

The background of the slide is a solid green color. In the foreground, there are black silhouettes of various plants. On the left, there are several tall, thin stems with small, clustered flowers. On the right, there are clumps of grass with long, narrow leaves and some seed heads. The overall effect is a naturalistic yet stylized representation of vegetation.

GREEN INFRASTRUCTURE APPLICATION FOR STORMWATER MANAGEMENT IN INFORMAL SETTLEMENTS :

The performance of a bioswale in
Diepsloot, South Africa

Ms Liezl Craig
PhD Candidate: Development & Management
(Water Studies)

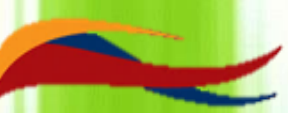
Supervisors: Prof Johann Tempelhoff (NWU)
Prof Willie Nel (Unisa)

UNISA



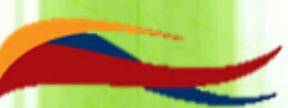
university
of south africa





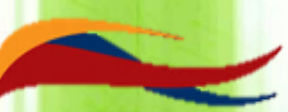
Green Infrastructure as Stormwater Management Tool





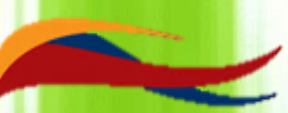
- Water-sensitive urban design (WSUD)
 - Low impact development (LID)
 - Water Sensitive Urban Settlements (WSUS)
-
- WSUD is an international **interdisciplinary** approach to **water service planning**
 - Developed as a response to the **increased water scarcity**
 - Due to **increased population growth, environmental degradation** and a need for **more resilient systems** in the **urban context** (Wong 2006; Wong & Ashley 2006; Brown & Clarke 2007; Cardon et al. 2013)





- Sustainable drainage systems (SUDS)
- This approach uses **biofiltration**, which relies on the **ecological services** of **wetlands** for the **retention and purifying** of water (Wong 2006; Hatt et al. 2009)
- Consists of **vegetative methods** such as **roof gardens, bioswales, extended detention basins, sand filters, infiltration trenches, infiltration basins, porous pavements** and **constructed wetlands** (Jurries 2003).

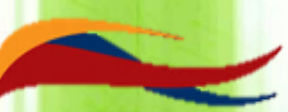




Research problem context

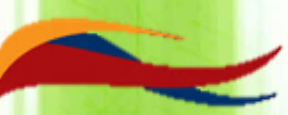





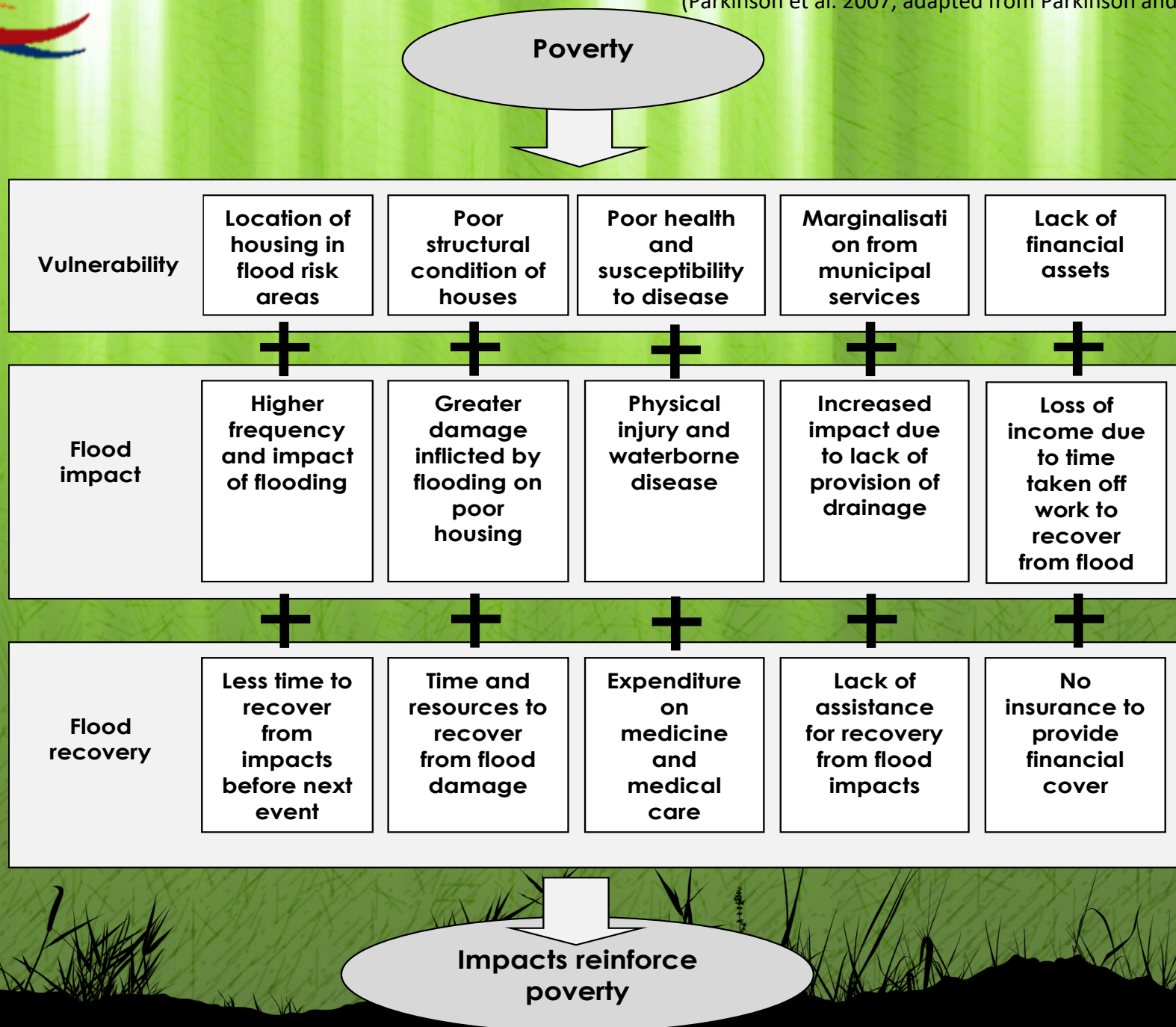
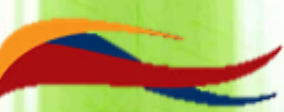


