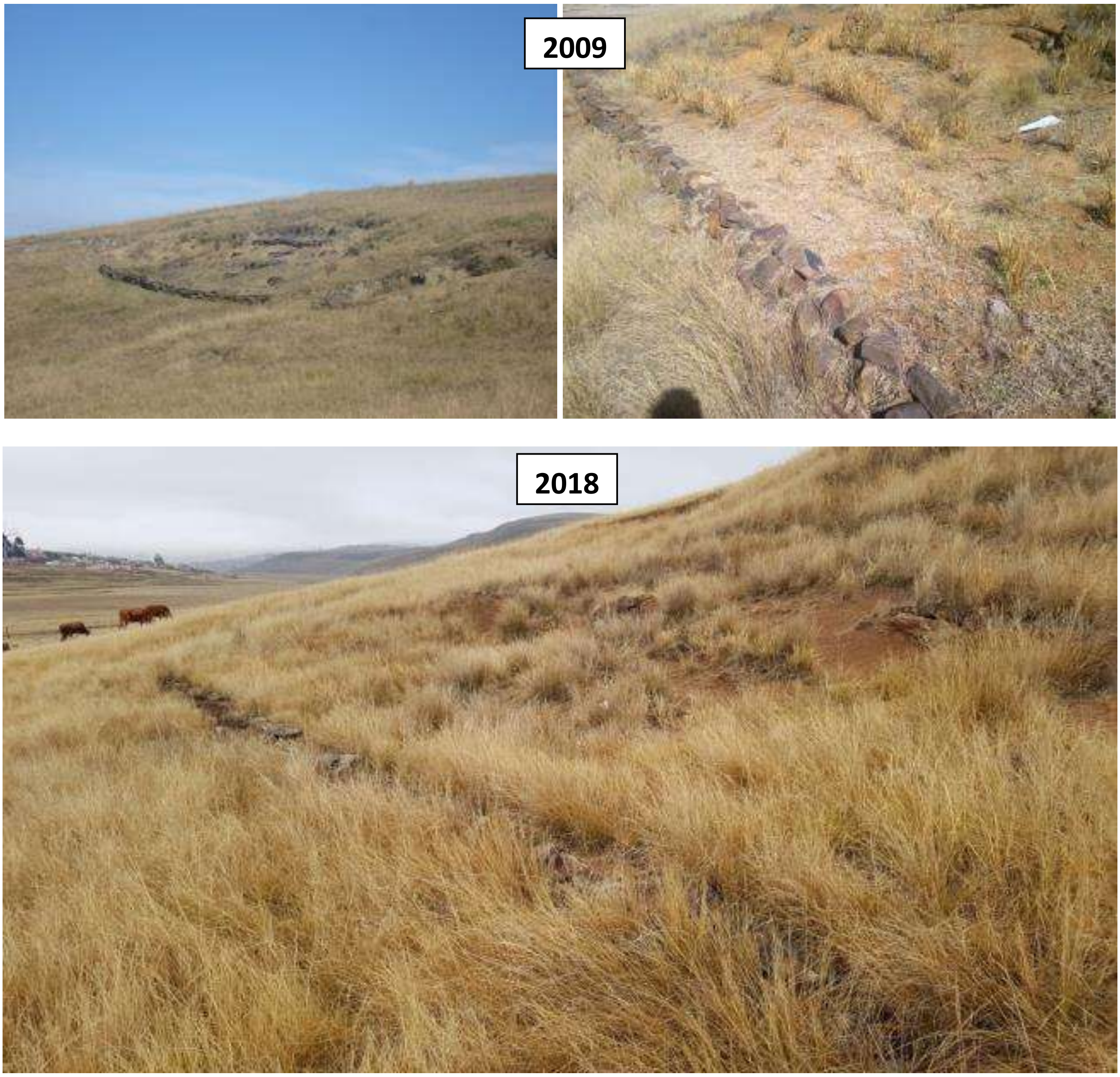



FIGURE 3-20: STONE LINES INSTALLED IN ELANDSKOP IN 2009 AND 2018. AFTER 9 YEARS, TOPSOIL HAS BUILT UP AGAIN AND THE BARE SLOPE HAS ALMOST BEEN FULLY COVERED IN GRASS.

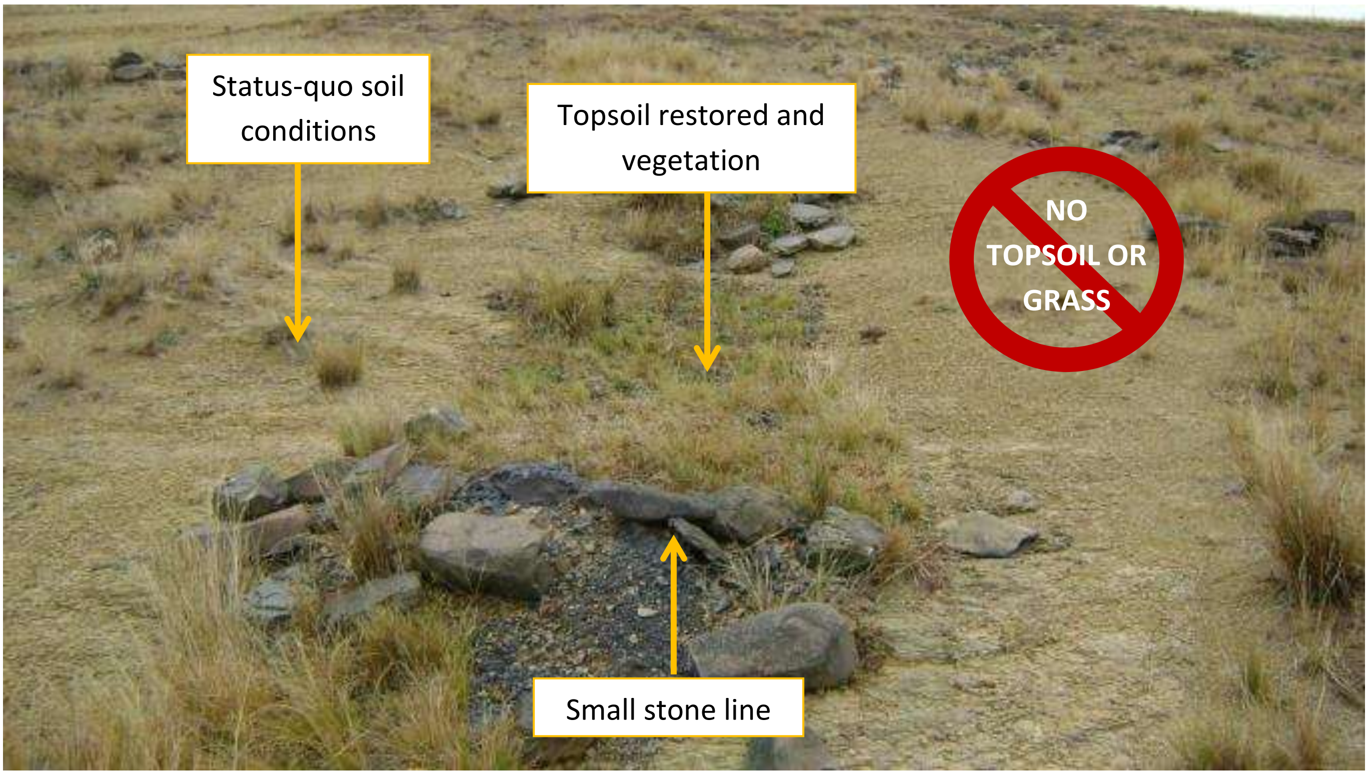



FIGURE 3-21: THE IMPACT OF A SMALL STONE LINE ON A BARE SLOPE

FIGURE 3-22: STONE LINES STABILISING AN ERODED SLOPE IN OKHOMBE (PHOTO COURTESY OF DR TERRY EVERSON, UKZN)

### *Stone packs*

Stone packs are used in dongas to slow runoff and trap sediment, thus allowing for rehabilitation. A stone pack's effectiveness will be demonstrated in the difference in soil heights above and below the stone pack over time. As more soil is trapped by the stone pack, the level will be raised, representing the effective trapping of sediment during storms.

**TECHNICAL GUIDELINE 3-5: STONE PACKS FOR EROSION CONTROL**

Dig a trench across the donga 30 cm wide by 10 cm deep. Pack stones close together in the trench and form a wall of stones. Ensure that stones are keyed in along the bottom and sides – this will prevent water from eroding underneath or around the stone pack. Build an apron of stone below the stone pack so that any overflow water hits the stone, rather than bare soil. Make sure the centre of the stone pack is the lowest point, which will allow for water to be discharged down the middle of the structure. Build stone packs at intervals in the donga to reduce the force of water and ensure the stone packs remain in place (Everson et al., 2007).

FIGURE 3-23 (LEFT): A STONE PACK IN A DONGA IN OKHOMBE (PHOTO COURTESY OF DR TERRY EVERSON, UKZN)

FIGURE 3-24 (RIGHT): CONSIDERING THE HEIGHT DIFFERENCE BETWEEN THE UP AND DOWNSTREAM SIDES OF THIS STONE PACK, ONE CAN SEE JUST HOW MUCH SILT HAS BEEN TRAPPED BY THE STONE PACK THAT WOULD HAVE OTHERWISE BEEN TRANSPORTED FURTHER DOWNSTREAM.


FIGURE 3-25: A STONE PACK IN ELANDSKOP IN 2008 AND 2018; EXTENSIVE SEDIMENT HAS BUILT UP ON THE UPHILL SIDE OF THE STONE PACK SINCE IT WAS FIRST INSTALLED

FIGURE 3-26: INDIGENOUS GRASS PLUGS (LOWER SLOPE) PLANTED BELOW KIKUYU RUNNERS (UPPER SLOPE) (PHOTO COURTESY OF DR TERRY EVERSON, UKZN)

### *Indigenous grass plugs*

Indigenous grasses have conservation benefits due to the fact that they are naturally occurring and can be utilised for income generation (e.g. *Hyparrhenia*, used for thatch). However, indigenous grasses will not establish naturally once they have been lost from the system due to poor seed germination. Indigenous grasses must be established in seedling trays and can then be transplanted in areas where sheet erosion is severe.

**TECHNICAL GUIDELINE 3-6:**
**PLANTING INDIGENOUS GRASS PLUGS**

Plant the seedlings in shallow furrows containing fertiliser and lime and water regularly during establishment (Everson et al., 2007).

### *Path rehabilitation*

Poorly-sited cattle and human paths can lead to erosion. This is one of the leading causes of dongas. These paths need to be rehabilitated to slow down erosion and ensure continued integrity of the paths. Some options for protecting paths are shown below.

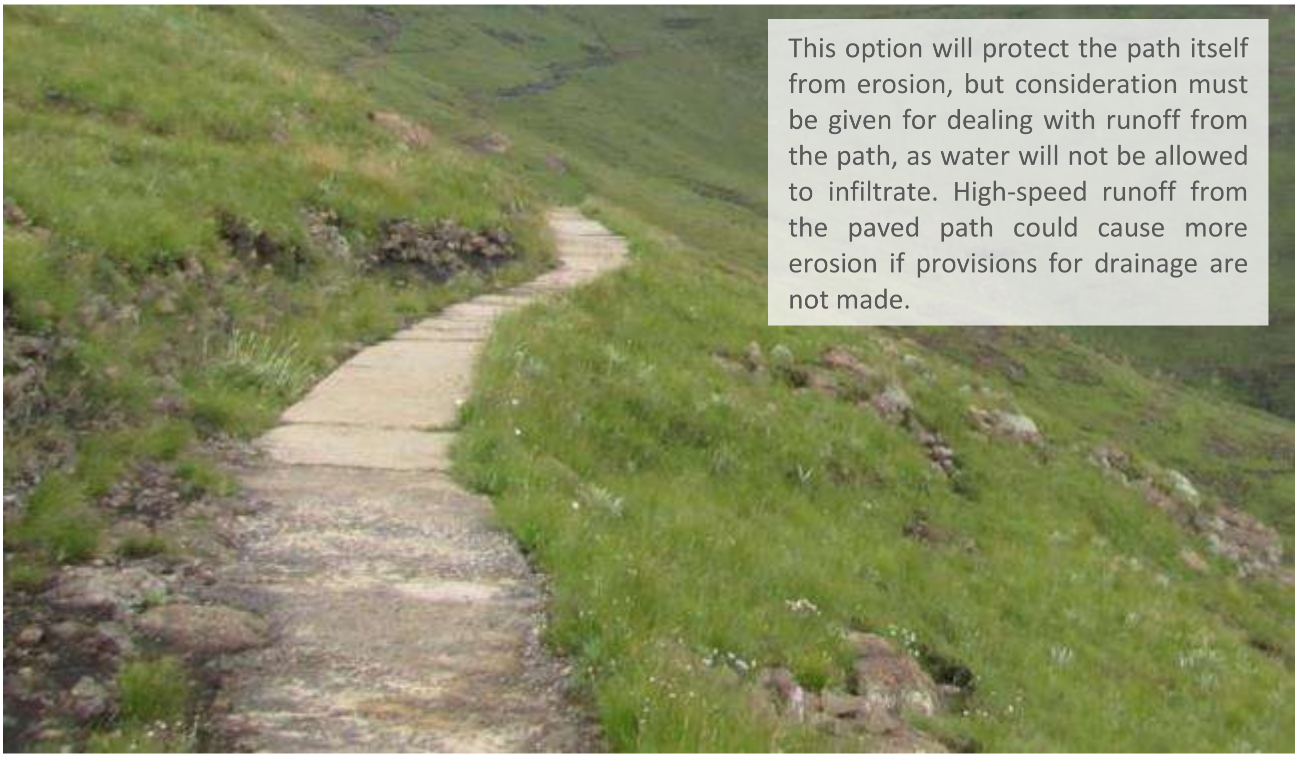



FIGURE 3-27: CONCRETE SURFACED FOOTPATH


**FIGURE 3-28: STONES ON A FOOTPATH**


**FIGURE 3-29: LOGS IN A FOOTPATH**

### TECHNICAL GUIDELINE 3-7: GUIDE FOR USING WOODEN POLES TO PROTECT FOOTPATHS

Poles (100-150 cm in diameter) are keyed into a shallow trench and dug across the slope at a 45° angle.

These poles can be pegged into place using steel droppers cut in half and bent into a U-shape. The wooden poles can also be held in place on a slope using stakes in the ground which are secured to the poles with wire, as shown below.

For very wide paths, additional poles can be added, with the ends of the poles overlapping.

If the path is so eroded that the poles are not flush with the soil surface, large stones should be placed below the poles and spaces should be filled with smaller stones and soil.

Drains should always be constructed to take runoff away from the path.

(Source: Everson et al., 2007)

FIGURE 3-30: WOODEN POLES FOR CREATING STEPS AND CONTROLLING EROSION ON A STEEP FOOTPATH

### *Kikuyu grass*

Kikuyu grass spreads rapidly and can be used to cover bare soil. Kikuyu grass spreads through vegetative shoots called stolons. Vegetative material can be collected from around homesteads and replanted in eroded areas.

**MONITORING AND COMMUNITY INVOLVEMENT**

The involvement of the local community in the monitoring of erosion control interventions can encourage residents to take initiative to implement their own erosion control measures (Everson et al., 2007). Everson carried out a 5-year project in the Okhombe community where community members were equipped with simple techniques to monitor soil erosion, providing a visual understanding for them of how to prevent erosion. The monitoring techniques used in this project and their effectiveness are described by Everson et al. (2007). This long-term project provided a positive picture of how community members empowered with information can play an active role in improving their environment and reducing erosion. The most sustainable way to improve eroded landscapes is to involve local community members on an ongoing basis. Everson and her colleagues are now pursuing this work through a Payment for Environmental Services route to encourage continued monitoring and job creation. While this may not be practical in other regions, the concept of establishing monitoring and including the local community in that monitoring will be beneficial in general.

PHOTOS COURTESY OF DR TERRY EVERSON, UKZN:

*Top left*: Runoff plots to measure runoff volumes using a 20-litre container

*Top right:* Splash board to record height of rain splash

*Bottom left:* Community members using a clarity meter to assess water quality

## VEGETATION

Vegetation is an important mechanism to:

1. Slow water down, thus reducing erosion
2. Provide shade and protection from the sun and wind

While development and vegetation sometimes seem "at-odds" with one another, the reality is that vegetation can assist with climate change adaptation, which will make developing communities less vulnerable to the impacts of climate change. Vegetation can also provide aesthetic benefits to communities. Some ideas for how vegetation should be used in communities are described below:

- ✓ Where possible protect as much natural vegetation as possible. This acts as a natural fire break, wind protection and slows down the movement of water after storms. It also helps protect the top soil from erosion.

- ✓ Where there is open space, **plant indigenous grasses or groundcover,** so that the land is not left vulnerable to erosion and loss of topsoil. These grasses will require maintenance, particularly while they are establishing. Once established, regular grass cutting will be required in order to combat fears associated with snakes in long grass.

- ✓ **Alien invasive species should be removed,** as these consume excessive water and weaken soil structures due to their shallow roots. For removal to be effective, planting of indigenous vegetation in its place should happen almost simultaneously. The indigenous vegetation should be maintained actively in order to avoid reestablishment of alien invasive plants.

- ✓ Where vegetation has already been removed, it is necessary to plant new trees and plants to ensure the above. **This goes beyond beautification, but is an essential part of the infrastructure to create resilience.**

- ✓ Trees or shrubs should be used to establish **windbreaks** in communities and on household property. A windbreak is a barrier (natural or constructed) that reduces winds by creating a "wind shadow" on the down-wind side. This reduces the velocity of wind, thus protecting adjacent activities from the impacts of wind. While windbreaks are typically used for agricultural applications (i.e. protecting fields), they can also be used in community planning to protect households and structures that are exposed to wind or open spaces where soil is exposed. Windbreaks can also improve air quality by capturing airborne pollutants. In this way, a windbreak can also have minor mitigating effects on climate change by acting as a "sink" for greenhouse gases.

- ✓ Trees provide shade for relief from hot weather and break the fall of heavy rains, reducing erosion potential.

