Investing in ecological infrastructure for our FUTURE WATER SECURITY

The South African government has promised massive infrastructure roll-out as part of its objective to improve the lives of its citizens. Aquatic scientists have called on authorities not to disregard the services of the country's natural 'infrastructure'.
Article by Petro Kotzé.

Peter Chadwick

"Ecological infrastructure is the nature-based equivalent of built or hard infrastructure, and is just as important for providing services and underpinning socio-economic development."

It is no secret that South Africa faces challenges to guarantee future water security. Government is gaining ground on providing basic needs like freshwater (the percentage of households with no access to piped water decreased to 9% in 2011), but a booming population growth will add more burden to an already stressed system. According to the 2011 census, the country's population has increased with 7 million people in the last decade alone. The latest report of the Department of Water Affairs' (DWA's) Green Drop certification programme, published in 2011, once again highlighted the challenges most municipalities face in terms of achieving excellence in sewage treatment and management. Only 40 sewage treatment works achieved Green Drop awards, with 20 of the previous 33 recipients 'falling off the wagon' and losing their Green Drop status.

Furthermore, projections would have it that there will be a 32% increase in water demand in South Africa within the next few decades, while 98% of our surface water has already been allocated. These challenges are exacerbated by deteriorating water quality and failing infrastructure.

To address these difficulties, the South African government is planning to invest in massive infrastructure development. A National Infrastructure Plan was announced in 2012, which intends to transform our economic landscape while simultaneously creating significant numbers of new jobs, and strengthening the delivery of basic services. The 20-year plan involves as much as R4-trillion to be spent on infrastructure development projects. This includes R573-billion for water provision infrastructure and R30-billion to rehabilitate abandoned mines.

Development of such magnitude is often seen as a competing interest to that of our environment – development of the one must necessarily be at the cost of the other. "Yet, it cannot be an either-or choice," says Dr Jeanne Nel, principal scientist at CSIR Natural Resources and the Environment (NRE). Earlier this year she delivered the keynote address at the Grasslands Partners Forum. Her address touched on some of the work undertaken as part of the CSIR's Project on Ecosystem Services (ProEcoServ) funded by the Global Environment Facility (GEF) and coordinated by the United Nations Environment Programme. The topic addressed the importance of ecological infrastructure as an integral part of the answer to future development in South Africa.

WHAT IS ECOLOGICAL INFRASTRUCTURE?

Ecological infrastructure refers to functioning ecosystems that deliver valuable services to people, such as freshwater, climate regulation, soil formation and disaster risk reduction. It is the nature-based equivalent of built or hard infrastructure, and is just as important for providing services and underpinning socio-economic development. Key elements of ecological infrastructure are located in rural areas where the restoration or maintenance of these systems contributes to rural livelihoods. Sectors such as farming and tourism will be bolstered, but the actions of restoration and maintenance in itself already involves direct job creation.

Yet, the infrastructure provided by healthy ecosystems is often not recognised. These include healthy mountain catchments, rivers, wetlands, coastal dunes and nodes and corridors of natural habitat, which together form a network of


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interconnected structural elements in the landscape. Strategic investment in ecological infrastructure lengthens the life of existing built infrastructure and can reduce the need for additional built infrastructure – often with significant cost savings. Examples include river or filter strips that absorb pollutants and provide habitat for our biodiversity or healthy rivers that can fix themselves by absorbing pollutants.

A CATCHMENT IN TROUBLE

The Olifants River catchment, stretching across Mpumalanga and Limpopo, is a prime example of a system where considerable investment is needed to improve water quality and service delivery. It also serves as an example of where investment in a combination of ecological and built infrastructure could support the various improvements that are needed.

This catchment is exposed to extreme degrees of pressures from multiple sources. While South Africa is the fifth-largest coal producer in the world, the bulk of this production is from the Witbank coalfields. This catchment is home to the second-largest irrigation scheme in South Africa. Over half of the vegetables of a major food company are grown here, and the area supports a R1-billion export market in crop production. Land uses here include intensive feedlots and the catchment supports large quantities of animals, resulting in huge amounts of animal waste.

There are also widespread impacts due to abandoned opencast coal mines, which release acid water containing toxic heavy metals that need to be removed. The impact of the mining outflow is far-reaching. Dose response studies by the CSIR's Dr Bettina Genthe show increased cancer risk, while a higher reporting of more general medical symptoms are evident in mining areas. As a result of the decreasing water quality, the treatment of water for drinking and power generation is very expensive.