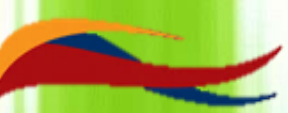
- **Opportunistic developments** and take advantage of **unused vacant land**, either publicly or privately owned (Huchzermeyer 2009)
- Usually unoccupied because it has been earmarked for **future development**, or it may be **unsuitable for construction** due to **geological or environmental factors** and subject to **drainage and flooding** problems (Parkinson, Taylor & Mark 2007)



- 
- Unsuitable location makes the settlement **vulnerable** to **water-borne diseases** and opens them to **risks caused** by **floodlines** (Parkinson 2003)
 - Constant flooding **increases** the **vulnerability** of these **already poor communities** when they **lose** their **limited resources** and **possessions** (Parkinson et al. 2007)
- 

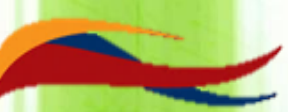






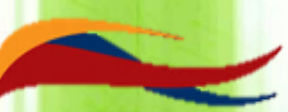
International approaches to upgrading informal settlements





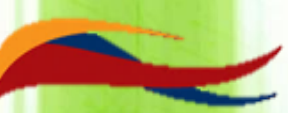
- Affected communities are often not accustomed to work with government organisations
- Configurations of informal settlements are also not conducive to conventional stormwater infrastructure due to their haphazard layout
- Results in stormwater infrastructure to one of the last priorities on the development programme (Parkinson et al. 2007)





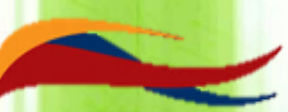
- Commonly **located in floodplains** which means that informal settlements play a large role in the **contamination of freshwater resources** (Jagals 1997; Fatoki et al. 2001)
- **Lack of solid waste management** has proved to be one of the **major challenges** in the informal settlement context from international case studies (Parkinson et al. 2007)





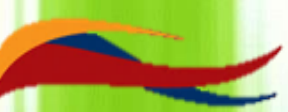
- Drainage **interventions** have opted for **open drainage channels** as it allows for **visibility of blockages**
- **Easy maintenance** with simple equipment
- Not addressed this problem adequately and open drains **still result in decreased capacity due to siltation** (Parkinson & Mark 2005; Parkinson et al. 2007)





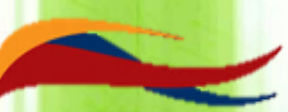
- Where the community were included in the **planning and construction process**, the **success rate** were much higher.
- Advantages were that the **community** firstly **supported the interventions**
- **Understood** the importance of **solid waste management**
- Received the **economic benefits** from contracting **local small enterprises** and **unskilled labour** (Parkinson et al. 2007; Parkinson & Mark 2005)





Can green infrastructure
management stormwater
in informal settlements?

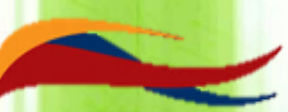




- Diffusion of innovation theory
- Rogers (2003) defines diffusion as

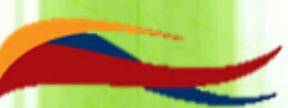
‘the process in which an innovation is communicated through certain channels over time among the members of a social system’.