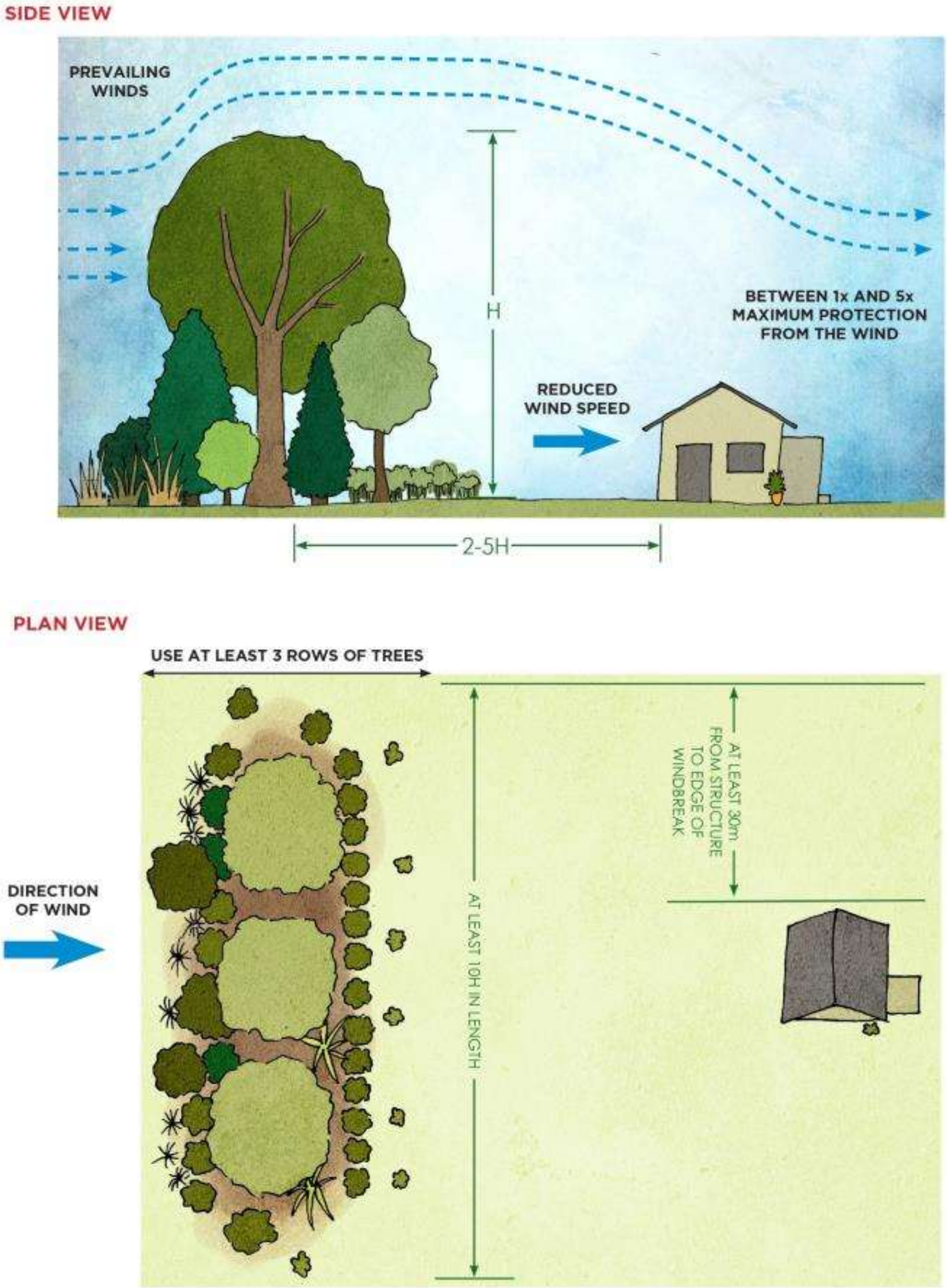



**FIGURE 3-31: IDEAL LAYOUT OF A WINDBREAK (SEE TECHNICAL GUIDELINE 3-8)**

### TECHNICAL GUIDELINE 3-8: ESTABLISHING WINDBREAKS

(Adapted from Training Manual for Applied Agroforestry Practices – 2015 Edition from the University of Missouri Center for Agroforestry)

- ✓ **WINDBREAK HEIGHT (H)**: The most important factor determining the downwind area of protection of a windbreak is height. Height is defined by the tallest row of trees or shrubs in the windbreak. For protection of households or structures, the tallest row of the windbreak should be 2-5H away from the area needing protection. The windbreak will have a positive impact out to a distance of approximately 10H from the windbreak, on the downwind side.
- ✓ **WINDBREAK DENSITY**: Density is the ratio of the solid portion of the windbreak to the total area of the windbreak. The more solid the windbreak, the less wind will pass through. Density can be manipulated by the choice of plant materials and arrangement. To protect structures, windbreak density should be approximately 60-80 percent during the period requiring maximum protection. This can be achieved using at least 3 rows of trees and shrubs with one row being conifer.
- ✓ **WINDBREAK ORIENTATION:** Where possible, windbreaks should be oriented perpendicular to the direction of prevailing winds. Since prevailing winds very rarely blow from only one direction, windbreaks are typically arranged to protect more than one direction (in an L, U, or E shape).
- ✓ **WINDBREAK LENGTH:** Provide an uninterrupted length of windbreak of at least 10H (e.g. a windbreak 10 metres tall should be 100 metres long). For protecting structures, the windbreak should extend approximately 30 metres past the edges of the structures, in order to avoid the impact of wind turbulence on the ends of the windbreak.
- ✓ **WINDBREAK WIDTH:** Adjusting windbreak width can manipulate the density of the windbreak. Width is impacted by the number of rows, distance between trees, and species composition. In addition, providing a wider windbreak can increase the wildlife value of the windbreak.
- ✓ **WINDBREAK CONTINUITY:** "Continuity influences efficiency." Gaps in windbreaks can become funnels for wind, which can increase wind velocities on the downwind side of the windbreak.

## FOOT PATHS, FOOT BRIDGES, AND STEPS

Provide paths for people so that they can access their homes regardless of the weather conditions. The aim should be to create footpaths which are safe to use (not too steep), allow for effective and efficient movement through an area (spatial layout) and provide safe crossing points for streams and rivers. Footpaths should not contribute further to erosion and should slow down the flow of water in heavy rain. As with roads, paths should, as much as possible, follow the contours of the land. On steep slopes, provide "switchbacks" (i.e. a zigzagging footpath) to avoid very steep paths and excessive runoff associated with very straight, very steep paths. Pavement and gravel will reduce the impact of mud on people's ability to get to their homes and help prevent further erosion of the paths.

Before developing new footpaths, 'read' the landscape by analysing existing footpaths. These usually represent the shortest distance between two points. As far as possible, use these as the layout for more formal footpaths. See photos above (page 50) for examples of foot paths that will improve access and reduce the risks of erosion.

## *Foot bridges*

Foot bridges are an important feature, especially where river crossings typically used by pedestrians can become flooded during flood conditions. If this happens, it could cut people off from reaching their homes or essential services, including preventing children from reaching school. If the number of river crossings is limited, requiring people to walk very far to cross the river, it may be a good idea to build a foot bridge. This also keeps pedestrians off roadways and therefore increases their safety. Similar to establishing footpaths, it is important to "read the landscape" to determine common paths that people take before establishing river crossings. If bridges are going to be built, they should be built in locations that serve the people using them and which are also suitable in terms of structural support for the bridge.

Bridges to Prosperity is an international NGO that has developed the ***Bridge Builders' Manual,*** which provides detailed guidance for assessment, design, and construction of footbridges for rural communities. This resource is very valuable and can be consulted by engineers during every step of footbridge development.

A **suspended cable bridge** is a relatively simple bridge in which cables that support the walkway hang from supports on the banks of the river. This bridge is suitable for short to mid spans in gentle sloping valleys or short to long spans in gorges. A **suspension bridge** uses strong cables that are strung between high towers on each side of the river, with the deck suspended from the cables.

FIGURE 3-32 (RIGHT): A SUSPENDED CABLE FOOTBRIDGE

FIGURE 3-33 (BELOW): A SUSPENSION FOOTBRIDGE

(SOURCE: BRIDGES TO PROSPERITY)

Figure 3-34 and 3-35 show typical design details for a suspension footbridge. While this example demonstrates the technical aspects of a bridge, it is important to note that the bridge design will be highly dependent on the site requirements and characteristics.

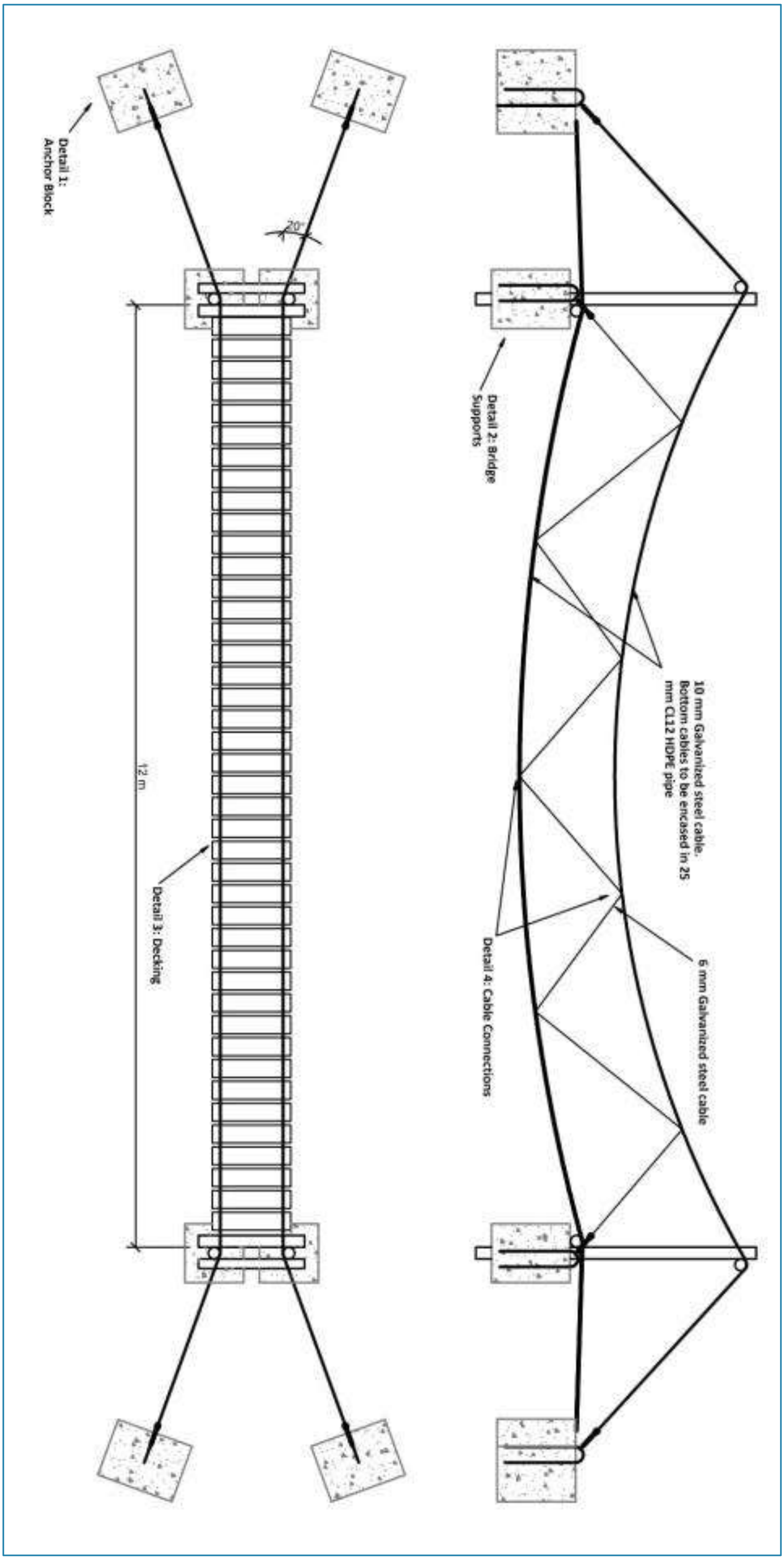



FIGURE 3-34: TYPICAL DESIGN LAYOUT FOR A SIMPLE SUSPENSION BRIDGE

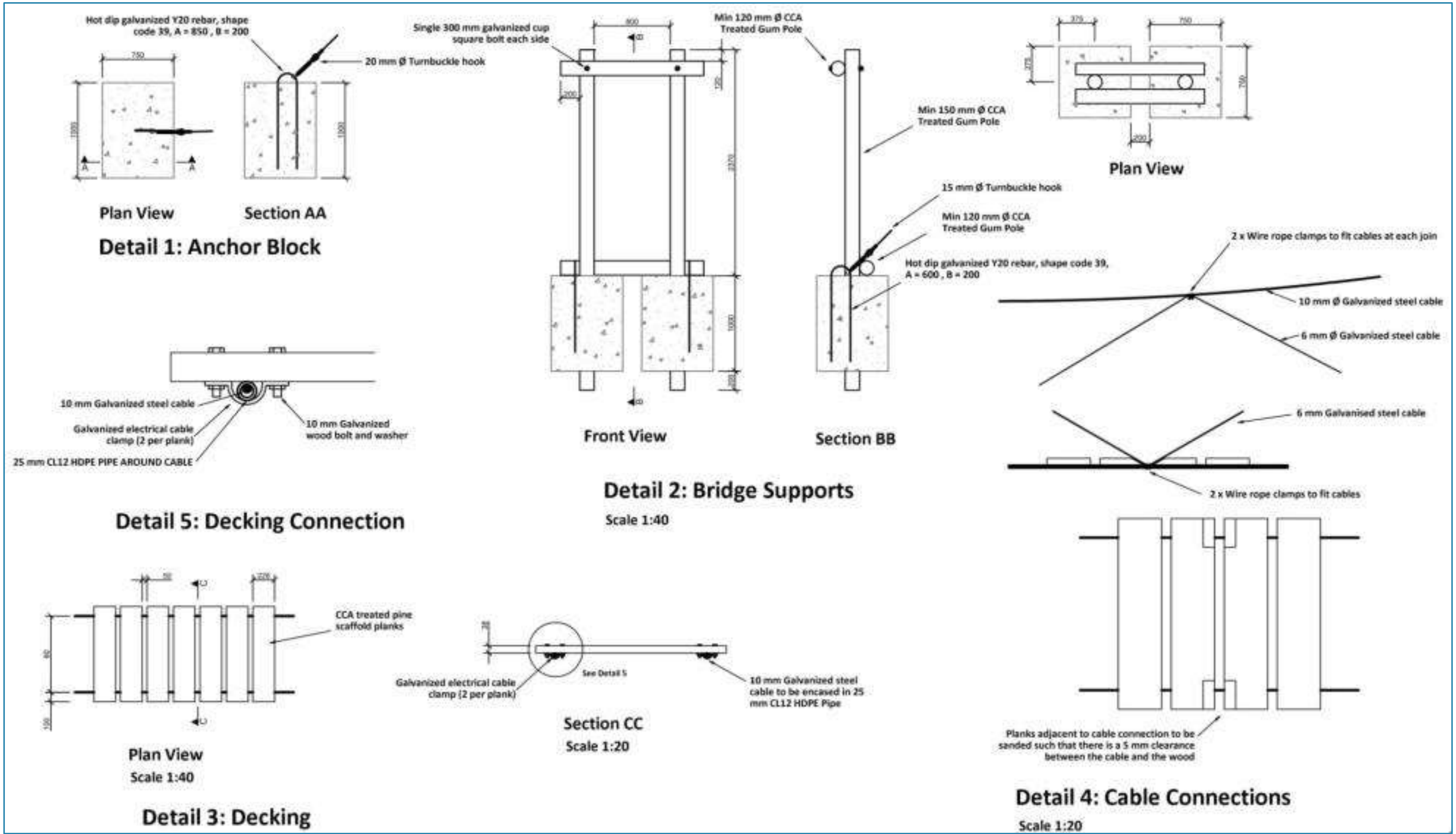



FIGURE 3-35: TYPICAL DESIGN DETAILS FOR A SIMPLE SUSPENSION BRIDGE

## FIRE BREAKS

See the guidelines on the National Veld and forest Fire Act no 101 of 1998, prepared by the Department of Agriculture, Forestry, and Fisheries HERE

The National Veld and Forest Fire Act no. 101 of 1998 requires landowners to prepare and maintain firebreaks. A firebreak is a strip of land where vegetation has been removed or modified to contain or reduce the spread and intensity of any wildfire that may occur in or enter a property. Firebreaks can be prepared by grading, ploughing, disking, hoeing, or burning.

## WASTE MANAGEMENT

The negative impacts of poor solid waste management will be made worse due to climate change impacts and impacts on general liveability of settlements. To reduce health and pollution risks, inhabited areas must have solid waste management systems in place. This is particularly challenging with isolated communities, due to restrictions related to transport of waste over long distances. If solid waste collection is not provided, it does not mean that solid waste is not produced. If it is not collected, it will be dumped in centralised areas that are selected out of convenience without regard for the impacts the dump sites could have on the local and regional environment. In the event of a storm with excessive runoff, this solid waste is often washed into nearby watercourses, leading to pollution. If the rubbish is burned by community members, there is a risk of fire spreading in an uncontrolled way. Proper solid waste management is vital.

Because centralised waste management is not always practical due to transport costs, local, community-based waste management systems should be adopted. One example could include employing community members to collect waste directly from households and deliver it to a designated waste disposal site. Alternately, households can be responsible for delivering their waste to designated collection points on a regular basis and from the collection points waste can be transported to the disposal site. Collection points should be visible and their boundaries should be clearly marked to avoid illegal dumping. Collection points should also be dispersed throughout the community, rather than large, centralised points. This will again encourage households to take their waste to the collection points rather than to illegal local dumping sites out of convenience.

Waste sorting can take place at the waste disposal site if there is potential for recycling in the community. Then, on a less frequent basis, municipal authorities can collect waste from the waste disposal site and deliver it to the regional landfill site.