Agricultural and urban outflows, rich in nutrients (particularly phosphorus and nitrogen), have also caused large algal blooms in water bodies (eutrophication). Today, many of the dams in the area are eutrophic or borderline eutrophic. The sources of these high nutrients are both point-sources such as wastewater treatment works and non-point sources (due to runoff that ends up back in the river after flowing over fertilized fields or intense feedlots with lots of dung).

__Above:__ Abandoned opencast coal mines can result in widespread impacts, including acid water with toxic heavy metals that need to be removed. Photographed is the heavily impacted Brugspruit.

__Left:__ Left to right, Dr Sibusiso Sibisi (CSIR CEO), Dr Harrison Pienaar (CSIR NRE) and Johan Beukes (CoalTech Research Association) get their feet wet in a very hard-working part of the upper Olifants River as CSIR water quality researcher, Tsungai Zengeya, demonstrates his fish-sampling techniques.

__Right:__ Ideally, the phosphorus loadings of sensitive river stretches should be reduced first.


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WHAT SOLUTIONS CAN SCIENCE OFFER?

Dr Nel presented various options where science can help provide the solution to these problems. "Compared to just monitoring water quality, which has been the previous focus and really only describes a depressing problem, our research now offers new, tangible and strategic things we can actually do about the problem", she says.

MAINTAIN EXISTING ECOLOGICAL INFRASTRUCTURE

Using the Freshwater Ecosystem Priority Areas (FEPAs) identified for all of South Africa provides a good starting point for pinpointing valuable ecological infrastructure in the Olifants River catchment. FEPAs identified in the catchment often pinpoint the smaller tributaries (e.g. Blyde and Mohlapitse rivers), which tend to be in better condition than the hard-working Olifants River mainstem. These smaller tributaries not only provide excellent opportunities for conservation, but also support the sustainability of hard-working rivers further downstream, such as the Olifants mainstem, by diluting poor water quality and 'flushing' pollutants. Rather than degrade the few remaining FEPAs we have in the Olifants, we should see them as existing ecological infrastructure whose healthy functioning provides an opportunity to complement built infrastructure solutions through filtering and flushing pollutants.

Indeed, throughout South Africa, the use of healthy tributaries to support hard-working mainstem rivers is an important realisation. The National Freshwater Ecosystem Priority Areas project (NFEPA) – the project that identified priority rivers and wetlands – found that 57% of tributaries in South Africa are in a good condition, compared to only 35% of large mainstem rivers. Another important aspect highlighted by this project is the need for a more strategic planning approach to resource utilisation. Of particular concern is the proliferation of mining and prospecting rights applications in ecological sensitive areas that are critical for the provision of valuable ecosystem services, such as good quality water. The lodging of applications in headwaters of catchments that are a national source of drinking water and which are also important conservation areas is of grave concern. This is especially critical considering that only 8% of South Africa's land area generates 50% of the country's river flow.

UNDERSTAND THE DRIVERS OF PHOSPHORUS LOADING AT CATCHMENT SCALE

"There are multiples pressures that contribute to the phosphorus loading in a system," explains Dr Nel, and fixing point sources in an ad hoc manner is not necessarily the most strategic way to go about restoring water quality.

Dr James Dabrowski from the CSIR NRE has applied the Soil Water Assessment Tool (SWAT model) to help identify the sources of phosphorus loading at a catchment scale. The model estimates phosphorus loads originating from point and non-point sources in each sub-catchment. While the model is still in the process of being refined, preliminary results indicate that non-point sources can be as important a source of phosphorus as point sources.

If the national effluent standard of 1 mg/ℓ ortho-phosphate at sewage works was met, the phosphate loads in the Witbank and Loskop Dams can, for example, be reduced by almost a half. A further reduction to the international standard of 0.1 mg/ℓ does, however, not result in a substantially lower reduction. In this instance, the potential positive effect of reduced phosphorus loading at point-sources (sewage works) is masked by the amount of phosphorus that originates from non-point sources.