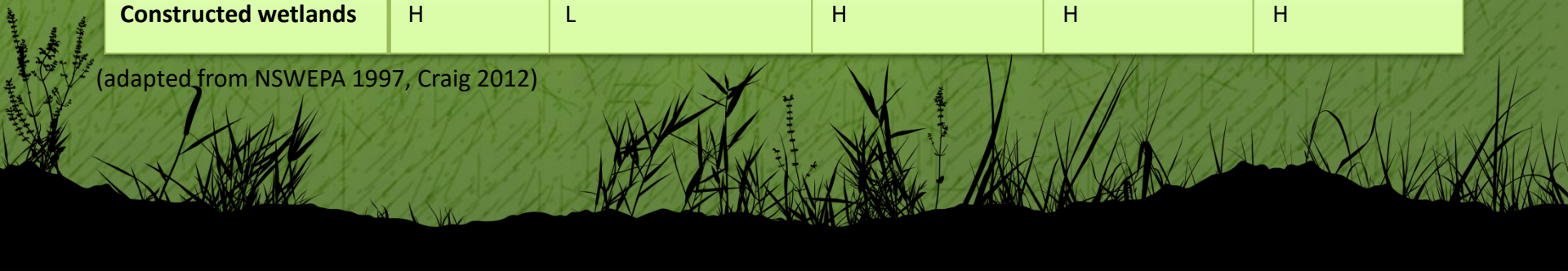
- Diffusion studies have shown that the **perceived benefits** of the **innovation** do **not guarantee** that the technology will be **adopted** by a particular group or individual
- Might **not be desirable** for a person or group to **adopt** the innovation.
- To effectively influence adoption process; the **needs, knowledge systems** and **context** of the target group must be **known and understood** (Rogers 2003)

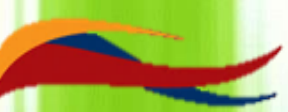




WSUD treatment measure	Indicative capital cost	Indicative relative operation/ maintenance cost	Effectiveness in improving water quality	Area required for installation	Skill level required for installation
Roof gardens	H	M	H	M	H
Bioswales*	L	L	H	L	M
Extended detention basins	M	L	H	H	L
Sand filters	M	M	M	L	L
Infiltration trenches	M	M	M	L	L
Infiltration basins	M	M	M	H	L
Porous pavements	H	M	M	H	H
Constructed wetlands	H	L	H	H	H

(adapted from NSW EPA 1997, Craig 2012)