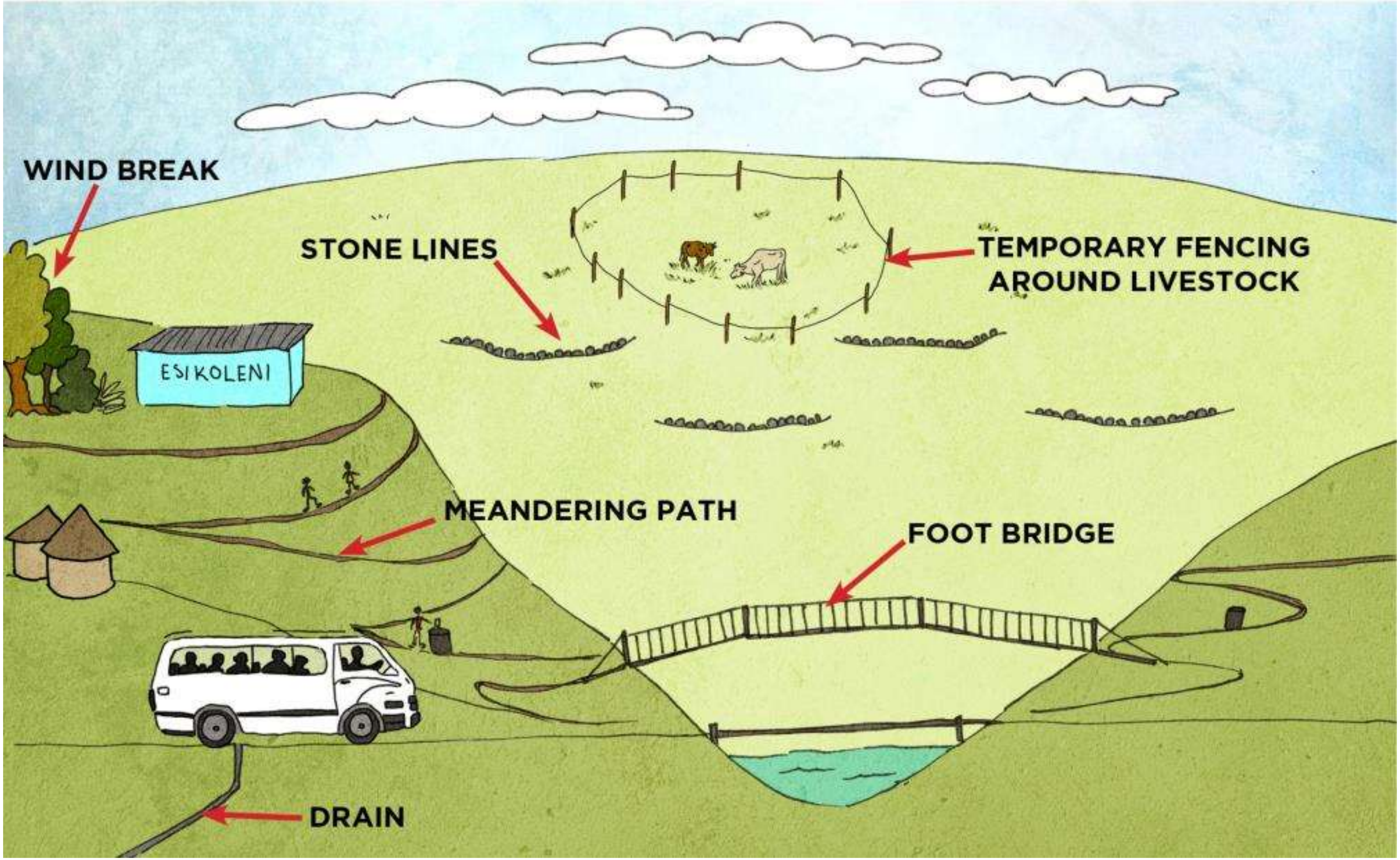
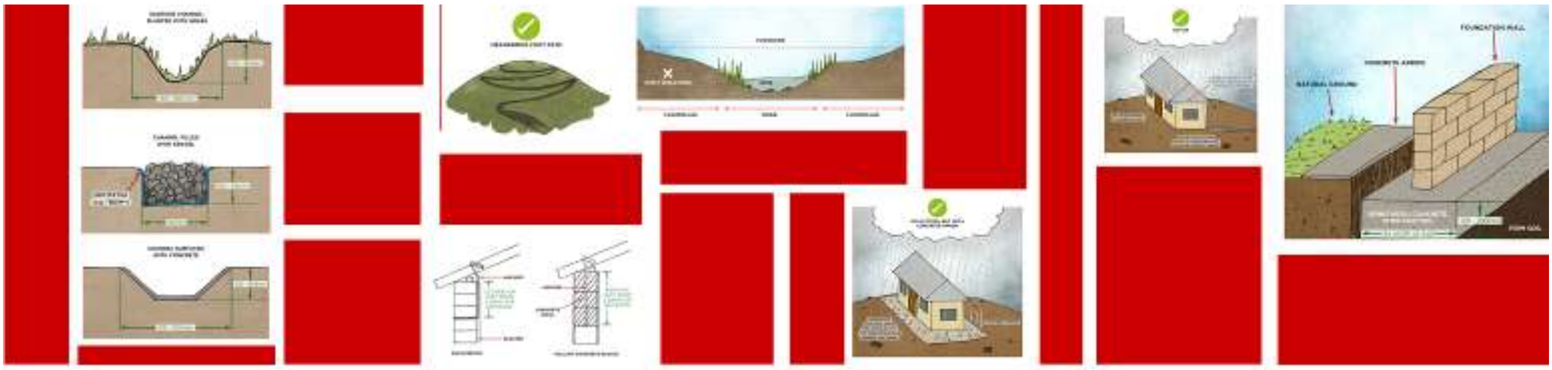
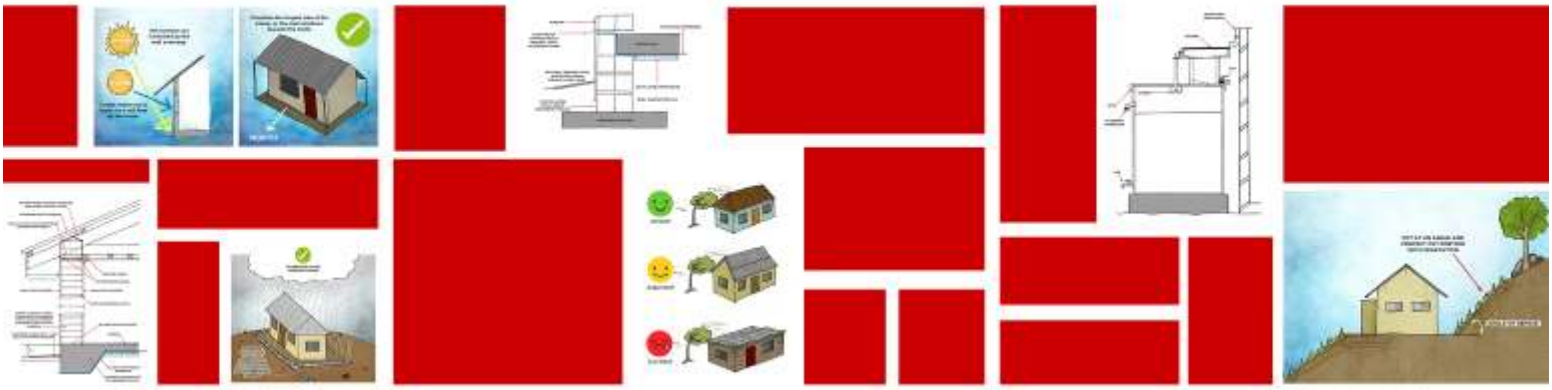



**FIGURE 3-36: A CLIMATE-RESILIENT VILLAGE**



# CHAPTER 4



# Household Resilience

uMgungundlovu Climate Change Adaptation Toolkit

# CHAPTER 4: HOUSEHOLD RESILIENCE

## OVERVIEW OF HOUSEHOLD RISKS AND VULNERABILITIES

FIGURE 4-1: HOUSEHOLD LEVEL RISKS AND VULNERABILITIES

## STORM AND WIND DAMAGE TO HOUSES

Informal houses are more vulnerable to damage from storms. Also, houses built with sub-standard materials can experience damage during storm events, particularly if no waterproofing is provided. Where roofs are not properly secured, they are easily blown off during heavy wind storms, exposing the house to the elements and requiring finances for repair.

FIGURE 4-2: IN NHLAZUKA, SOME BUILDING MATERIALS HAVE BEEN COMPROMISED OVER TIME AND MANY FAMILIES USE BUCKETS, TYRES, BRICKS, AND/OR STONES TO KEEP ROOFS FROM BLOWING AWAY IN THE WIND.

## FLOODING AND EROSION

Flooding and erosion can destroy houses and paths and compromise access during periods of flooding. If flood risks are not adequately considered when siting and building houses, entire households can get flooded, which puts the householders, the structure, and furniture inside the house at risk. A house must provide safety for residents and thus, flooding during large storm events is unacceptable.

Erosion of soil around buildings leads to weakened soil structure and can make structures less stable. The increase in storm intensity will lead to greater volumes and velocities of stormwater runoff, which will contribute to erosion of soils around households.

## SLOPE RISKS

Building on steep slopes increases the risk of houses being washed away. Development on steep slopes is also costly and at a greater risk of erosion. Steep slopes also make access more difficult, both by foot and by vehicle.

FIGURE 4-3: A HOUSE BUILT INTO A STEEPLY SLOPED PLOT OF LAND, WHICH HAD BEEN CUT IN ORDER TO BUILD THE STRUCTURES. THE SHARP EDGE CREATED BY THE CUT IS EXPOSED TO EROSION, WHICH WILL HAPPEN OVER TIME. THE EDGE ALSO MAKES FLOODING OF THE STRUCTURES ON THE PLOT MORE LIKELY.

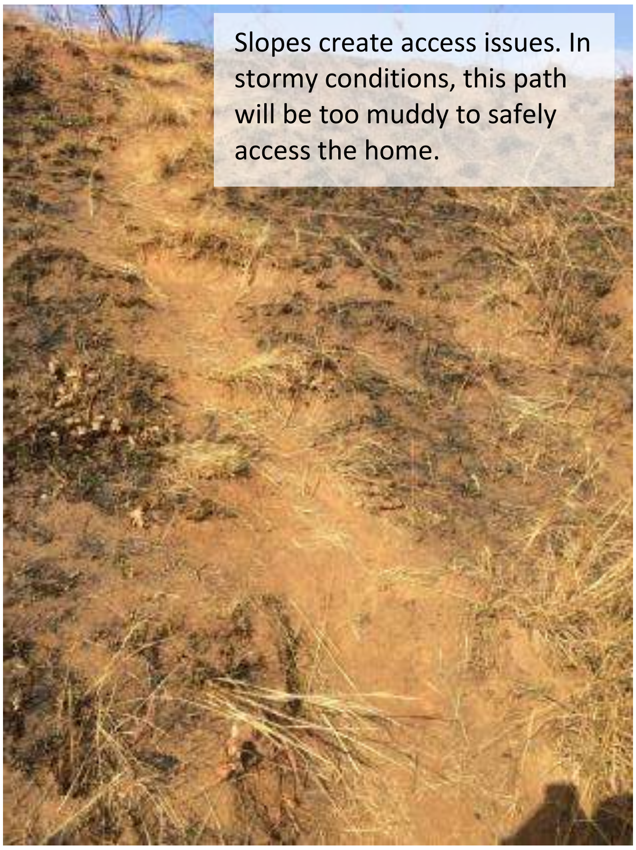



FIGURE 4-4: PRECARIOUS SLOPES LIMITING ACCESS IN NHLAZUKA

# TECHNICAL CONSIDERATIONS FOR BUILDING RESILIENCE AT THE HOUSEHOLD LEVEL

These considerations can be used by officials at municipal (local and district) level as well as householders building their own houses. The guidelines can be distributed to Izinduna and Amakhosi to communicate to householders.

## CHOOSING WHERE TO BUILD AND WHERE NOT TO BUILD

- ✓ Most importantly, new housing should not be located in areas which are vulnerable to flooding. This means that houses should not be built too close to rivers (Figure 4-5).
- ✓ Outside of flood prone areas, houses should be located on the flattest piece of land possible.
- ✓ Steep slopes should be avoided. If they cannot be avoided, proper reinforcement, such as retaining walls, should be provided.
- ✓ Choose sites that are near to good roads but not too close to main busy roads.
- ✓ Choose sites that have access to schools and public amenities.
- ✓ If not enough sun, must use winter sun well and must try to exclude or limit summer sun.
- ✓ Avoid sites that are exposed to and unprotected from wind (e.g. on top of a tall hill).
- ✓ Aim to build where the land is relatively flat and on higher ground out of the risk of flooding. Do not develop or allow new housing on slopes steeper than 1:10.
- ✓ Where a house has to be located on a slope, the platform for the house should be oriented on the contour.
- ✓ Reserve space for the house to grow and be added onto, so don't build up too close to other structures.
- ✓ Homes built in shaded areas can become cold and very damp. Avoid this by building in areas where winter sun is not blocked out by trees or the slope of the land.

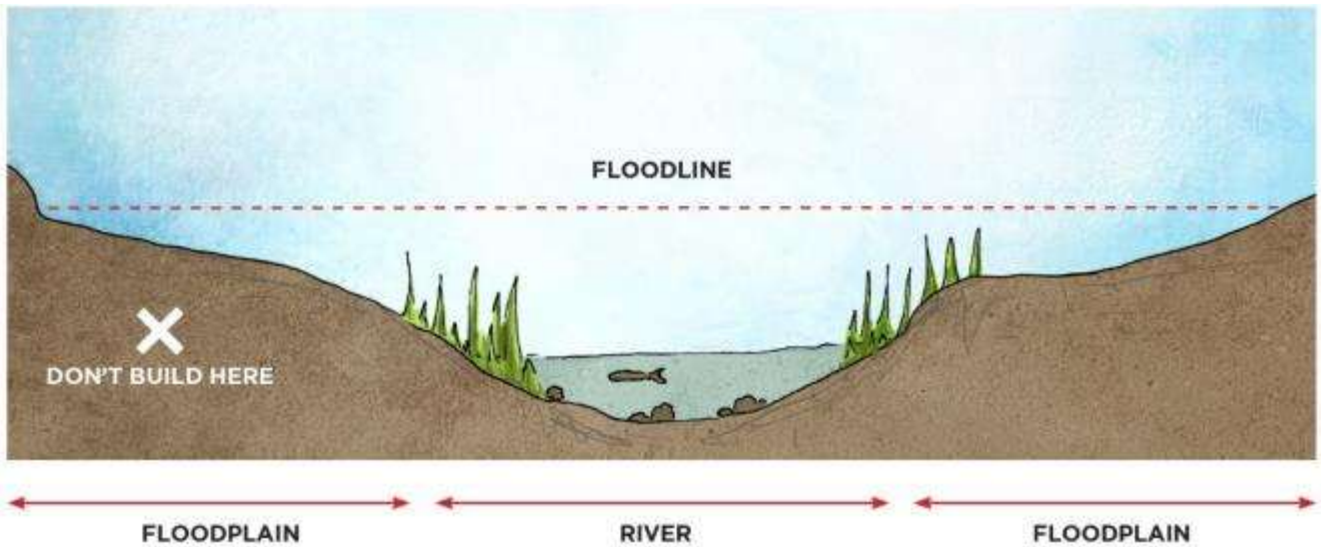



FIGURE 4-5: AVOID BUILDING NEAR RIVERS AND IN THE FLOODPLAIN

### *If building on a steep slope…*

If building in a steep area is unavoidable, the hill should be cut as shown in Figure 4-6. Make sure that the earth is sloped at less than the **angle of repose** for the type of soil on site. This is especially important if no retaining wall is provided on the uphill side of the house. The cut portion must be protected from erosion, which can be done by planting shrubs or tall grasses.

The **angle of repose** refers to the steepest angle (relative to the horizontal plane) that a material can be piled without slipping. If earth is cut to a steeper angle than this, it will be unstable, making erosion and mudslides more likely.

You can find estimates of the angle of repose for a few different soil types here: http://structx.com/Soil_Properties_005.html

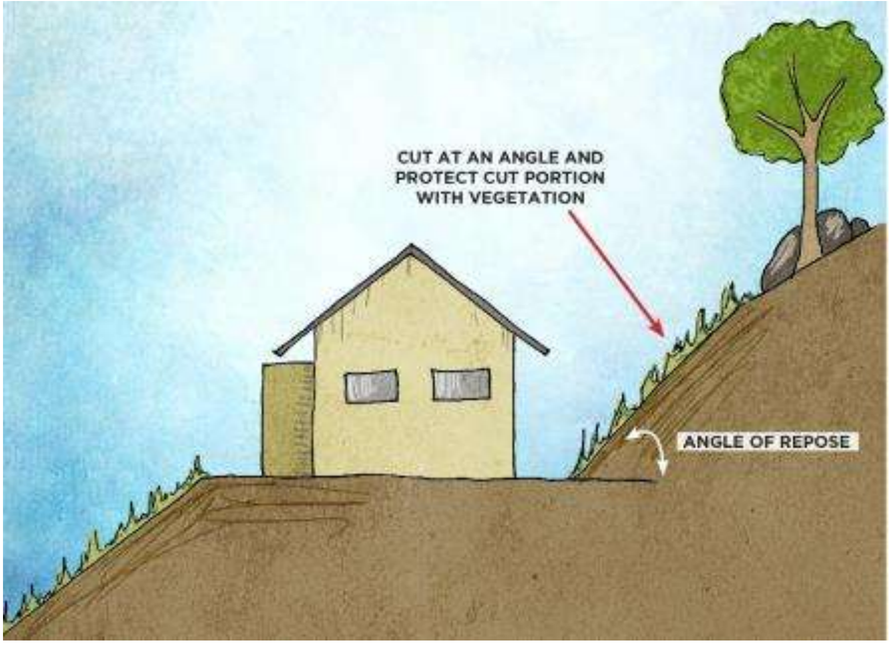



**FIGURE 4-6: BUILDING ON A STEEP SLOPE**

If cutting at an angle is not possible, retaining walls should be incorporated into the site, which will protect the banks from erosion. A simple and relatively cheap way to build a retaining wall is using used tyres filled with soil. This can be done on the uphill and downhill sides to help stabilise soil that has been cut.