Once this dynamic is understood, science can help to develop the most effective phosphorus reduction strategies. "The key is to understand the load and be strategic about it," Dr Nel says. The solution is thus not necessarily only investing in built infrastructure like sewage works, but also in initiatives such as enforcing setback lines when agricultural activities take place next to rivers. Ideally, the phosphorus loads of sensitive river stretches should be reduced first. "Go to the catchment and find the most offending areas and target them first," advises Dr Nel.

Guidance is also offered by the phosphorus sensitivity index developed by Dr Paul Oberholster of CSIR NRE. According to this index, bedrock streams are particularly sensitive, while sand or mud bottomed rivers are less sensitive. The sensitive

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Activities, such as farming, mining and industrial development, affect the ability of rivers to filter and flush pollutants, resulting in poor quality water. People in rural poor areas often benefit least from the economic development, but suffer the consequences most.

areas where attention should be given first would logically include areas where sewage works discharge into, or cattle drinking points and feedlots are located close to, cobble or bedrock streams.

RESTORE WETLAND FUNCTIONS

Wetlands filter out sediment and pollutants. A team of CSIR water quality specialists, led by Dr Klaudia Schachtschneider, are now also studying the uptake of heavy metals by indigenous wetland and riparian plants in the upper Olifants.

"We are hoping to build on this work through a project funded by CoalTech Research Association focused on the restoration of the Zaalklapspruit wetlands located in a mining-impacted area", says Dr Nel. Together with CoalTech Research Association, researchers from South African National Biodiversity Institute, CSIR and the Water Research Commission are bringing their knowledge together, in order to restore this wetland. Impacted by acid mine drainage (AMD), this wetland was selected on the basis of helping to protect the Wilge River from AMD. Work is set to proceed soon. The restoration work will include planting indigenous wetland plants that can filter out heavy metals.

"We are hoping to extend our work on heavy metal uptake to developing a practical manual or guideline for restoration practitioners on indigenous plants that can effectively remove heavy metals, says Dr Nel. "CSIR is only now beginning its practical work on plant uptake of nitrogen and phosphorus."

It thus seems as if indigenous plants that sequester nutrients can help with technical solutions, particularly in rural areas. Here, limited knowledge and funds are often constraints to operational maintenance of high-tech infrastructure. Combining them with ecological solutions might provide a cost-effective long-term option.

SETTLING PONDS FOR SEWAGE WORKS

In the Tubatse sewage works in the rural areas of Limpopo, the settling ponds have not been cleared of plants. If there was cement lining in the past, it is now cracked and has disappeared in places. "We think that plants that have established there are fulfilling the very important function of filtering out nutrients," says Dr Nel. The water flowing into the sewage treatment works is rich in nutrients, but the water flowing out is 'not too bad'. By changing these systems more towards artificial wetland systems (with plants and no underlying cement) researchers might be able to come up with a more effective systems in the future for low-resourced, rural areas. "We also may be able to develop microbial and phytoplankton supplements to improve efficiency of the systems, especially when plants are dormant in the winter."

MAKE BETTER USE OF ARTIFICIAL WETLANDS

Wetlands are less expensive to construct than traditional built infrastructure and only require periodic maintenance. The system reuses and recycles water and provides a habitat for plants and animals. Such a project also has the potential to create job opportunities.

For wetlands – natural or artificial – to deliver the best results, you need a big area and low flow, and we have that her in South Africa, says Dr Nel. "Development often hems wetlands in but we must not foreclose on using space – we need it to get the most out of wetlands."

SWITCH FROM FERTILIZERS TO MICROBES

While this suggestion does not directly relate to the use of ecological infrastructure, this switch would help support ecosystem functioning by not loading the ecosystems with too much nutrients.

"Some prominent farmers in the Olifants River catchment have already made the switch," notes Dr Nel. "This helps plants to utilise natural organic phosphorus in the soil, so there is no need for added fertilizer." Compost tea, for example, stimulates microbial action which stimulates root and plant growth.

In conclusion, Dr Nel maintains that for any of these suggestions to be effective, they need to be incorporated into development planning. The key is investment in both ecological as well as built infrastructure. "Wouldn't it perhaps be wise to allocate some money to ecological infrastructure as part of the Presidential Infrastructural Plan?"

"We must also be smarter with the water that we have," Dr Nel continues. "Water should be put at the centre of the decision when trade-offs are made between development decisions." ❑

Jeanne Nel

Areas where attention to the reduction of phosphorus loads should be given first include cattle drinking points and feedlots.