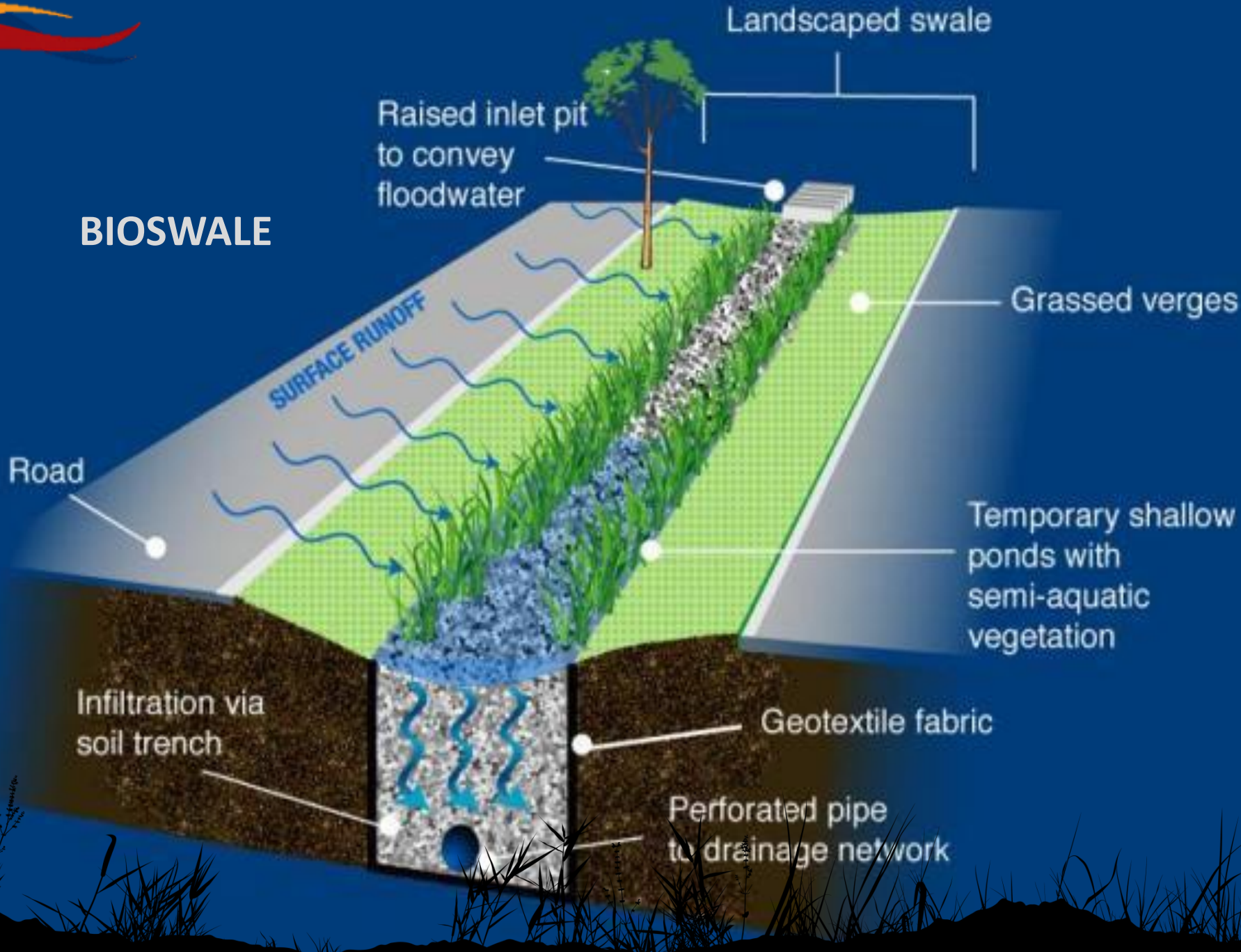


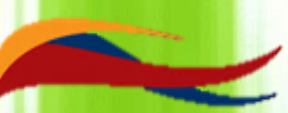


Basic bioswale



BIOSWALE





Research approach?





Basic Research

Scientific disciplines

governance

ethics

engineering

ecology

sociology



Problem fields

infrastructure backlog

poverty

stormwater management

land degradation

health

Actors in the life-world

private sector: ...

civil society: ...

public agencies: ...

...

Applied Research

Scientific disciplines

governance

ethics

engineering

ecology

sociology



Problem fields

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stormwater management

land degradation

health

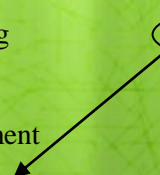
Actors in the life-world

private sector: ...

civil society: ...

public agencies: ...

...



Transdisciplinary Research

Scientific disciplines

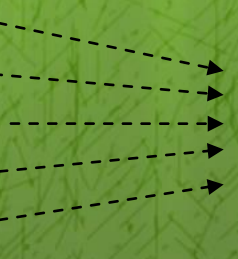
governance

ethics

engineering

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Problem fields

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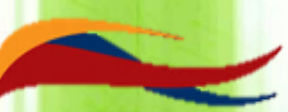
public agencies: ...

...



(Hirsch Hadorn et al., 2006:123-124; adapted by Hirsch Hadorn et al., 2008b:33) adapted





- Transdisciplinary research phases:
- **Phase 1: Problem identification** and structuring
- **Phase 2: Problem analysis**
- **Phase 3: Design problem solving** instrument
- **Phase 4: Bringing results into fruition**
- **Phase 5: Monitoring, evaluation and adaptation**
- **Phase 6: Close out and synthesis**

(Pohl and Hirsch Hadorn, 2007:124)