FIGURE 4-7: A SIMPLE RETAINING WALL MADE USING OLD TYRES

### TECHNICAL GUIDELINE 4-1: BUILDING A RETAINING WALL WITH OLD TYRES

There are many different methods for building retaining walls, most of which can be seen on the sides of roadways in built up areas. One of the simplest methods is the gravity wall, which is built at a slope rather than vertically. The many different types of mortarless concrete block retaining walls and rock gabion retaining walls are all variations of the gravity wall. An inexpensive gravity wall can be made from old car tyres using the following method:

- Collect the required number of tyres, all of the same diameter and width.
- Cut the side walls away from the tyres (only the tread portion is required).
- Create a level foundation for the first row of tyres.
- Place a 50 mm thick bedding layer of river sand on the foundation and rake it even and level.
- Lay the first row of tyres flat on the foundation, side by side.
- Fill the tyres and the space behind the tyres with soil and compact the soil.
- Place the second row of tyres on top of the first. This row must be set back to make a small step, with the offset distance being at least half the height of the tyre. The tyres in the second row must be horizontally offset by half a tyre diameter (i.e. the way bricks are laid – not in stacks but interleaved).
- Fill the tyres in the second row and the space behind those tyres with soil and compact the soil.
- Use half tyres to make up the spaces on the ends of the second row.
- Continue with the third row as for the second, and so on up to the desired height.

Using this method one can safely build retaining walls up to 3 metres high. For higher walls it would be advisable to get professional advice. After the wall is completed it is advisable to plant the wall with a suitable spreading groundcover. This will greatly improve the wall's aesthetic appearance and will prevent the proliferation of ugly weeds.

## ORIENTING THE HOUSE

The orientation of the house can make a big difference to how comfortable it is to live in. This can be done using passive solar design principles.

### *Aim to use the winter sun well, and limit the impact of the summer sun.*

- ✓ Make sure the roof on the northern side of the house overhangs by about 500cm. This allows the warm winter sun to get in, but will stop the hot summer sun.
- ✓ Lay solid brick or concrete floors to create a thermal mass which is able to absorb the warm winter sun and warm up the whole house.

### *Windows*

- ✓ Place windows so that when it is hot, they can be opened to allow for a through breeze. Try to put windows facing each other on opposite walls to make the breeze path as easy as possible.

### *House colour*

- ✓ In cool areas, darker colours will heat up and keep the house warm.
- ✓ Lighter colours will reflect the sun and keep the house cool.

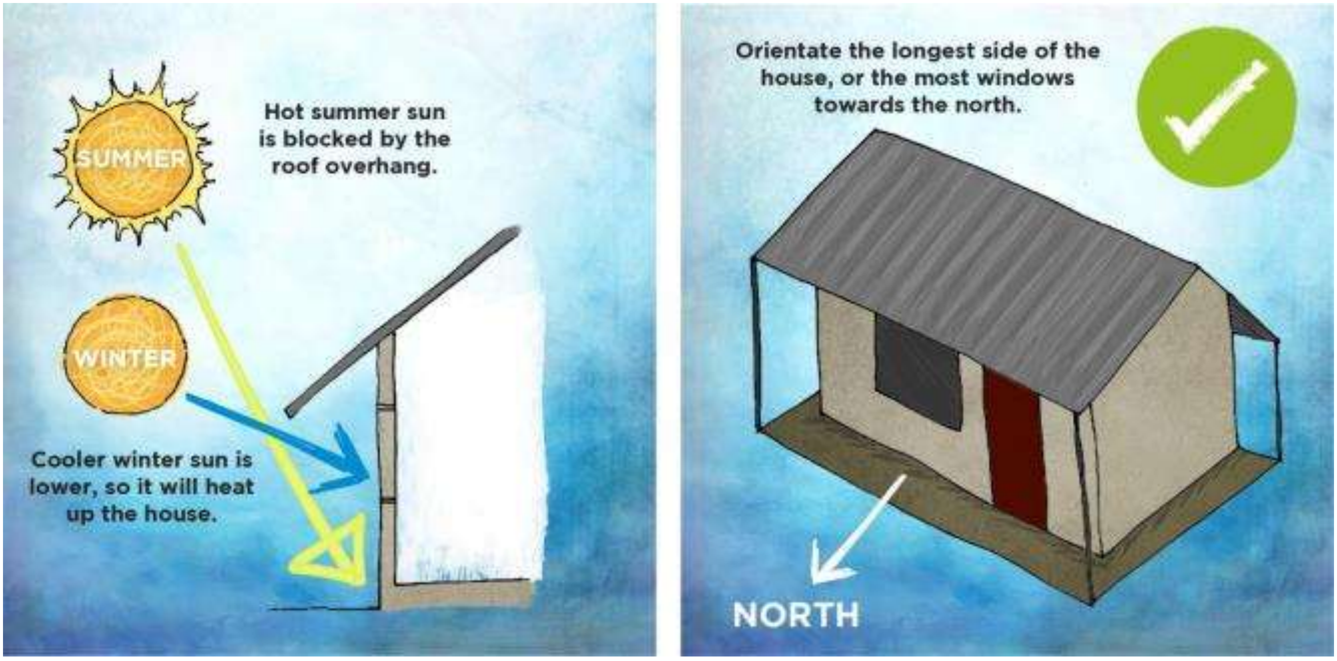



**FIGURE 4-8: HOUSE ORIENTATION FOR PASSIVE SOLAR DESIGN**

## CONSIDERATIONS WHEN CHOOSING A LOCATION FOR A PIT TOILET

**Don't build too near to water –** As a general rule, do not build a pit toilet within 30 metres of a borehole. Build the toilet as close as possible to the main dwelling to make it safely accessible at night and during stormy weather. Ensure that stormwater is diverted around the toilet and does not flood the toilet. Orient the pit toilet so that it is sheltered from prevailing inclement weather (primarily rain from the Eastern Cape and winds from the NW Drakensberg).

## BUILDING TO RESIST STORMS AND CHANGES OVER TIME

Climate resilient design features *make homes resilient to climate vulnerabilities, such that they maintain an acceptable level of functioning and structure.*

(Madjumar, 2015)

***KEY CONSIDERATIONS FOR HOUSING***

- ✓ LOW MAINTENANCE
- ✓ ADEQUATE VENTILATION
- ✓ GOOD INSULATION
- ✓ DAMP-PROOFING

***COMMON PROBLEMS IN LOW COST HOUSING:***

- ✓ CRACKS IN WALLS
- ✓ FLOODING OF HOUSE
- ✓ DAMP

Apart from wildfires, extreme storms can cause the most damage to houses due to excessive rain and wind. There are a number of options for adapting existing households as well as designing new ones so that they are resilient to climate vulnerabilities associated with extreme storms. Main considerations, among others, include: durable building materials; roofs that can withstand high wind velocities and will not cause damage to the house during heavy rains; and designing buildings to reduce flooding and erosion potential. Concrete blocks and clay bricks can be used to construct durable houses, but in certain areas, delivery of these materials to site is restricted. Wherever possible in difficult to reach areas, local materials should be used. This will limit costs associated with delivering materials to site.

### *The starting point: Foundations*

Good foundations will help ensure that houses do not shift and move over the course of time, reducing the chances of cracks in the walls and other structural issues. The foundation must extend to the solid ground, providing the house something firm to sit on.

**Strip foundations** are the most common type of foundations and are the simplest to build.

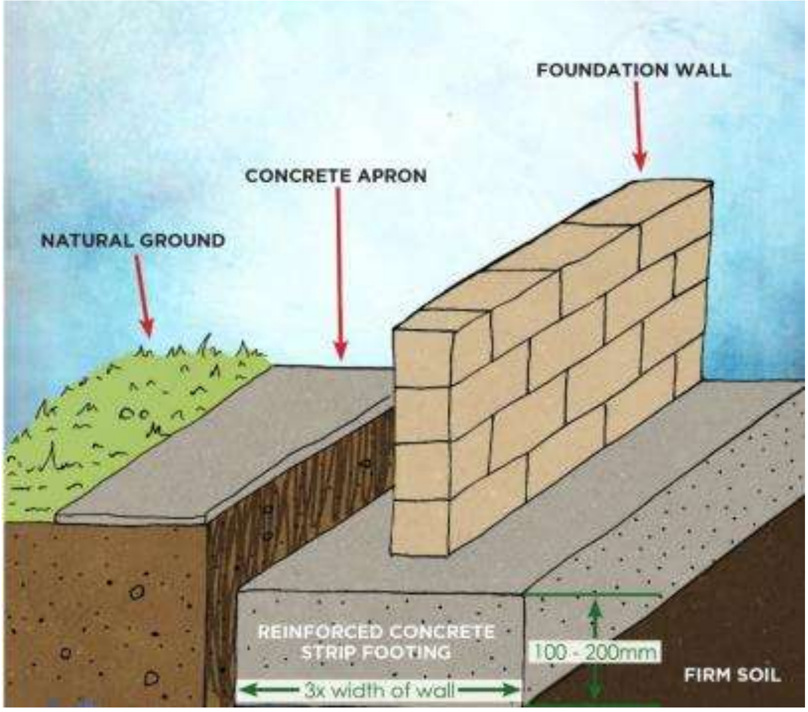



FIGURE 4-9: STRIP FOUNDATIONS

## Technical guideline 4-2: House Foundations

The most important factors to consider when selecting the type of foundation are:
**SOIL CONDITIONS** and **THE HEIGHT OF THE GROUNDWATER TABLE**

Sometimes, the amount of water in soil changes, which causes movement and cracking in walls. This is particularly likely in soils with high clay content. This is why a well-prepared foundation is vital.

**Compaction** can occur when soil particles move closer together under the weight of the top structure. This can also happen as a result of a change in the soil moisture content.

Typically, strip foundations are used for building, except in special cases, such as unstable soil. **PILE FOUNDATIONS** or **RAFT FOUNDATIONS** can be used in special circumstances. Pile foundations reach down to stable layers in the ground and are therefore very deep in the ground. Raft foundations spread the weight of the top structure over a large surface.

Though both of these will result in greater construction costs, they will also result in less maintenance costs in the future, as the walls will be less likely to crack.

The National Homebuilders Registration Council states the following requirements for strip foundations:

1. For single-storey buildings, the minimum width of strip foundations should be 500mm for external walls and 400mm for internal walls, and for double storey buildings, strips should be 750mm minimum for external walls and 600mm for internal walls.
2. The average minimum thickness of the foundation must be at least 200mm, and the strength of concrete for unreinforced footings should be 15 MPa.
3. The minimum depth of a strip foundation trench must be at least 400mm below the original ground level.
4. 48 hours after the concrete foundation has been placed, the first 500mm of brickwork can be built to above the ground level. Concrete should then be carefully wetted and the trenches backfilled with soil.
5. Only 7 days after placing the concrete foundation should walls be built up to roof level.

Resources that might come in handy when designing and building structures:

"A Guide to the Home Building Manual" (2014) is available on the National Home Builders Registration Council website at https://www.nhbrc.org.za

https://sans10400.co.za is a website that has been created to explain SANS 10400, South Africa's National Building Regulations. The website provides simple explanations of different parts of the regulation, which can be useful, especially for non-technical people.

## *Dealing with damp*

**Damp** in houses is a health and safety related issue and can be caused by a number of things, including penetration of water through leaks or cracks, moisture rising from the ground into a wall, and condensation of water on surfaces. Damp can impact the health of householders, as it provides an ideal environment for growth of mould. This can make allergies worse and in some extreme cases can cause permanent health damage. Also, especially in houses built with materials that are sub-standard and not waterproof, damp can reduce the structural stability of the house, posing serious safety risks. Reduce the risk of damp by:

1. Ensuring the floor level of the house is at least 150 mm above ground level;
2. Sloping the ground around the dwelling gently away from the building to protect it from damp and flooding;
3. Where the plot is sloped, providing surface drainage channels to ensure drainage away from the building;
4. Building a cement strip, like a veranda, along the front entrance to the dwelling;
5. Providing regular maintenance of any leaks or cracks in the structure;
6. Providing adequate ventilation to prevent water droplets from settling on the walls;
7. Installing a damp proof course. A diagram of a physical damp proof barrier is shown in Figure 4-10.
8. Making outside walls cavity walls to stop moisture from entering homes and to provide insulation.

**Damp** refers to moisture that is present in a household structure. Different types of damp occur in houses and are caused by different things.

**Penetrating damp** is caused by water entering the structure through leaks in the roof or cracks in the walls. It may also be caused by leaky plumbing.

**Rising damp** typically shows up on the lower parts of internal walls and results from groundwater moving up through brickwork.

**Condensation** occurs when moist, warm air makes contact with a colder surface, leading to water in the air settling on that surface. This is often caused by steam from showers, baths, or even from people's breath in a closed room. It is usually an indication that ventilation is poor.

### TECHNICAL GUIDELINE 4-3: DAMP PROOF COURSE

- ✓ A damp proof course refers to the first layer of bricks laid over a damp-proof barrier. The damp-proof barrier acts as a moisture barrier for foundations, preventing moisture from rising into the brickwork or floor.
- ✓ The damp proof barrier should be a membrane that will not allow water to pass through, such as a 375 micron plastic membrane.
- ✓ The membrane sits between a sand base and the concrete floor and extends into the brick wall. The membrane should slightly stick out of the brick wall, being visible.
- ✓ The floor of the house should be at least 150mm above ground level to avoid flooding.
- ✓ Plaster on the outside walls should extend to approximately 50mm above the concrete footing. This will protect the walls from damp while still allowing for drainage of water from inside the wall.

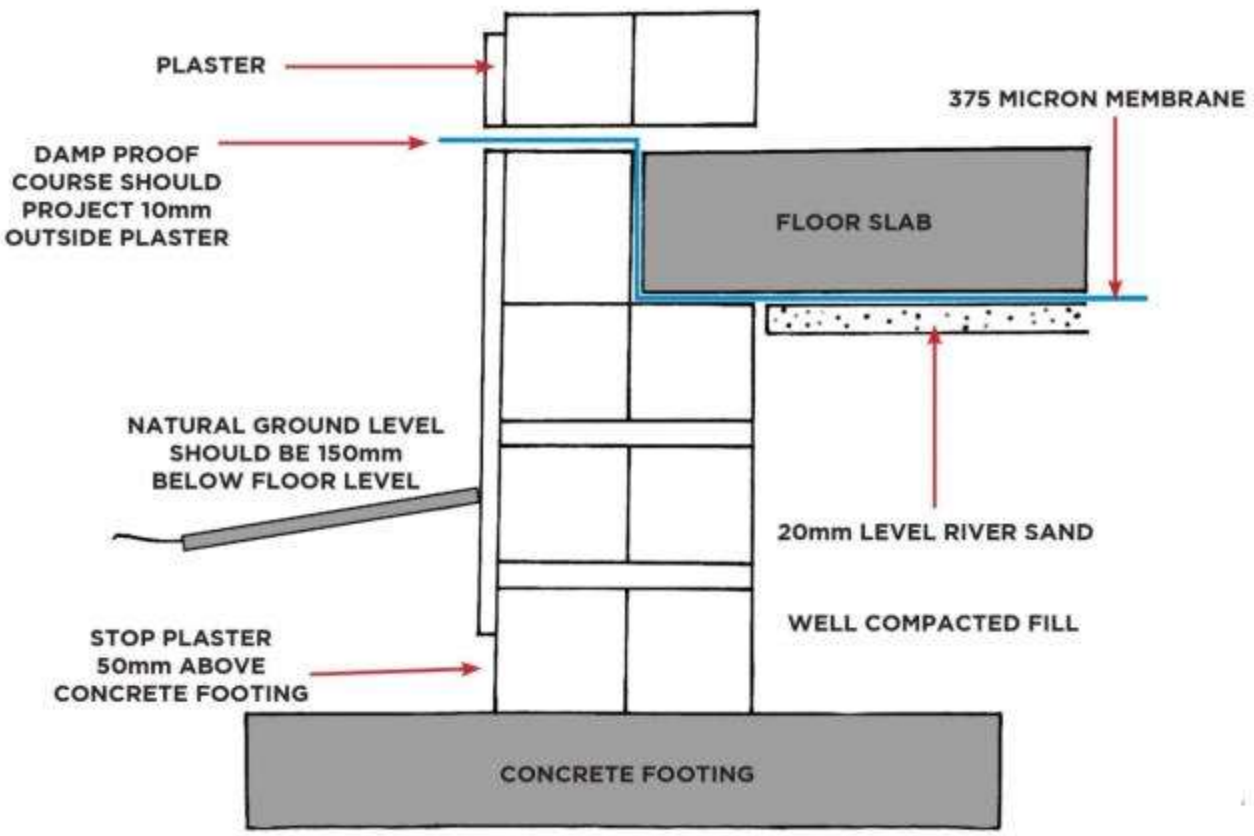



FIGURE 4-10: DETAIL OF DAMP PROOF COURSE AND PLASTER TO HELP WATERPROOF HOME FOUNDATIONS AND PREVENT RISING DAMP (ADAPTED FROM *THE* PROUD *HOME OWNER* BY ALBERT VAN WYK)

### *Considering materials*

Building materials should be selected to last the longest and resist damage from excessive rainwater. Commonly-used bricks and concrete blocks provide a sturdy structure, but waterproofing plaster should be applied to help them resist damp.

Building with wood has some benefits, including the fact that wood is lightweight, making it easier to transport; wood is strong *and* flexible; wood is relatively cheap; and properly treated wood can last a long time.  Using treated wood is vital, because without treatment, wood is extremely vulnerable to damp which will lead to decay and growth of mould.

Roof overhangs should always be provided, extending at least 300 mm from the walls of the house. This is sufficient for waterproof materials, such as concrete blocks with plaster, but less waterproof materials should be provided with a wider roof overhang to ensure water does not flow down the house walls (see guidance for mud and compressed earth block construction below).

***TRADITIONAL MUD CONSTRUCTION***

In Nhlazuka, as is very common in other parts of uMDM and South Africa, mud construction is very common for owner-built houses. It is incorrect to assume that homes built with mud will automatically be unable to withstand extreme storms. In fact, **mud homes, if constructed properly, can have a similar lifespan as those built with modern bricks.** However, owner-built houses often lack the necessary features for drainage and waterproofing, making them vulnerable to heavy storms. In addition, building guidelines in South Africa do not make mention of mud as an optional building material, suggesting that it is not seen as an option for permanent, government led initiatives. However, given the large amount of mud homes existing in South Africa, climate-proofing mud houses should be considered as one option for improving resiliency.