**Phase 1: Problem identification
and structuring**

Phase 2: Problem analysis

**Phase 3: Design problem solving
instrument**

**Phase 4: Bringing results into
fruition**

**Phase 5: Monitoring, evaluation
and adaptation**

Phase 6: Close out and synthesis

Researcher

Agora

Community

Municipality

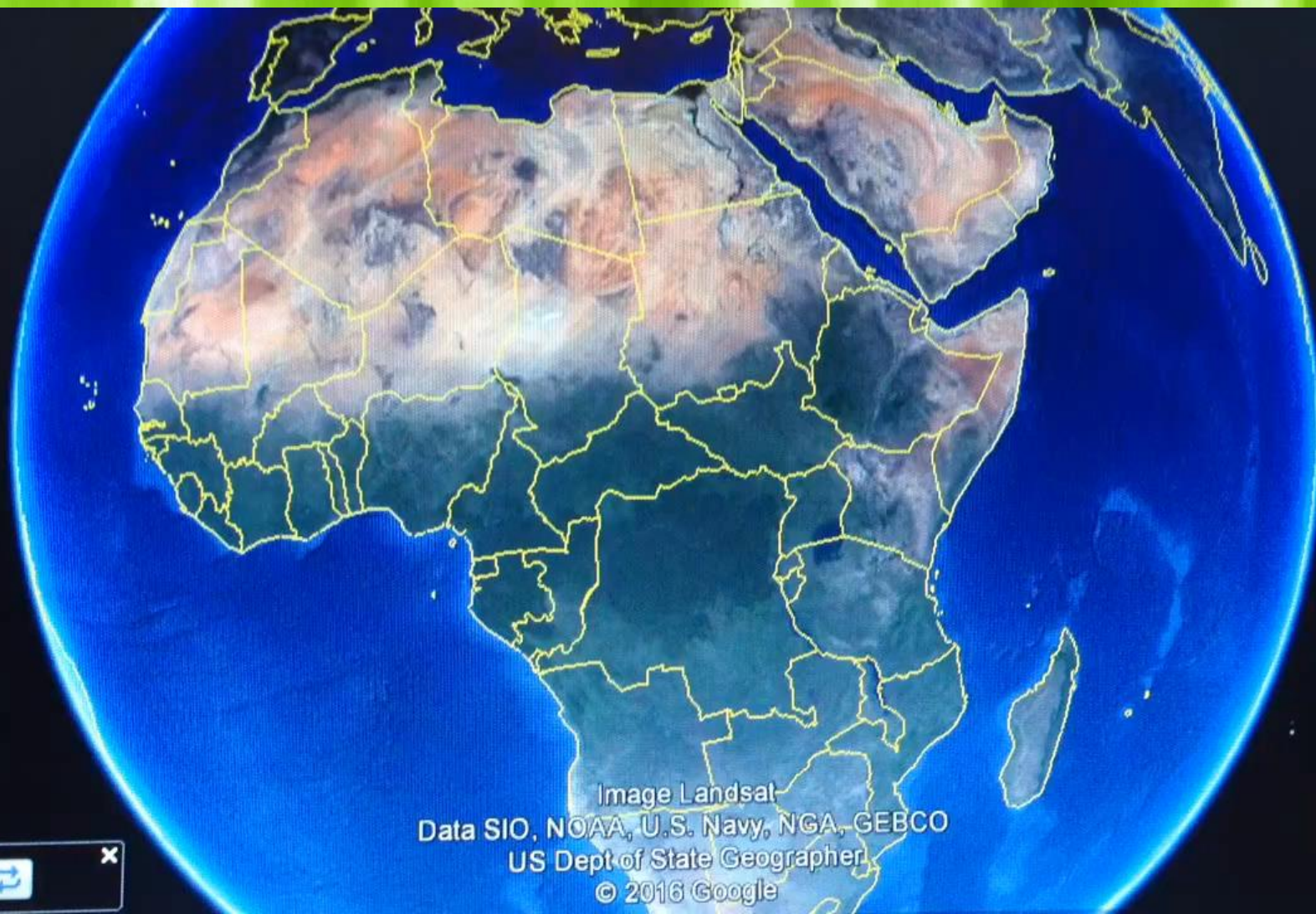
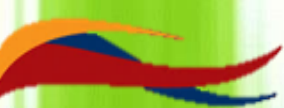
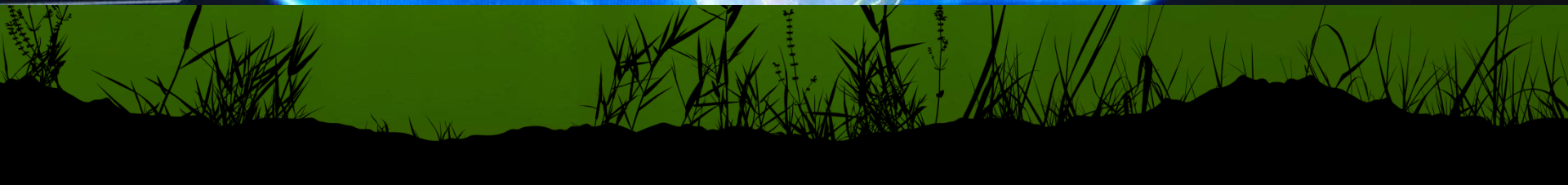
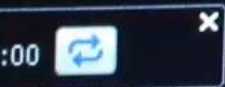
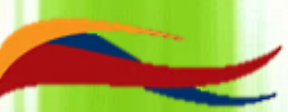


Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer
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Go





Study site 1







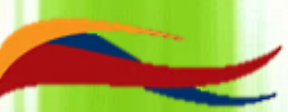






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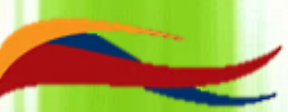
Study site 2





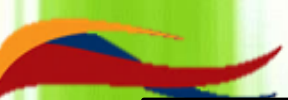






Results:





**Phase 1: Problem identification
and structuring**

Phase 2: Problem analysis

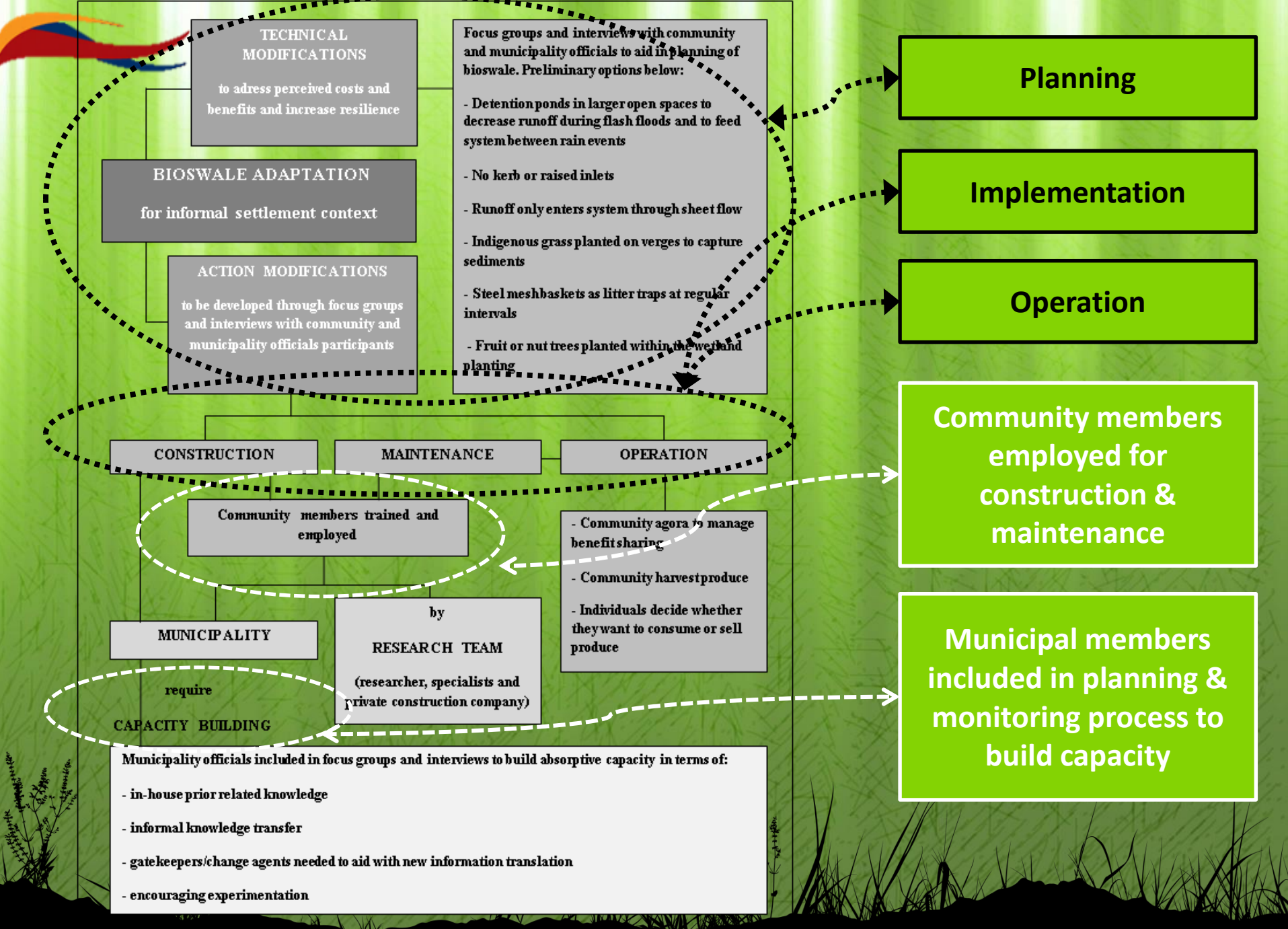
**Phase 3: Design problem solving
instrument**

**Phase 4: Bringing results into
fruition**

**Phase 5: Monitoring, evaluation
and adaptation**

Phase 6: Close out and synthesis





**Phase 1: Problem identification
and structuring**

Phase 2: Problem analysis

**Phase 3: Design problem solving
instrument**

**Phase 4: Bringing results into
fruition**

**Phase 5: Monitoring, evaluation
and adaptation**

Phase 6: Close out and synthesis



- flooding
- space constraints
- solid waste management
- vandalism & theft
- sewerage leaks
- maintenance operations
- sedimentation
- local sub-contractor

**Phase 1: Problem identification
and structuring**

Phase 2: Problem analysis

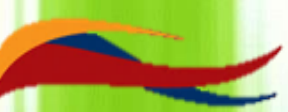
**Phase 3: Design problem solving
instrument**

**Phase 4: Bringing results into
fruition**

**Phase 5: Monitoring, evaluation
and adaptation**

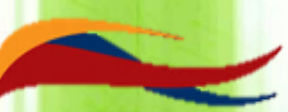
Phase 6: Close out and synthesis



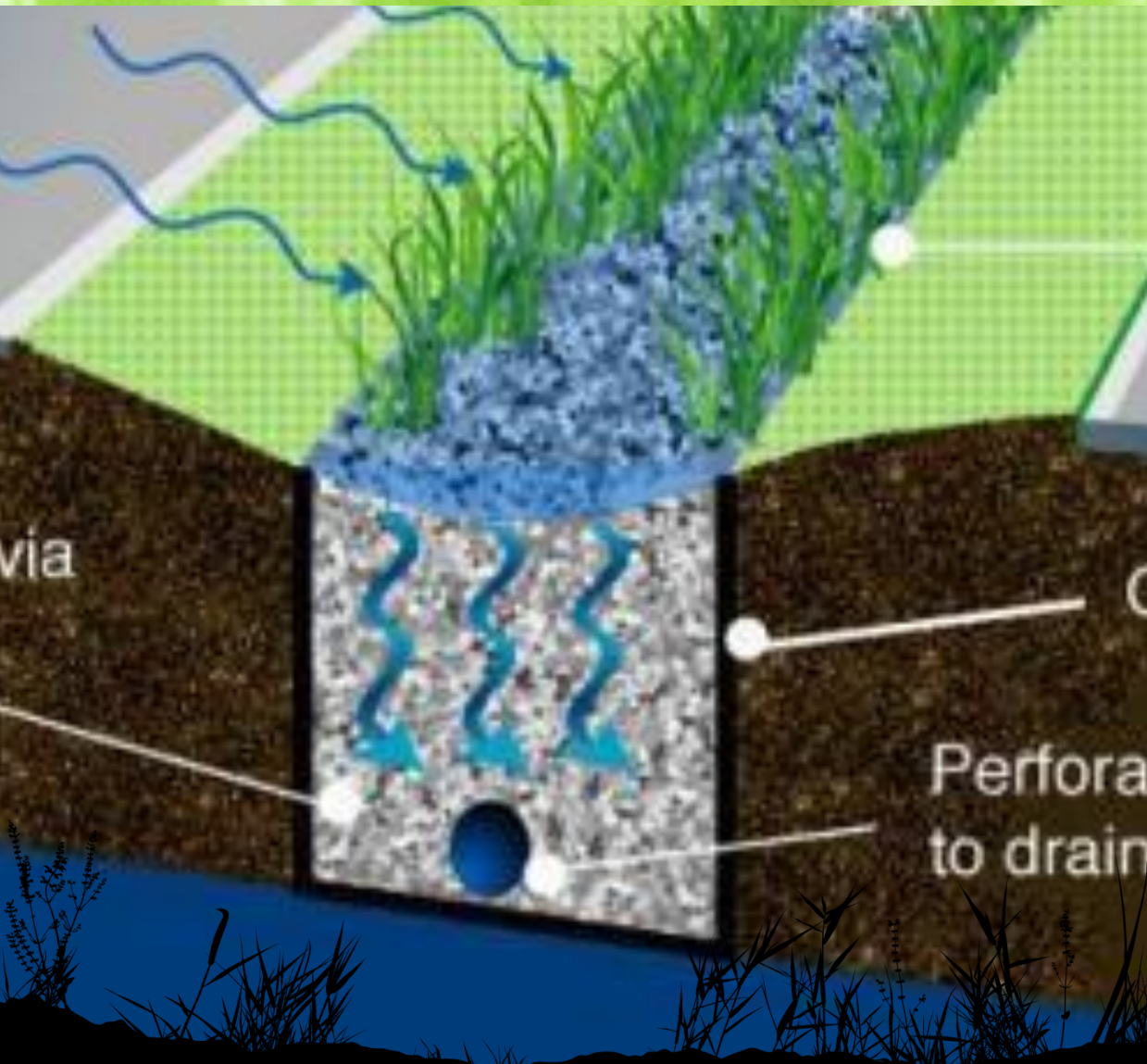


Bioswale Prototypes





Prototype 1: standard bioswale

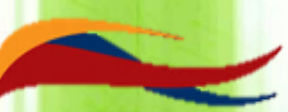


wetland plants

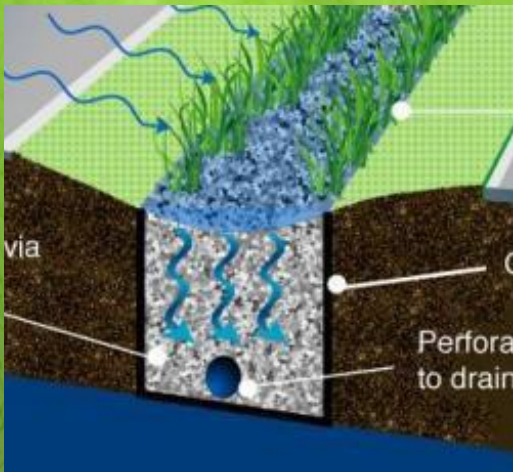
dryland plants

filter medium

french drain



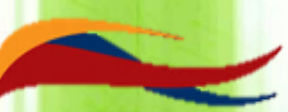
Prototype 2



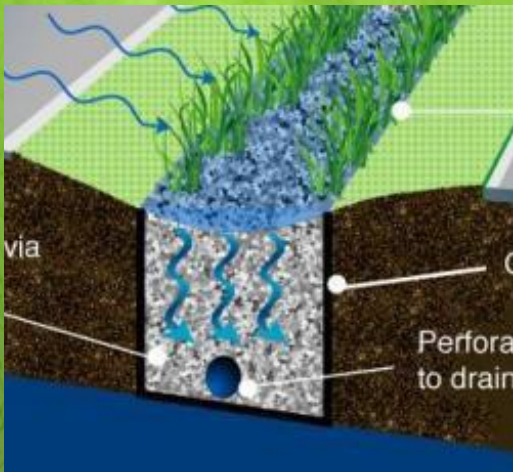
standard bioswale



food producing
tree



Prototype 2

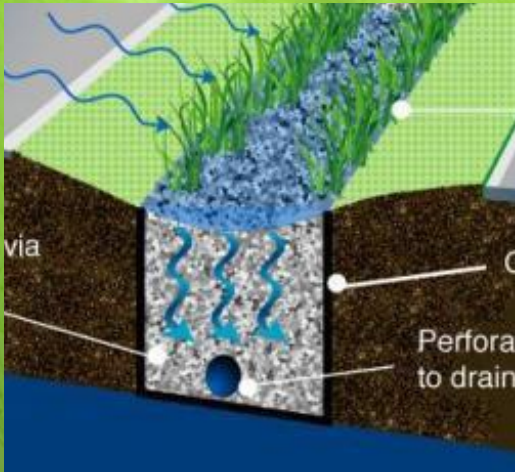


standard bioswale

shade tree



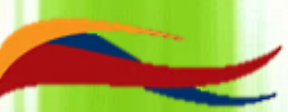
Prototype 3



standard bioswale



mycelium filtration



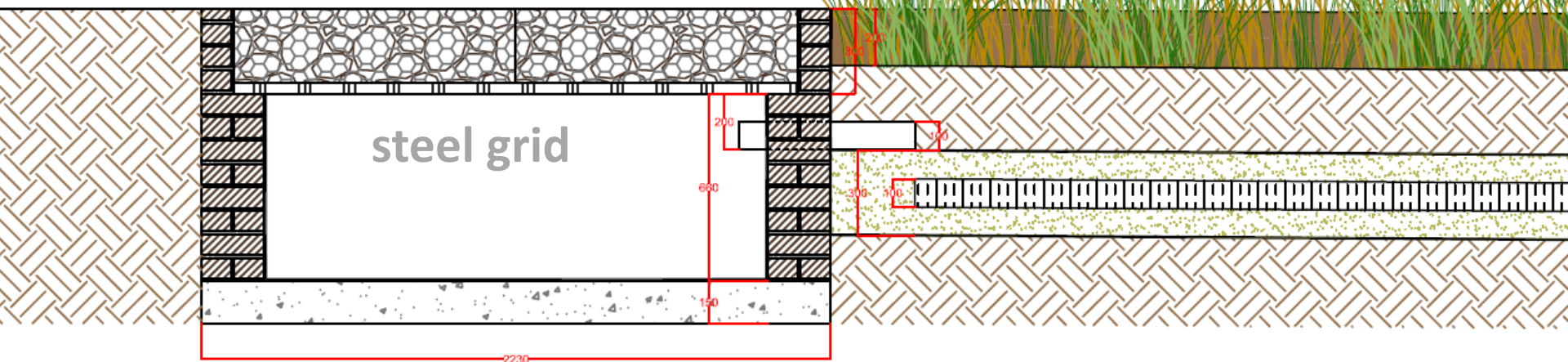
Sedimentation & Litter Trap






outlet pipe

reno mattress



concrete foundation



**Phase 1: Problem identification
and structuring**

Phase 2: Problem analysis

**Phase 3: Design problem solving
instrument**

**Phase 4: Bringing results into
fruition**

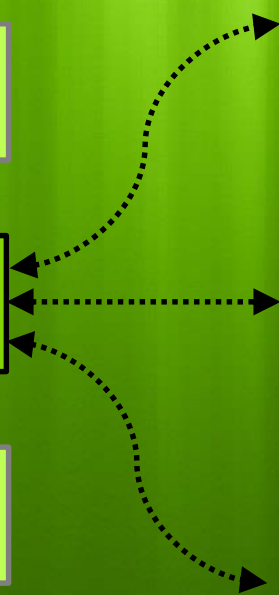
**Phase 5: Monitoring, evaluation
and adaptation**

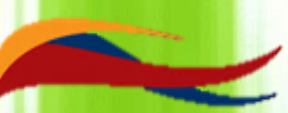
Phase 6: Close out and synthesis