For mud houses (or other materials without waterproofing), provide **roof overhangs that extend 700 mm from the wall of the house**. This will ensure that rainwater hitting the roof is drained away from the house, rather than running down the side of the mud home. A **1-metre concrete apron** should also be provided around the house to ensure that rainwater drains away from the house.

### *COMPRESSED EARTH BLOCKS*

Compressed earth blocks (CEBs) are made mostly of soil with a small percentage of a stabiliser (e.g. cement) and water to form a brick. They provide similar structural benefits of traditional clay and concrete blocks, but they are typically **cheaper**, more **breathable**, better **insulators**, and more **sustainable** to make. These can be specified in place of concrete bricks, which is the typical material used in household construction. Compressed earth blocks are typically made on site, which means that **access limitations related to delivering large loads of concrete blocks do not apply**. Once the compression machinery is on site, all blocks are made there in a similar, yet slightly more sophisticated manner as that used for making traditional mud bricks. This also provides job opportunities for the local community.

CEBs have now secured approval from the South African Bureau of Standards (SABS), the National Homebuilder Registration Council (NHBRC), and Construction Industry Development Board, giving the system validity under the laws of South Africa. In KwaZulu-Natal, a non-profit company called **Use-It** has developed compressed earth bricks/blocks using cement for stabilisation, which have now been commercialised as Rambrick. Use-It successfully received the Agrèment Certificate for the "Compressed Earth Blocks Building System," which provides a regulatory framework for using this technology in practice. The certificate provides standards for water-proofing the foundation of these buildings and protecting the bricks from being inundated with rainwater.

### TECHNICAL GUIDELINE 4-4: MAKING A COMPRESSED EARTH BLOCK HOUSE WEATHER-RESISTANT

The following characteristics will make a CEB home resistant to the negative impacts of weather:

1. A damp proof membrane beneath the concrete foundation keeps water from inundating foundations.
2. A concrete apron sloped away from the building to ensure proper drainage.
3. The beginning of compressed earth bricks is 150mm (minimum) above the concrete apron, reducing chances of flooding compromising their integrity.
4. The overhang of the roof (700mm minimum) ensures that rainwater draining from the roof will be effectively drained away from the structure.

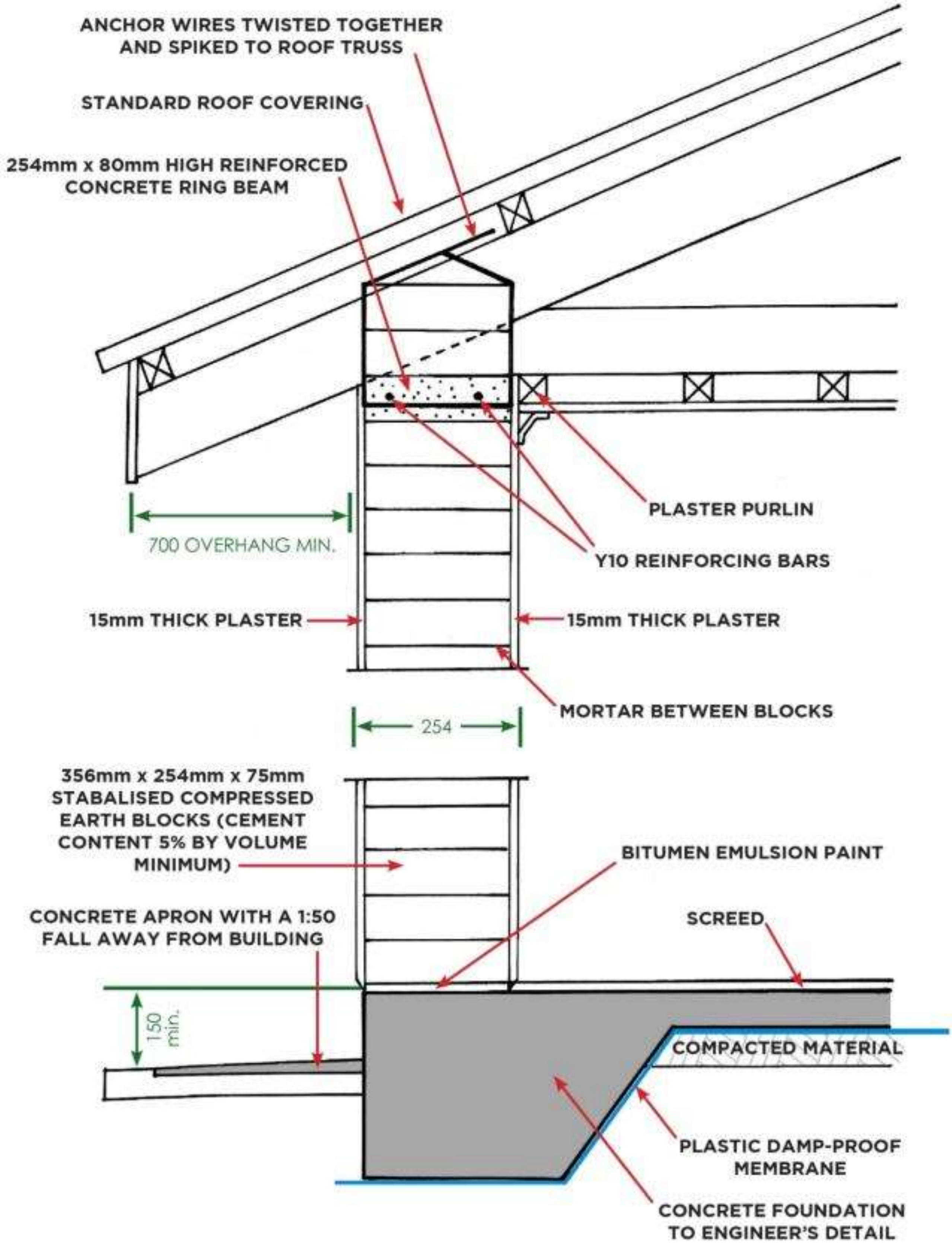



FIGURE 4-11: WEATHERPROOFING A COMPRESSED EARTH BLOCK HOUSE (ADAPTED FROM USE-IT AGRÈMENT CERTIFICATE 2011/397: COMPRESSED EARTH BLOCKS BUILDING SYSTEM)

### *Building to resist wind damage*

The shape of the house is important in reducing the impact of heavy winds on houses. Simple shapes are best, including round and square houses. With these shapes, wind typically moves more effectively *around* the house. Rectangular houses should not be longer than 3 times their width, because the length makes them vulnerable to wind. T and L shaped houses often channel wind into corners, which strengthens the wind and can lead to failure of the structure.

Wind breaks can also be installed along the boundary of households to reduce the impact of wind on the plot of land. These were discussed in Chapter 4 in Technical Guideline 3-8 and Figure 3-31.

## BUILDING MATERIALS: IMPROVING INSULATION

Insulation can save the money and energy used for keeping poorly-insulated homes warm in the winter. For those who do not have access to heating or cooling, insulation makes staying in the home much more bearable. A number of options for building well-insulated houses are described below. **Traditional construction using mud and thatched roofs is effective in terms of insulation. The more modern method of using concrete blocks and corrugated iron roofs requires additional measures to ensure good insulation.**

| | |
|---|---|
| **Natural insulators** | Mud, sawdust, wool, straw, cork, seaweed, waste wood |
| **Manufactured insulators** | Cardboard, polystyrene, plastic bubble insulation |
| **Cavity walls** | Cavity walls are double walls with an air gap in between the two. The air acts as an insulator for the house, since air is a poor conductor of heat. |
| **Straw bale construction** | Straw bale homes are well insulated. They are constructed using straw bales, which in South Africa are most often made of leftover bits from harvesting wheat. First, a wooden frame is built and the walls are built up using straw bales. The structure is made more secure by inserting thin steel bars or wire through the bales. Finished walls can be wrapped in galvanised chicken wire and then finished with cement plaster. Straw bale houses are a relatively simple and cost-effective way to produce a well-insulated house. |
| **Thatch roofs** | Thatched roofs are good insulators and can be built of locally-sourced materials. |
| **Ceilings** | Ceilings are the most effective measure to keep warm air inside. Installing a ceiling below the roof provides a buffer, which keeps cold air out of the living space. |
| **Cellulose Fibre Insulation** | Cellulose fibre insulation can be used to insulate households by restricting loss of heat during winter and the penetration of heat into houses during summer. This type of insulation is produced from finely-shredded, recycled newsprint. The material is treated with products that make it fire resistant and rodent and insect repellent. It does not have harmful or toxic consequences like other chemical-based insulating materials. |

## BUILDING DURABLE ROOFS

Roofs must be able to withstand heavy winds and rains associated with extreme storms. A roof's ability to resist strong winds depends on a number of factors, including: the roof's shape; connection to the house; material; and slope. Roofs must also be able to drain properly when rain falls on them.

A hip roof is the most resistant to high winds and is recommended for all houses to ensure that the roof remains intact during storms. However, hip roofs are more expensive to construct. A gable roof can be used, but it should have a steep pitch (30 degrees or more). The overhang of the roof should also be limited to 450mm to 600mm to avoid wind building up beneath the overhang. This will keep the roof from being lifted from the house during strong winds. Flat roofs are cheaper but are less resistant to high winds.

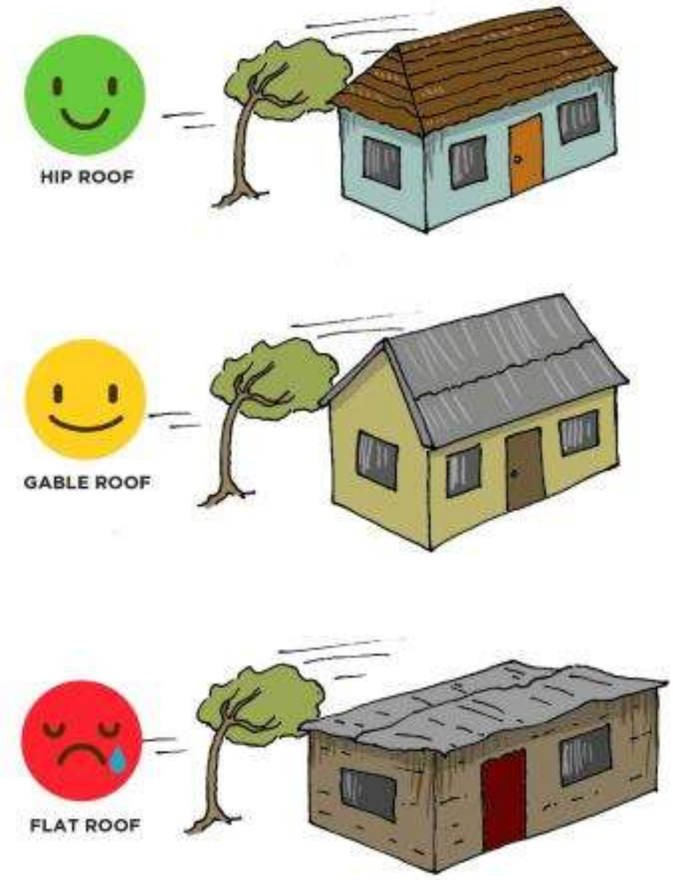



FIGURE 4-12: WIND RESISTANCE OF ROOF SHAPES

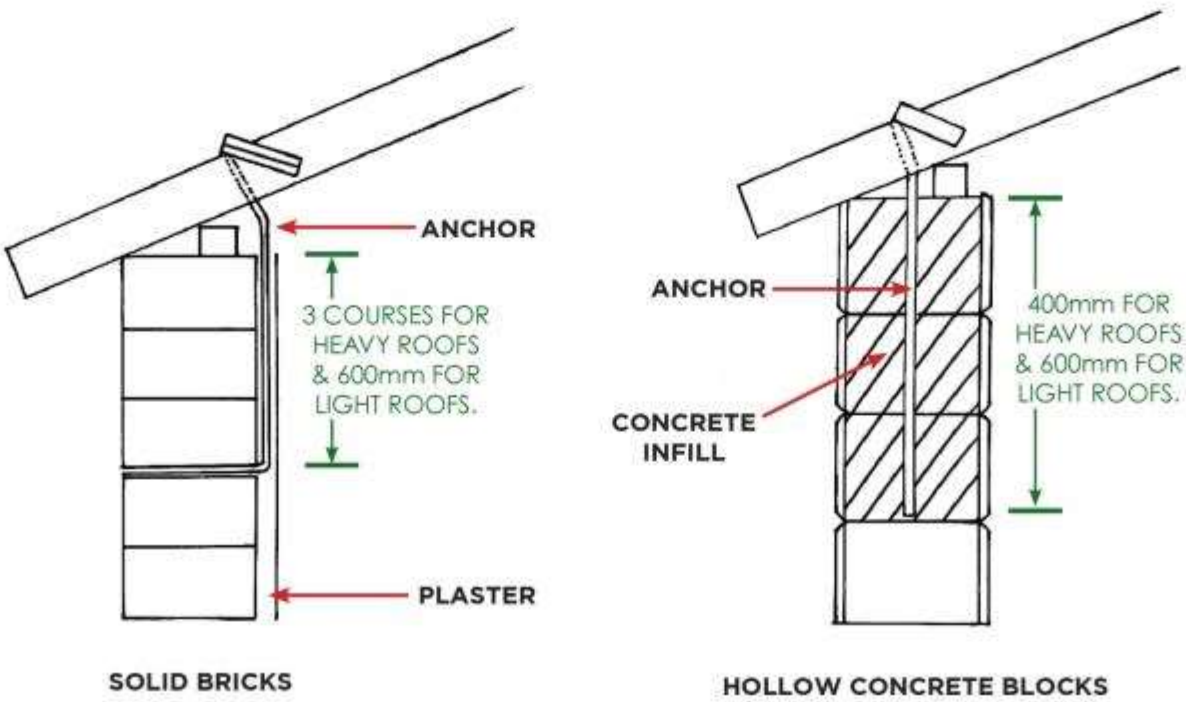



FIGURE 4-13: A STURDY ROOF CONNECTION

## Technical guideline 4-5: Securing roofs to the structure

"Light" roofs incorporate metal profile sheeting, metal roof tiles, fibre cement fibre sheeting, or fibre cement slates.

"Heavy" roofs incorporate concrete or clay roof tiles, thatch, or slates.

When fixing roof sheeting to timber, use galvanised nails or self-tapping screws with washers, to avoid leakages. If using corrugated sheeting, near the eaves (overhang), use one nail every corrugation, as the eaves are the most vulnerable to wind. It is also advised to use one nail every corrugation at the pitch (top point) of the roof. Between these areas, nails can be used every other corrugation.

SANS 10400 states that: "Where any roof truss, rafter, or beam is supported by any wall, provision shall be made to fix such a truss, rafter, or beam to such wall in a secure manner that will ensure that any actions to which the roof may normally be subjected will be transmitted to such wall." These anchors are installed before any roofing can be installed.

Anchors that can be used to fix roof trusses include:

1. Two strands of 4mm diameter galvanised steel wire can be used for heavy roofs and light roofs with a slope less than 15 degrees
2. 30 x 1.2mm galvanised strapping can be used for light roofs. For slopes less than 30 degrees, maximum truss/rafter centres should be 760mm.
3. 30 x 1.6mm galvanised strapping may be used for light roofs with trusses/rafters more widely spaced.

Guidelines for location of anchors: Trusses or rafters must be evenly spaced, and anchors must extend adequately into the masonry (see Figure 4-13):

- ✓ Anchors for heavy roofs should extend 3 brick courses into the wall or, for hollow concrete blocks, 400mm into the wall.

## Technical guideline 4-6: Waterproofing roofs

The National Building Regulations and Building Standards Act state that **roofs must be waterproof**:

- Roofs must be durable and must not allow the penetration of rainwater or any other surface water to its interior
- Roofs must not allow the accumulation of any water on its surface

To achieve this requirement, the SANS 10400 provides the guidelines below for various roofing materials. Note that the roof slope refers to the angle of the roof relative to horizontal.

**Minimum Roof Slopes of Sheeted Roofs**

| Roof covering | Minimum angle of slope (degrees) | Minimum end lap (mm) | |
|---|---|---|---|
| | | End laps scaled | End laps not scaled |
| Corrugated (including box rib) profile (galvanized) iron, polycarbonate and fibre glass | 11<br>15<br>17<br>22 | 150<br>150<br>150<br>150 | 250<br>225<br>200<br>150 |
| Corrugated fibre-cement sheets | 11<br>15<br>17<br>22<br>26 | 200<br>175<br>150<br>150<br>150 | 300<br>275<br>250<br>200<br>150 |
| Specialized long span sheets (metal and fibre-cement) | 3-5 depending on the manufacturer's design and specification | As specified by the manufacturer | |
| **It is important that the manufacturer's instructions are followed at all times** | | | |

| Minimum Roof Slopes of Non-Sheeted Roofs | | |
|---|---|---|
| Roof covering | | Minimum angle of slope (degrees) |
| Type | Description | |
| Tiles, slates and shingles | Fibre-cement slates:<br>a) with an approved underlay<br>b) without an approved underlay | <br>11<br>17 |
| | Concrete and clay tiles, and shingles:<br>a) with an approved underlay<br>b) without an approved underlay | <br>17<br>26 |
| | Metal tiles:<br>a) with an approved underlay<br>b) without an approved underlay | <br>11<br>15 |
| | Natural slate on open battens:<br>a) with an approved underlay<br>b) without an approved underlay | <br>11<br>15 |
| Thatch | Thatch | 45 in general, but 35 at dormer windows |

| Minimum Thickness of Thatch Layer | | |
|---|---|---|
| **Type** | **Stem or butt diameter (mm)** | **Layer thickness (mm)** |
| Fine thatching grass or reed | 1.2 to 2.5 | 175 |
| Coarse thatching grass or reed | 2.5 to 4.0 | 200 |
| Water reed | 1.0 to 7.0 | 300 |

**Installing gutters on homes will assist with controlling the flow of stormwater so that sheet flow does not run off of rooftops. Install gutters on the down slope side of the roof, sloping towards downpipes positioned in locations where stormwater drainage will make sense.**

The downpipe should be positioned so that stormwater can drain to the lowest point of the property, and adequate drainage channels must be provided for water coming from downpipes. Gutters also allow for harvesting of rainwater and collection in a storage tank, providing an additional water supply. If gutters and downpipes are unaffordable, the Department of Human Settlements will accept a 1 metre width concrete apron around the house to prevent runoff from undermining the foundations.