Challenges

Successes

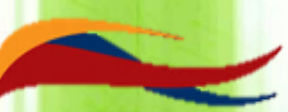
Lessons learned





Challenges

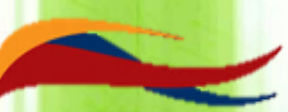




Existing roads and stormwater infrastructure



April 2015



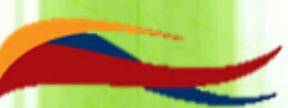
December 2015



Flooding and site
drainage during
construction







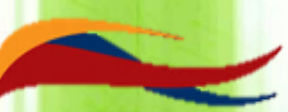
**Service delivery strikes
and dumping**



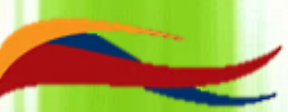
Sewerage leaks and
OHS



Theft and vandalism

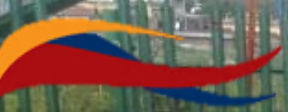


Rats and cows



Successes





Litter trap proves effective





Sediments trapped effectively

Skills transfer & training



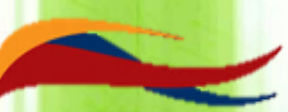








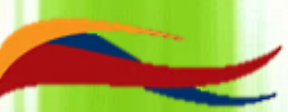




September 2016

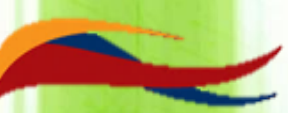


Road repaired,
stormwater inlet
uncovered and
sedimentation cleared



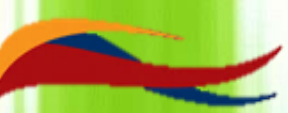
Lessons





- Timing of construction
- Community education
- Municipal collaboration
- Skills transfer
- Solid waste management
- Monitor, evaluate & adapt





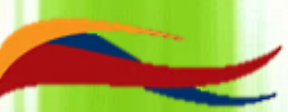
Current condition











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