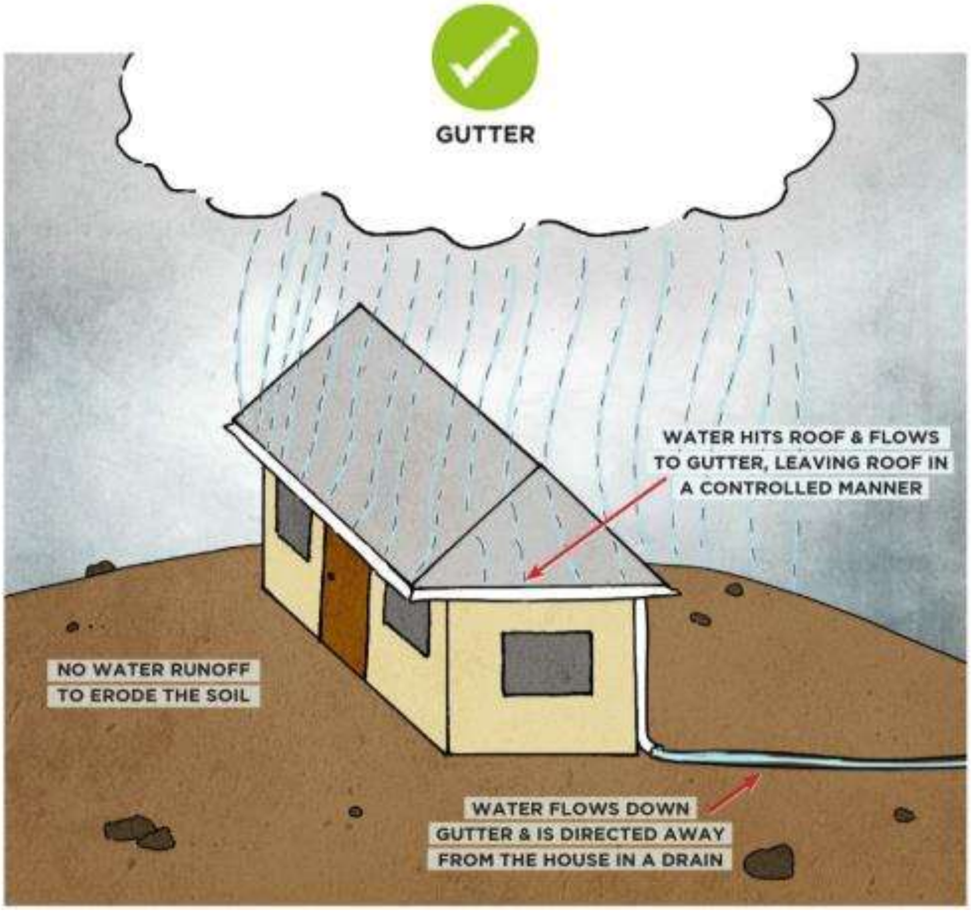




**Figure 4-14: Comparison of house drainage when gutters are provided and when they are not**

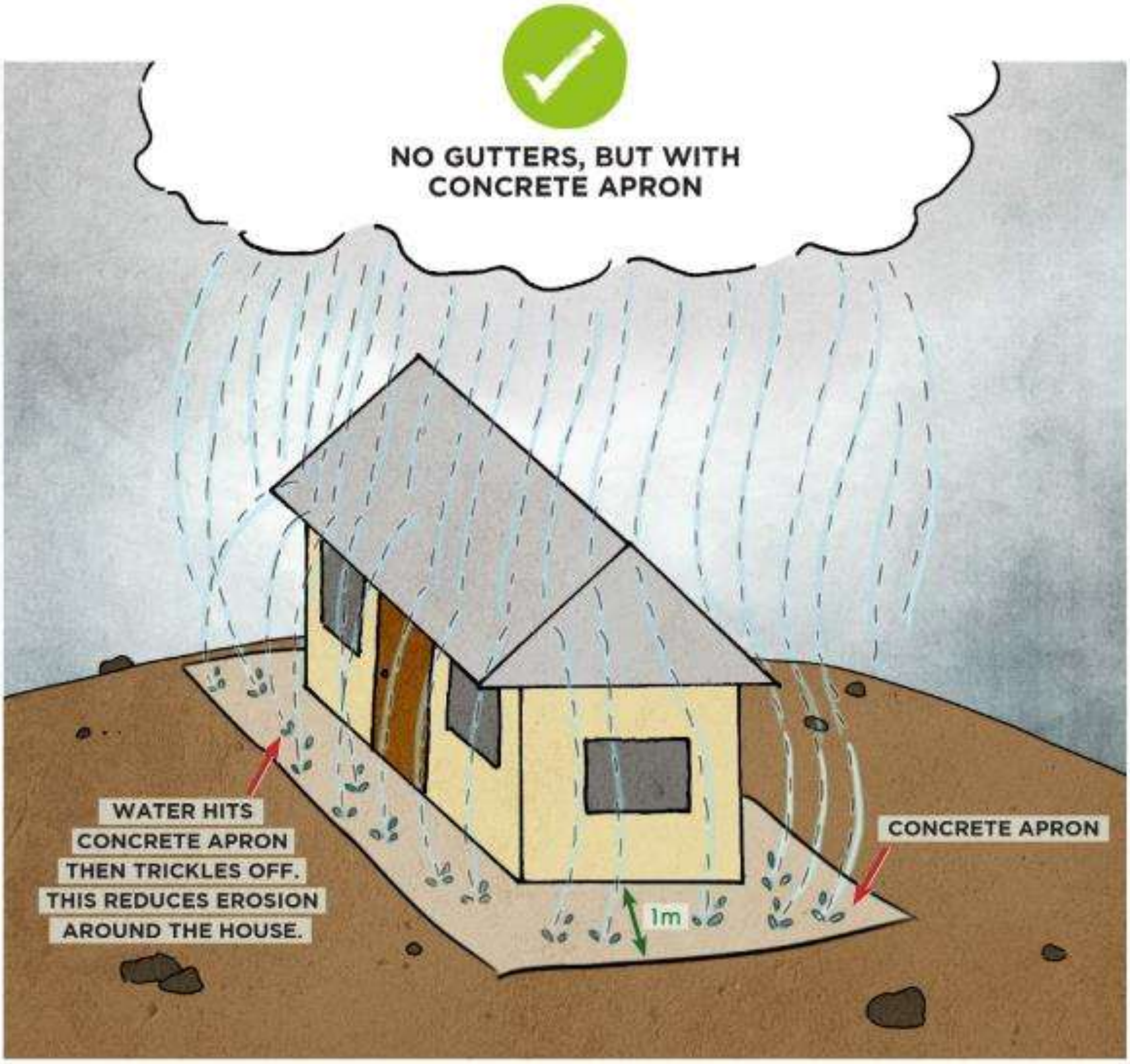



FIGURE 4-15: IF GUTTERS ARE NOT FEASIBLE, A CONCRETE APRON WILL SERVE THE PURPOSE OF DIRECTING RUNOFF AWAY FROM THE HOUSE AND ABSORBING THE FORCE OF RAINWATER COMING OFF THE ROOF

## BUILDING TO RESIST FIRE

If fire reaches a house, it is not a question of *if* the fire will damage the structure, but a question of *when.* Therefore, building to resist fire really means building to slow down the impacts of fire, which allows occupants time to escape. Some materials that provide greater fire resistance include:

1. **Concrete** is not combustible and has a low thermal conductivity. This means that it will take a long time for fire to affect the structural integrity of concrete. The actual fire resistance of concrete depends on the mix of aggregate and cement.

2. **Cement plaster** made with sand and lime is a durable and fire resistant finishing material for structures.

3. **Drywall** is generally fire resistant, due to its gypsum core which is non-combustible.

4. **Bricks** are made in a very hot kiln, which results in them being extremely fire resistant. However, it is important to note that individual bricks are more fire resistant than a brick wall, due to the presence of mortar to hold the bricks together in the wall.

Most commonly used building materials are fire-resistant, except for timber and thatch. While timber is not commonly used for the structure of houses in South Africa (typically only for roofing), thatch roofing is common in rural areas due to its cultural significance as well as its breathability, aesthetic appeal, and insulating ability.

### Technical guideline 4-7: Fire Safety and Thatch Roofs
### (adapted from A Guide to Good Thatching Practice, CSIR, 1998)

Thatch roofs have cultural significance as well as benefits of breathability, aesthetics, and insulation, when compared to other roofing materials. The largest risk for thatch roofs is flammability.

Fire safety of thatched roofs is not only dependent on treating the thatch material with fire resistant materials. Fire safety is also determined by design and construction, additional fire safety measures, and good housekeeping and maintenance.

Some guidelines for good thatching practice that improve fire safety include:

1. Thatch density should be at least 35 to 50 kg/m$^2$ for thicknesses of 175mm to 200mm. When thatch is density compacted, it burns slower due to restricted air flow.
2. Sisal binding twine should be used in place of polypropylene binding.
3. No wires should be used in the roof construction if there is any risk of lightning. Rather, suitable natural materials should be used for sways and binding of the thatch.
4. If a chimney is installed in a thatch roof house, a full brick thickness should be provided as a buffer between the inside and outside of the chimney. The top of the stack must extend such that a 1-metre radius is provided between the top of the stack and the roof.
5. No electrical or telephone wires should enter the building via the thatch roof but rather underground. Any cables in the roof area should be installed in plastic conduits.
6. Timber should be treated with an approved fire retardant.
7. Thatch should be treated on both sides with a suitable fire retardant.
8. Fire-protective membranes can be installed beneath the thatch to delay burn-through of the thatch in the event of a fire.
9. No combustible material should be allowed to accumulate near the building.

## *Fire safety for households*

In addition to selecting fire resistant building materials, certain other considerations for the *site* of the house can help reduce the risk of fire reaching the house in the first place.

- ✓ Siting homes near roads assists with access in the event of an emergency. This also places the house near a firebreak, which can hinder the spread of fire. Even if the fire eventually jumps across the road, the occupants will still have more time to evacuate.

- ✓ Locating firebreaks around homes intentionally can also protect the house from fire. A **firebreak** is a gap in vegetation that acts as a barrier to slow or stop the spread of fires. Creating a firebreak around the boundary of a property will protect the property from wildfires and also protect neighbouring plots.

*A Guide to Good Thatching Practice* can be found on the website for the Thatchers Association of South Africa (www.sa-thatchers.co.za)

A **firebreak** is a gap in vegetation that acts as a barrier to slow or stop the spread of fires.

**Firescaping** refers to landscaping strategies which make the area around households more fire resistant.

Invasive plants often burn more intensely than indigenous plants. Removing them can help reduce the intensity of fires.

Indigenous plants should actively be planted in yards to keep invasive species from taking over, and to provide other benefits, like erosion control and outdoor enjoyment.

- ✓ Yards should be maintained with “firescaping” principles in mind. **Firescaping** involves first removing flammable plants, especially **invasive plants** such as wattle, pine, and gum, as well as exotic species, such as bottlebrushes, melaleucas, and conifers. **These plants generally burn more intensely than indigenous plants.** In addition, removing shrubs beneath larger trees or near larger shrubs will prevent a “fire ladder” which allows flames to climb. Finally, removing dead and decaying wood, fallen branches and other fuel debris from around the property will reduce the fuel load. Once these fuel loads are removed, active planting of indigenous plants that contribute less to the spread of fire will assist with firescaping.
- ✓ Other flammable materials should not be present in the yard, including rubbish.
- ✓ After wildfires, soils are bare and heavy rains can cause mudslides. Keep this in mind when siting homes on slopes.
- ✓ Access must be provided for households so that evacuation by householders and access for emergency responders is easy.

## *Lightning protection*

A lightning protection system (LPS) typically consists of both internal and external lightning protection systems. An external LPS is intended to:

1. Intercept a lightning flash to the structure
2. Conduct the lightning current safely towards earth
3. Disperse lightning current into the earth

An internal LPS prevents dangerous sparking by providing a barrier between the external LPS system and electrically conducting elements inside the structure.

An LPS should be installed based on guidelines regarding the lightning ground flash density for a specific area. Installation of an LPS must be done by a professional to ensure full safety. Installation must closely follow the SANS 62305-3 standard and SANS 10313.

## Reducing flood risks

- ✓ A plinth is the structure from the footing of the building to the floor level. By adjusting the height of the plinth, one can adjust the floor level to achieve the above technical guidelines. If the floor is too high above the ground level for some household members to comfortably enter the house, provide a ramp at a slope ideally greater than 1:12.

- ✓ Approximately a 2-metre buffer around the house should slope (approximately 50mm for every metre) away from the house to encourage drainage.

- ✓ Construct **diversion ditches**, leading to a drainage canal in order to channel water away from houses. **Lined open stormwater channels are better than underground stormwater drains that are blocked.** Diversion ditches should be placed in relation to downpipes (if applicable) to ensure that roof runoff is effectively channelled away.

- ✓ Temporary measures to cope with flooding – since it may take time to improve stormwater management in existing settlements requiring upgrading, some simple temporary measures include:
  - Line floors and a little way up the walls of houses with plastic sheets
  - Use bags of sand during emergencies to block water from entering doorways
  - Use sandbags to build walls, which can divert floodwater away from structures
  - Raise furniture inside houses using bricks or crates.

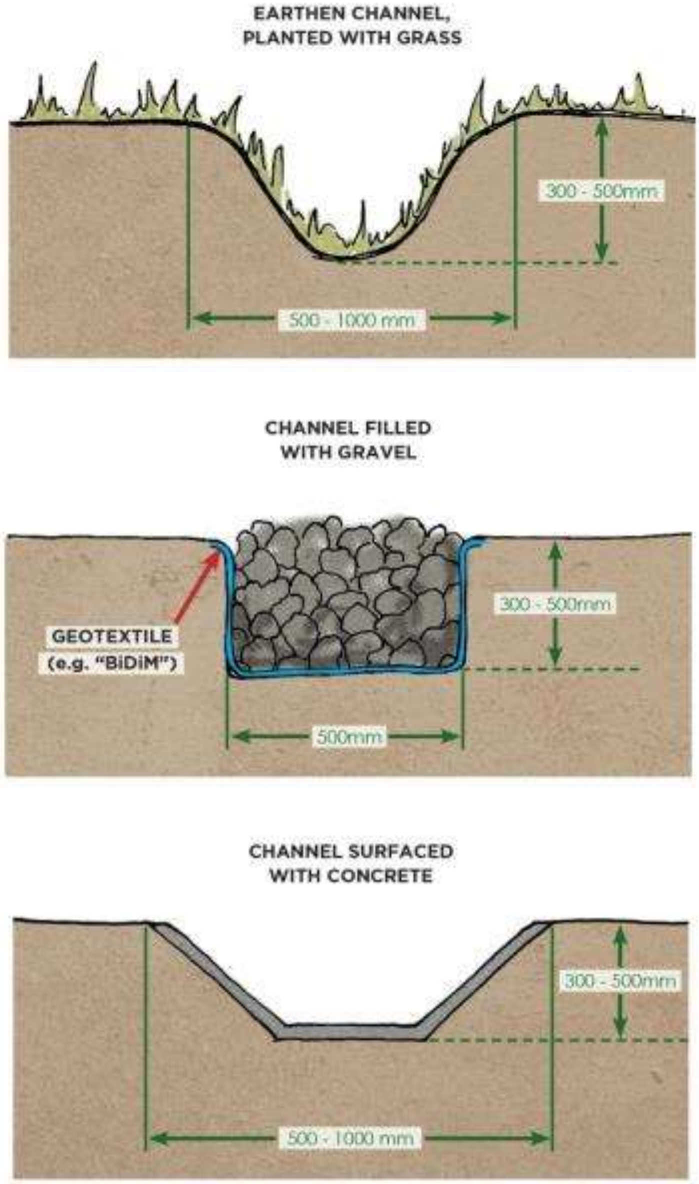



Figure 4-16: Diversion ditch options

A **diversion ditch** is a channel constructed **on contour** for the purpose of intercepting surface water and diverting it to a safe and suitable outlet.

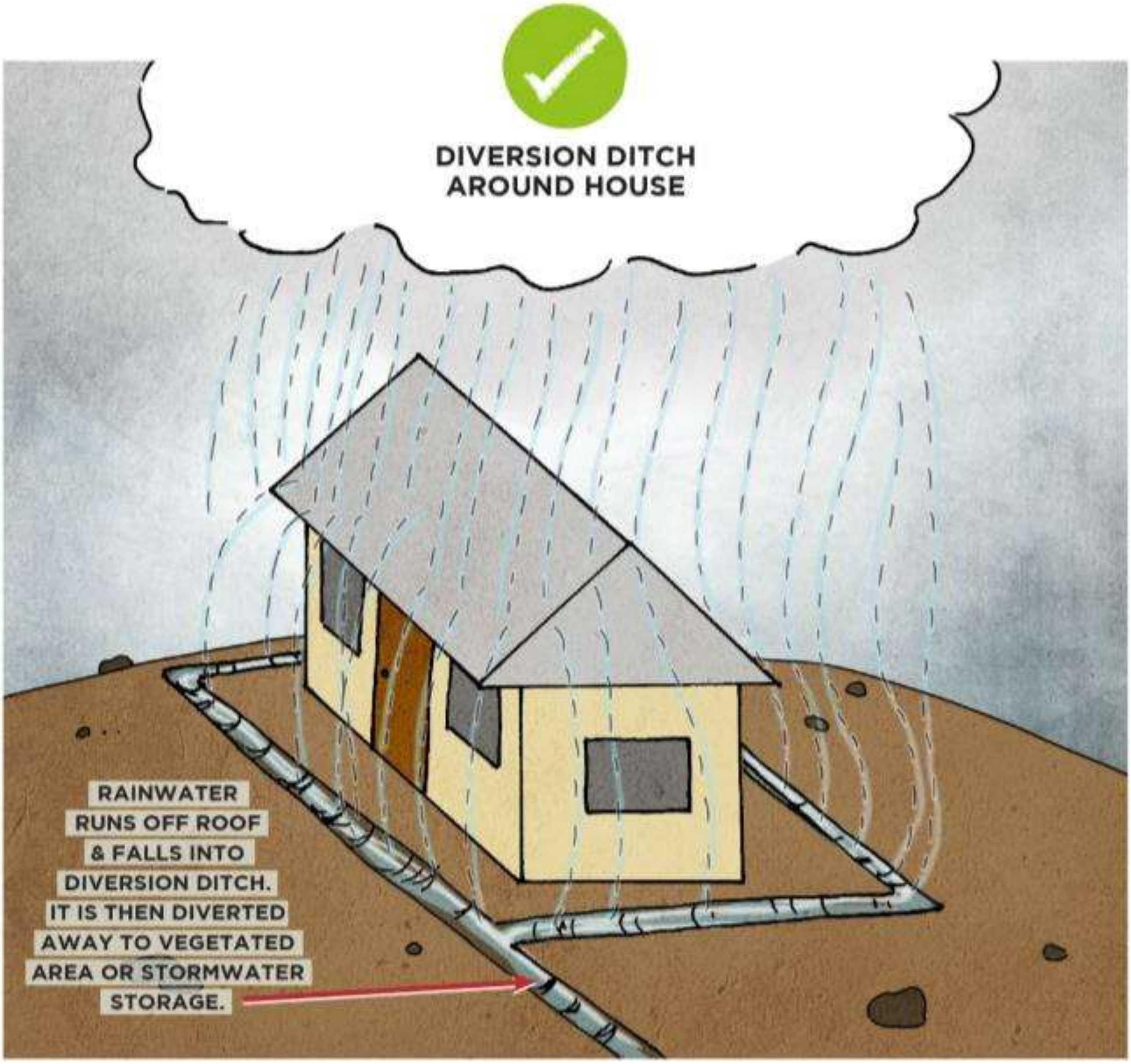



FIGURE 4-17: SIMPLE SCHEMATIC OF A DIVERSION DITCH FOR DRAINAGE

**TECHNICAL GUIDELINE 4-8: REDUCING HOUSEHOLD FLOOD RISKS**

The floor levels should be 300 mm (minimum) above the 1:100 year floodplain.

## IMPROVING THE AREA AROUND THE HOUSE

- ✓ Install a concrete or paved apron at least 1 metre wide around the house beneath roof overhangs in order to keep water away from the building's foundation. This apron must slope away from the household to ensure that water does not flow towards housing foundations.
- ✓ Vegetation should be maintained around the house in order to reduce dust pollution and combat erosion caused by stormwater draining off of roofs. Grass planted around houses will strengthen the soil beneath the roof overhangs, reducing the chances for erosion.
- ✓ The area around the house should be kept free from all kinds of rubbish. Any rubbish lying around the house when a storm occurs is likely to be washed to other areas on the site or downhill from the site.

## ENSURING SAFE ACCESS (WALKWAYS, STEPS)

**Ensure that people can safely reach their house in any conditions.** Building proper pathways will help to avoid dangerous short cuts from developing (like the one below). The informal path shown below is far too steep for physically handicapped and elderly people to utilise, even when the weather is dry. In case of emergency, it does not provide a swift and safe access point. In the case of heavy rainfall, this path will become extremely muddy and slippery, making it even more hazardous for all people, especially the elderly and those with disabilities.

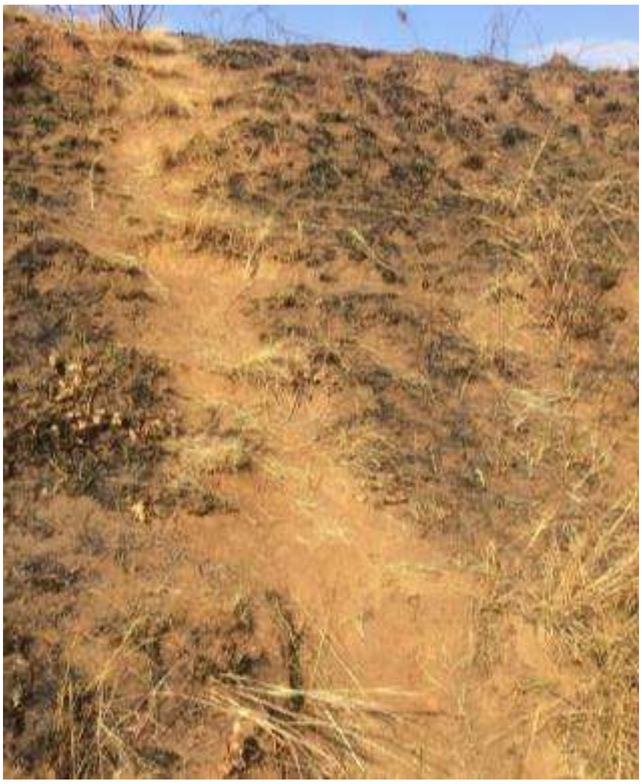



FIGURE 4-18: STEEP ACCESS TO HOUSEHOLDS IN NHLAZUKA – TO IMPROVE ACCESS AND DECREASE EROSION, THE PATH SHOULD BE REALIGNED AND EROSION PREVENTION MEASURES SHOULD BE MADE

When setting out foot paths, use the same principles used in designing roads: wherever possible, foot paths should be **on contour**. Paths should not run straight down steep slopes but rather meander slightly. Wherever possible, foot paths should follow the contours of the site (or be placed at a very shallow angle from the contours). In some cases this is not possible due to space restrictions. In other cases, pedestrians will continue to take the shortest route (i.e. directly downhill), regardless of whether a footpath has been set for them. In these cases, steps may be beneficial, and they can be installed relatively cheaply using gumpoles. In the design below, gravel provided on each step protects the steps from eroding and helps to keep the pathway clean and firm. Inclusion of a handrail is advised, particularly in steep areas.

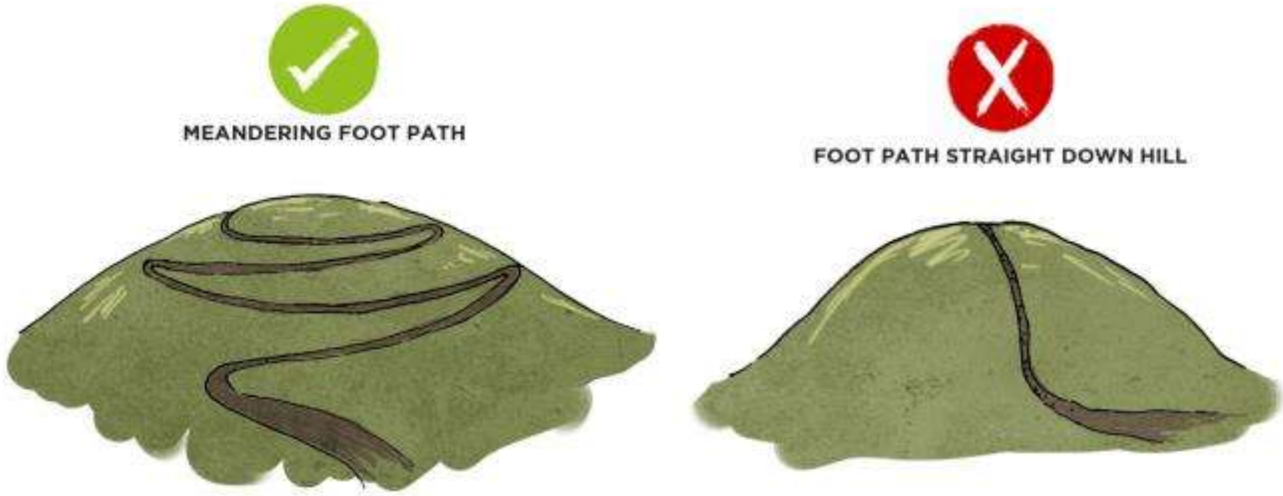



**FIGURE 4-19: MEANDERING FOOTPATH ON SLOPES**

**FIGURE 4-20: EXAMPLE OF GUMPOLE AND GRAVEL STEPS FOR IMPROVED ACCESS ON STEEP SLOPES**

## DIVERSIFIED WATER SUPPLIES

With the unpredictability of water supply, households with diversified water supplies are likely to have water more days in the year than those relying on only one supply. Though water supply is considered as a basic human right, the provision of a municipal water supply does not guarantee resilience against water shortages and drought. This was experienced first-hand by communities throughout KZN during the recent drought and is still experienced as drought continues in certain parts of the province.

Rainwater harvesting systems will provide benefits in terms of stormwater management and drainage as well as water security. With the unpredictability of rainfall, rainwater cannot be a household's sole water source, as periods of drought will severely jeopardize the household's water supply. However, by diversifying the water supply, rainwater harvesting can make households more resilient if other sources of water are cut off or reduced (such as borehole water or municipal water). This also provides a resilient water supply for back-up if (and when) water cuts occur. Firstly, gutters and down pipes will be required to achieve rainwater harvesting. The *Revised Red Book* provides guidelines for rainwater harvesting, which are as follows:

1. Place tanks on a solid foundation, preferably minimum 75mm thick concrete slab

2. The first water to run off a roof can contain debris and dirt that has accumulated on the roof or gutter. Some mechanism for discarding the first flush should be implemented. The inlet storage tank can be protected by a gauze screen to keep debris, mosquitos, and insects out.

3. Multiply roof area in plan by the mean annual rainfall and adjust by an efficiency factor to determine the average quantity of rainwater available from the roof area.

   Average rainwater (litres) = catchment area ($m^2$) x mean rainfall (mm) x efficiency (between 0 and 1). An efficiency of 0.8 is typical for roofs.

**RESOURCE**
The WRC CSAG Water Harvesting Tool website can be used in design decision making processes for rainwater harvesting. Find it here: http://cip.csag.uct.ac.za/webclient2/waterharvest/

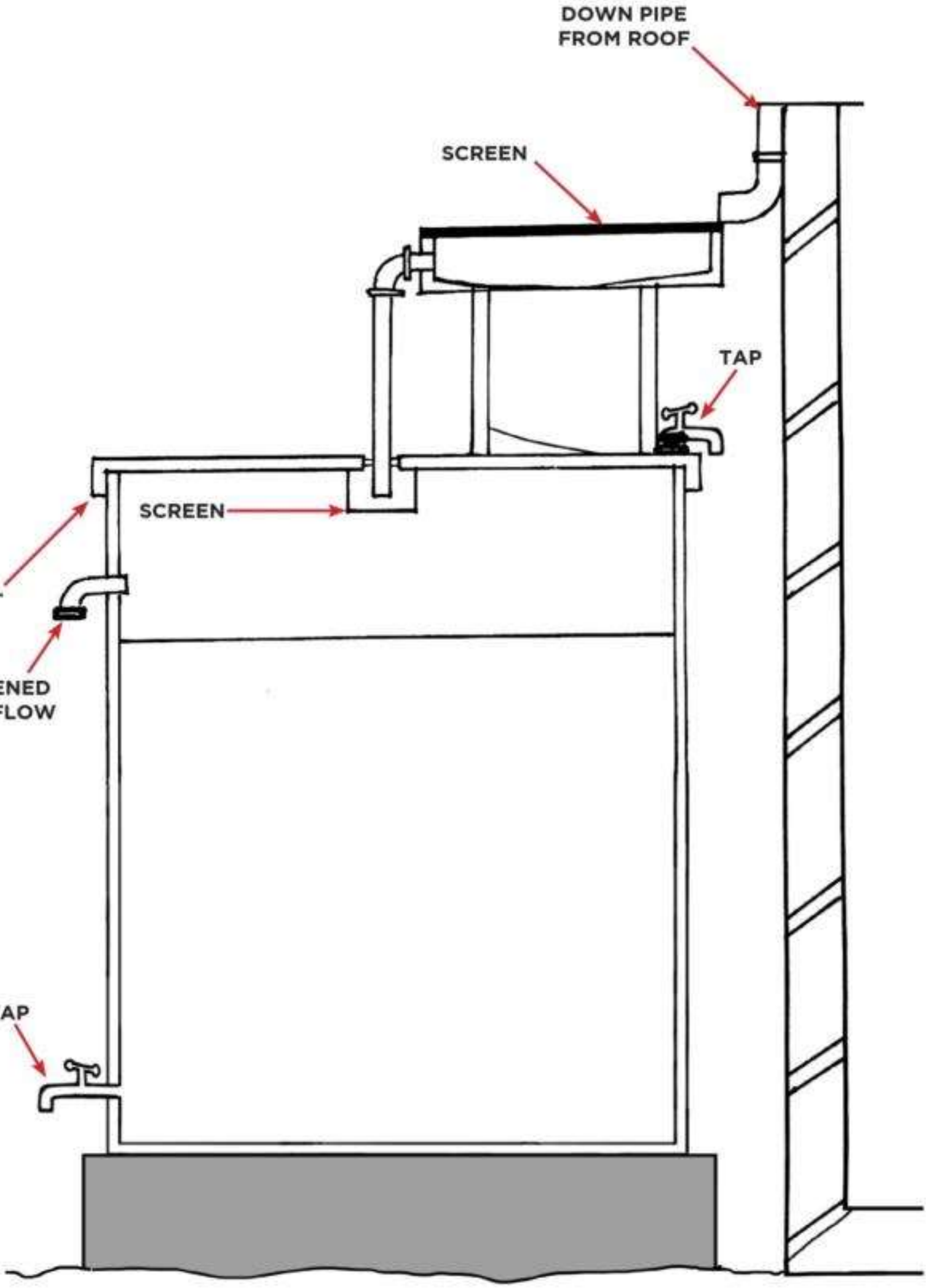



FIGURE 4-21: DIAGRAM FOR THE FIRST FLUSH DIVERSION OF RAINWATER (ADAPTED FROM CSIR, 2018)

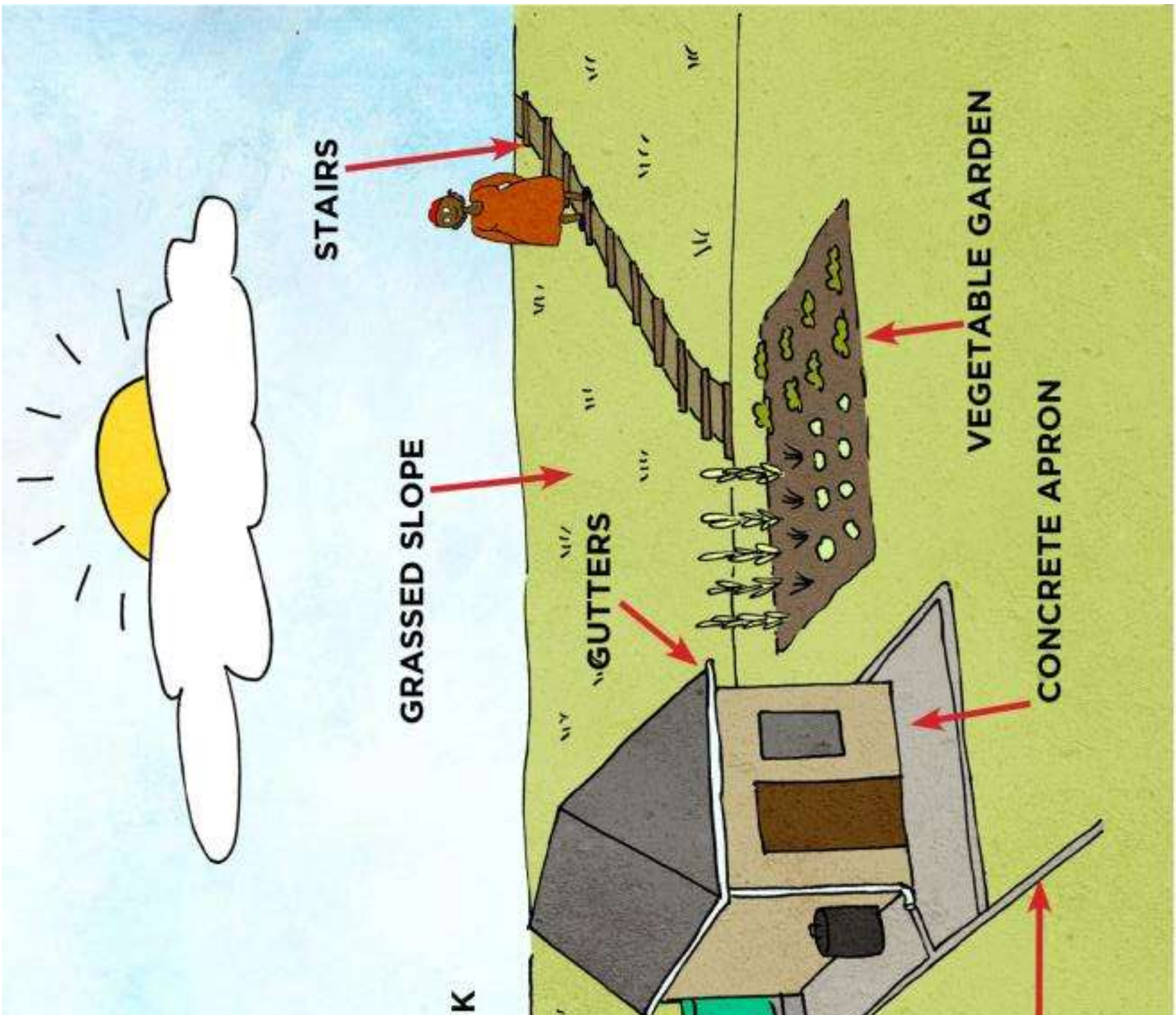



**Figure 4-22: A climate resilient household**

# CHAPTER 5: More information

## LINKS TO OTHER INFORMATION

| Issue addressed | Title | Organisation | URL or citation | Description |
|---|---|---|---|---|
| **CC Adaptation (general)** | Community-based Adaptation to Climate Change in Durban | eThekwini Municipality, South Africa | Golden Associates. (2011). *Community-based Adaptation to Climate Change in Durban*, (February), 1–152. | Informational report on community-based adaptation to climate change in Durban |
| **CC Adaptation (general)** | National Climate Change Response White Paper | Department of Environment and Natural Resources, South Africa | Department of Environment and Natural Resources. (2010). *National Climate Change Response White Paper*, 1–56. | National paper which defines South Africa's stance and needs with regards to climate change |
| **CC Adaptation (general)** | Long Term Adaptation Scenarios for Human Settlements | Department of Environmental Affairs, South Africa | Department of Environmental Affairs South Africa. (2015). *Long Term Adaptation Scenarios for Human Settlements*. | Provides policy background; climate change impacts on human settlements, migration and human conflict and climate change adaptation responses |
| **CC Adaptation (general)** | Climate change Adaptation Sector Strategy for Rural Human Settlements | Department of Rural Development and Land Reform, South Africa | Department of Rural Development and Land Reform. (2013). *Climate Change Adaptation Sector Strategy for Rural Human*. | Sector strategy nationally for adapting development in rural human settlements |
| **CC Adaptation (general)** | Climate Change Adaptation Summary Report | uMgungundlovu District Municipality, South Africa | uMgungundlovu District Municipality. (2017). *Climate Change Adaptation Summary Report*. | uMDM's climate change adaptation framework |
| **CC Adaptation (general)** | Climate Change Municipal Adaptation Plan for Health and Water | eThekwini Municipality, South Africa | Constable, L., & Cartwright, A. (2009). *Climate Change Municipal Adaptation Plan: Health and Water*. eThekwini Municipality. | eThekwini's plan for addressing climate change impacts, specifically in the water and health sectors |
| **CC Adaptation (general)** | Climate Information Platform | Climate Systems Analysis Group and UCT, South Africa | http://cip.csag.uct.ac.za/webclient2/app/#datasets | Datasets on long term climate factors, namely rainfall and temperature |
| **CC Adaptation (general)** | SA Risk and Vulnerability Atlas | DST and NRF, South Africa | http://sarva2.dirisa.org/ | Spatial database providing maps and associated data relevant to risks and hazards in South Africa |

| Issue addressed | Title | Organisation | URL or citation | Description |
|---|---|---|---|---|
| **CC Adaptation (general)** | Climate Change Adaptation Training Programme | Department of Rural Development and Land Reform, South Africa | https://climatechangetraining.org/ | A training program to introduce you to the theory and practice of climate change adaptation within the rural development and spatial planning context in South Africa |
| **CC Adaptation (general)** | Puzzling Climate Change | WESSA, South Africa | | Creative and interactive training material on climate change, for use in group settings |
| **CC Adaptation (general)** | Mainstreaming Climate Change Adaptation into Development Planning: A guide for Practitioners | United Nations Environment Program, United Nations Development Program, International | United Nations Environment Program, & United Nations Development Programme. (2011). *Mainstreaming climate change adaptation into development planning: a guide for practitioners*. | Guide for practitioners for mainstreaming climate change into planning and projects |
| **CC Adaptation (general)** | Screening tools and guidelines to support the mainstreaming of climate change adaptation into development assistance - a stocktaking report | United Nations Development Program, International | Olhoff, A., & Schaer, C. (2010). *Screening tools and guidelines to support the mainstreaming of climate change adaptation into development assistance - A stocktaking report*. UNDP: New York. | Climate change adaptation tools for development work |
| **CC Adaptation (general)** | Mainstreaming Climate Change Adaptation: A Practitioner's Handbook | CARE International, Vietnam | Hustable, J., & Yen, N. T. (2009). *Mainstreaming climate change adaptation: A practioner's handbook*, 60. | A climate change mainstreaming toolkit for workers from an international NGO in Vietnam |
| **CC Adaptation (general)** | Environmental Management Framework for the uMgungundlovu District Municipality | uMDM, INR, GroundTruth | Cox, D., Sennoga, D., Quayle, L., Bredin, I., Rajah, P., McCosh, J., … de Winnaar, G. (2017). *Environmental Management Framework for the uMgungundlovu District Municipality*. Pietermaritzburg. | |
| **Erosion Control** | *Community-based Research on the Influence of Rehabilitation Techniques on the Management of Degraded Catchments* | Water Research Commission, South Africa | Everson, T., Everson, C., & Zuma, K. (2007). Community Based Research on the Influence of Rehabilitation Techniques on the Management of Degraded Catchments. Water Resarch Commission. | Paper describing experiences with community-based erosion control and monitoring techniques for improving degraded catchments and eroded landscapes |
| **Erosion Control** | *Soil Erosion* | Landcare South Africa, National Department of Agriculture | https://www.nda.agric.za/docs/erosion/erosion.htm | Basic description of soil erosion (definition, causes, types, etc.) |

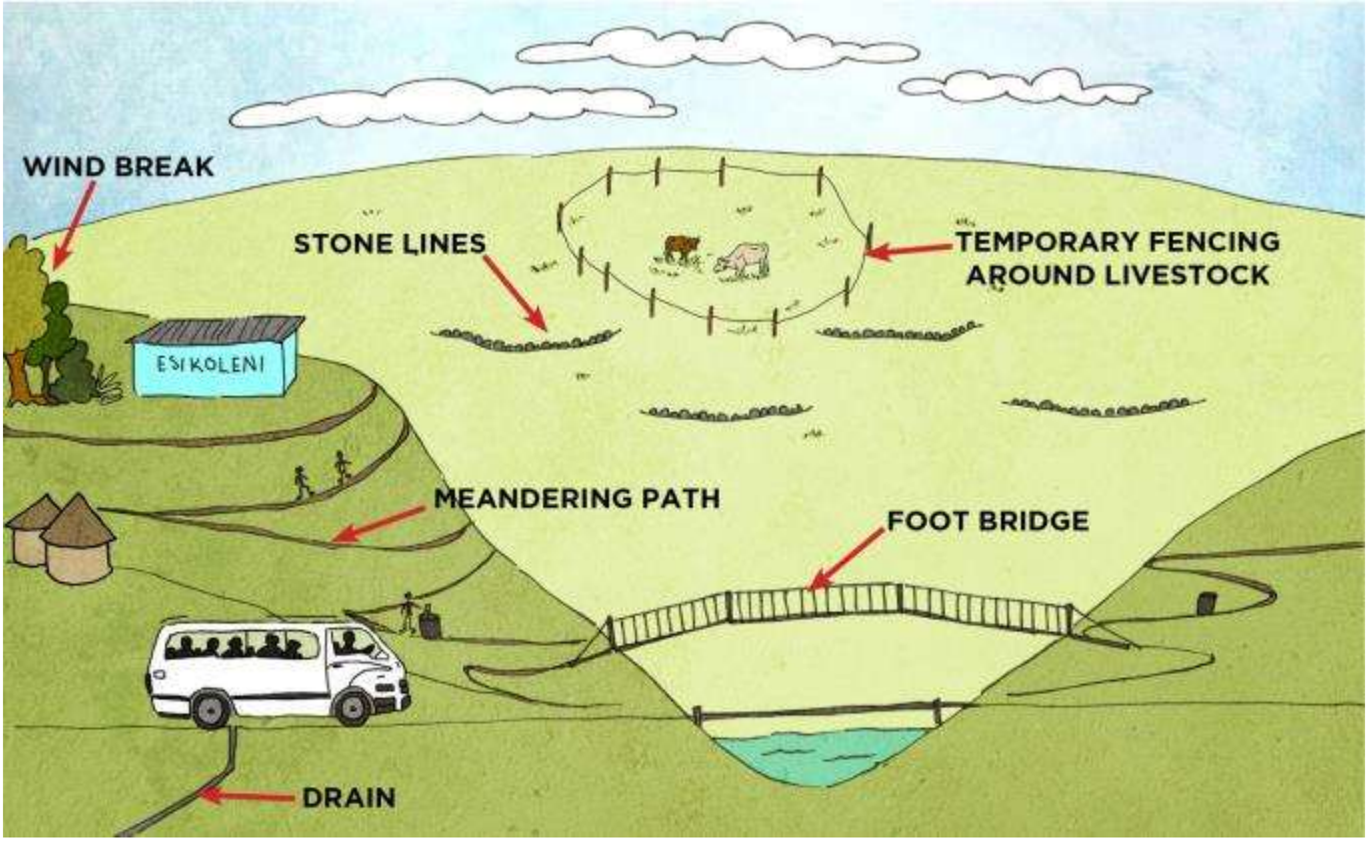
| Issue addressed | Title | Organisation | URL or citation | Description |
|---|---|---|---|---|
| **Fire** | Resource Materials on the National Veld and Forest Fire Act No 101 of 1998 | Department of Water Affairs and Forestry, South Africa | https://bit.ly/2UXTtrd | Website with materials to assist in interpreting South Africa's Veld and Forest Fire Act |
| **Fire** | A Guide to Integrated Fire Management | FynbosFire and UNDP, South Africa | https://bit.ly/2GDwEpA | Guide on integrated fire management, developed in South Africa |
| **Fire** | FireWise Resources Website - Be Firewise | FireWise, South Africa | http://landworksnpc.com/resource-centre/ | Resources and training materials on fire safety |
| **Flooding** | Bridge Builder Manual | Bridges to Prosperity, International | Bridge Builder Manual. 5th Edition. N.p. Print. | Manual with guidelines for planning a pedestrian bridge project - includes technical drawings |
| **General housing** | A Guide to the Home Building Manual | The South African Housing Landscape, South Africa | The South African Housing Landscape. (2014). *A Guide to the Home Building Manual*. | Guidelines for housing - general (not specifically climate change related) |
| **General housing** | SANS 10400 Building Regulations | Independent, South Africa | https://sans10400.co.za/ | Website with useful information about various sections of SANS 10400, the National Building Regulations; professionals answer questions about the standards |
| **General housing** | Green Building Features for Climate Resilient Buildings | TERI, India | Majumdar, M. (2015). *Green Building Features for Climate Resilient Buildings*. Teri. | PowerPoint presentation with guidelines for designing buildings and settlement that are climate resilient - practical design information |
| **General housing** | *A Place Called Home: Environmental issues and low-cost housing* | N/A | Sowman, M. & Urquhart, P. (1998). *A Place Called Home: Environmental issues and low-cost housing.* University of Cape Town Press. | Book written for the South African context to address environmental issues and planning, design, and construction of low-cost housing and settlements. |
| **General housing** | *The Proud Home Owner* | Abert van Wyk, South Africa | https://www.proudhomeowner.co.za/ | Book with guidance for constructing homes and other key information on housing |

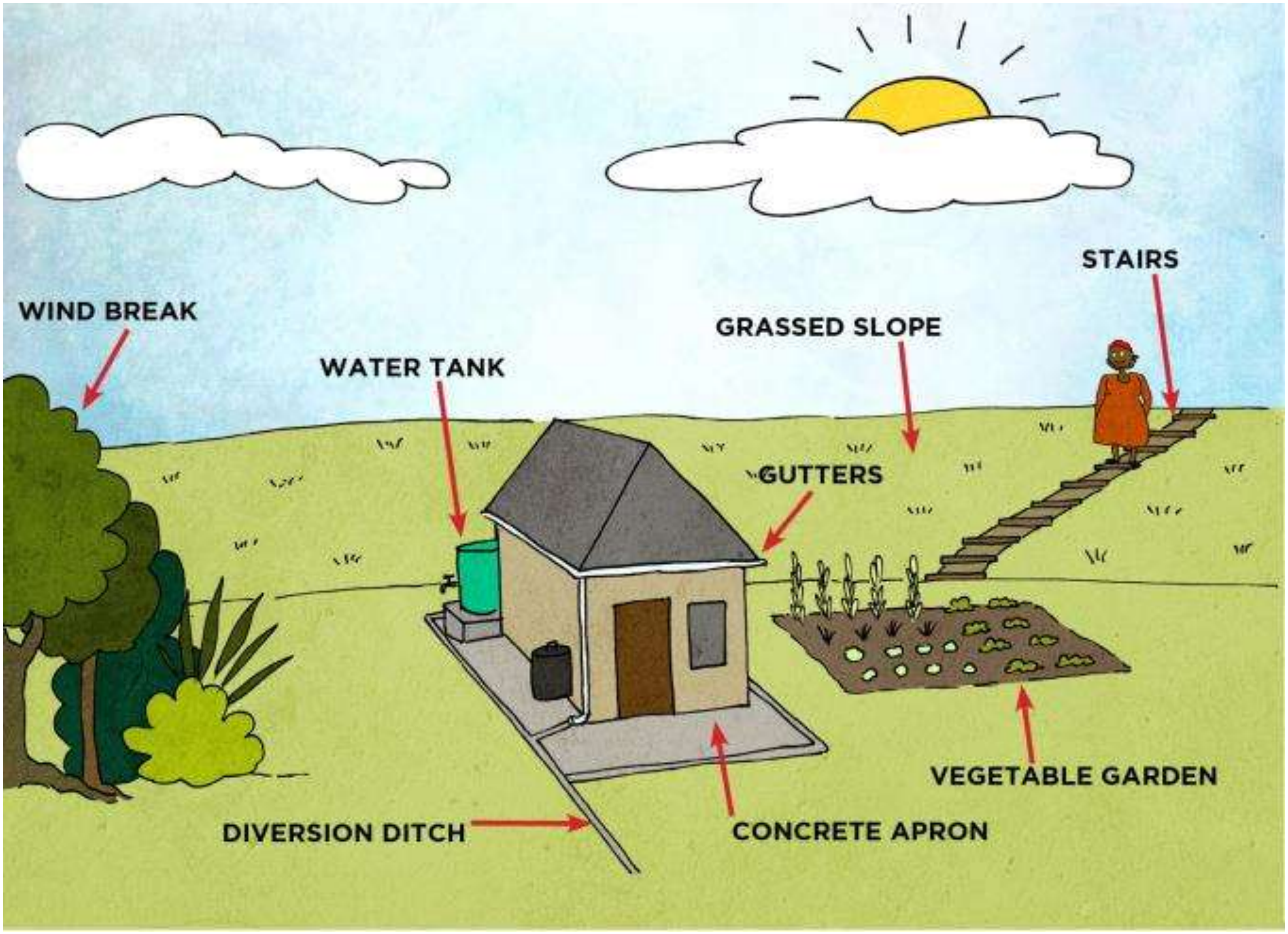
| Issue addressed | Title | Organisation | URL or citation | Description |
|---|---|---|---|---|
| **General housing** | A Guide to Good Thatching Practice | Division of Building and Construction Technology, CSIR, South Africa | CSIR. (1998). A guide to good thatching practice.<br><br>http://www.sa-thatchers.co.za/wp-content/uploads/2016/06/AGuideToGoodThatchingPractice-1.pdf | |
| **Planning** | Climate Change: What does it mean for eThekwini Municipality? | eThekwini Municipality, South Africa | eThekwini Municipality. (2007). *Climate Change - What Does it Mean for eThekwini Municipality?* | |
| **Planning** | uMgungundlovu District Municipality Climate Change Response Strategy and Plan | uMgungundlovu District Municipality, South Africa | Golder Associates. (2013). *uMgungundlovu District Municipality Climate Change Response Strategy and Plan*. | uMgungundlovu's strategy for climate change response |
| **Planning** | LetsRespond Toolkit | Department of Rural Development and Land Reform, South Africa | http://www.letsrespondtoolkit.org/ | Support programme for local government to adapt to Climate Change - includes resources as well as plans from different DMs |
| **Stormwater** | The South African Guidelines for Sustainable Drainage Systems | Water Research Commission, South Africa | Armitage, N., Vice, M., Fisher-Jeffes, L., Winter, K., Spiegel, A., & Dun. (2013). *South African Guidelines for Sustainable Drainage Systems*.<br><br>www.suds.co.za | Guidelines for SuDS in South Africa, including some design details, options, etc. |
| **Stormwater** | Water Sensitive Urban Design (WSUD) for South Africa: Framework and guidelines | Water Research Commission, South Africa | Armitage, N., Fisher-Jeffes, L., Carden, K., Winter, K., Naidoo, V., Spiegel, A., & Mauck, B. (2014). *Water Sensitive Urban Design (WSUD) for South Africa: Framework and Guidelines*, 1–234. https://doi.org/10.13140/2.1.3042.5922 | Detailed framework and guideline on WSUD in the South African context |
| **Stormwater** | Development of a Raster Database of annual, monthly, and daily rainfall for Southern Africa | Water Research Commission, South Africa | | |
| **Water** | Integrated Water Resources Management for Climate Change Adaptation | Venice Centre for Climate Studies / GFZ, Europe | Giupponi, C., & Gain, A. K. (2017). *Integrated water resources management (IWRM) for climate change adaptation.* Regional Environmental Change, 17(7), 1865–1867. https://doi.org/10.1007/s10113-017-1173-x | |

## WHO TO CONTACT FOR MORE INFORMATION AND ASSISTANCE

| |
|---|
| uMgungundlovu District Municipality |
| Your local municipality (e.g. Richmond, uMngeni, etc.) |
| Department of Environmental Affairs |
| Department of Economic Development, Tourism, and Environmental Affairs |
| Duzi-uMngeni Conservation Trust (DUCT) |
| Liberty NPO |
| Virtual State |
| 14water |
| Green Champs |
| Duka Thole |
| Green Network |
| WESSA |

Now, let's plan, design, and build climate-resilient communities!



In summary, there are a number of ways in which current and future risks can be reduced:

- ✓ Planned retreat - Moving housing and structures that are built in very vulnerable areas
- ✓ Building protective measures - Such as bridges, or stormwater culverts to direct the water away from dwellings
- ✓ Upgrading informal structures - properly and formally constructed houses withstand poor weather incidents much better than informal
- ✓ Planting 'soft' infrastructure to absorb risks, such as trees and other vegetation
- ✓ Improving operational management to ensure current infrastructure is able to withstand heavy rains and increased volumes of water
- ✓ Ensure drainage systems are fully operational and kept clean in order to reduce flooding in heavy rain
- ✓ Improve waste collection systems can reduce disease exposure
- ✓ Education – learning where to put new structures, what to think about when building, what infrastructure to build and how to minimise the risks

This toolkit is accompanied by 4 leaflets and a training programme.


For more information please contact us:

| | |
|---|---|
| Website: | http://www.umdm.gov.za |
| Email: | info@umdm.gov.za |
| Tel: | 033 897 6700 or 0800 864 911 |



The uMngeni Resilience Project is funded by the Adaptation Fund. The uMgungundlovu District Municipality (uMDM) is the Executing Entity responsible for overall project implementation, working with the University of KwaZulu-Natal's School for Agriculture, Earth and Environmental Sciences (UKZN SAEES) who are the Sub Executing Entity. The South African National Biodiversity Institute (SANBI) is the National Implementing Entity responsible for project oversight in partnership with the Department of Environmental Affairs (DEA).