WETLANDS

UFS graduate's PhD findings adopted as national standard for wetland mapping

An alternative approach for large-scale wetland mapping in South Africa was developed as part of a recent PhD study which will be considered for use by the national institute responsible for wetland data in the country. Jorisna Bonthuys reports.

Lani van Vuuren

Dr Nacelle Collins, a wetland ecologist from the Free State, used a multi-criteria decision-making approach as part of his PhD study to develop an alternative method for wetland mapping in South Africa. The results of his study will be considered by the South African National Biodiversity Institute (SANBI) as an option for wetland mapping in South Africa. SANBI is the data custodian for the national wetland mapping base data. The institute maintains, manages, integrates, uses, and disseminates wetland information.

Collins, a wetland ecologist in the Department of Economic, Small Business Development, Tourism and Environmental Affairs, oversees conservation and management strategies for the Free State's wetlands. Collins, who is also a research fellow at the University of the Free State's Centre for Environmental Management, believes that wetland protection, rehabilitation, and wise use will become increasingly important given the impact of climate change and continued pressure on our water resources. "It's crucial to understand the significance of wetlands in the landscape," he says. "Wetlands play an essential role in addressing many of the challenges that humanity faces today. Wetlands are, for instance, crucial for ensuring water security, mitigating climate change, and providing a safe environment for many aquatic species. The importance of wetlands in sustaining life cannot be overstated, and we need to make every effort to protect them."

According to Collins, accurate maps are essential for biodiversity assessments, wetland conservation and management decisions. He says the most recent wetland map of South Africa (National Wetland Map 5) is considered to be of too low accuracy to be used with confidence at the national level. "The most recent wetland map showed a low confidence rating for representing the extent of wetlands. It is characterised by an estimated omission error of 50%."

While this map did improve on its predecessor, the NWM4, accuracy assessments showed that 30%, 70%, and 90% of wetlands in the Vaal River, the Olifants River, and the Free State study areas are not represented in the most recent wetlands map when compared to reference datasets. In his study, Collins explored alternative mapping approaches, hoping for comparable or better results to the multispectral approach that has been the most commonly used approach for large-scale wetland mapping.

An alternative approach

In April, Collins received his PhD in the Department of Geography at the University of the Free State. He was the first recipient of the PhD in geography, majoring in geoinformatics at the university. In this discipline, scientists use advanced technologies, such as remote sensing, to interpret and apply geographic data. Collins' dissertation titled ***An alternative approach for large-scale wetland mapping in South Africa*** explored the potential for an alternative method to multispectral imagery for mapping wetlands.

He aimed to find a solution that could quickly and accurately map wetland extent over large regions, using the least amount of available data and funds while requiring minimal technical skills. With this in mind, Collins created a conceptual framework that integrated the best features of both on-screen and digital elevation model-based valley-bottom extraction approaches. This framework consists of a spatial and data structure that paved the way for a more efficient and effective mapping approach.

The results of his study will also inform a wetland management system that can be applied in the Free State and potentially elsewhere. "To manage wetlands, we must be able to assess and prioritise them for a range of different objectives and values. Achieving this goal requires many data inputs, of which my study addresses only one."

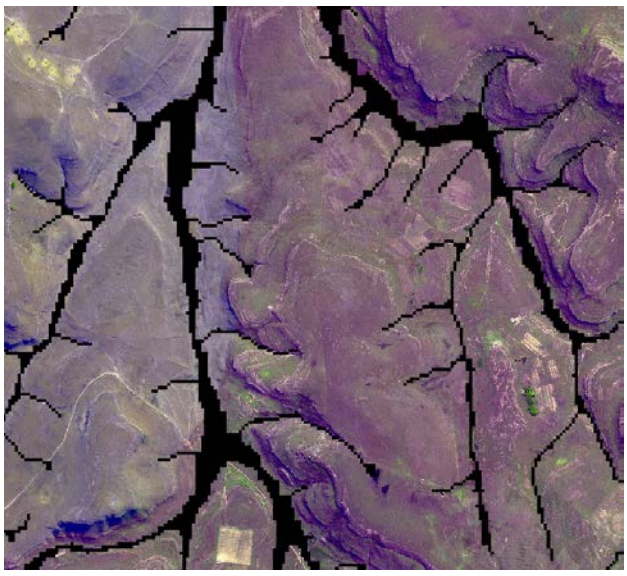
Collins' framework allows for wetlands to be mapped and described using existing data. This means traditional approaches, such as multispectral image analysis, can also be incorporated into the topographic mapping approach. With his framework, users can create improved maps that reflect the most up-to-date information. In addition to providing the technical requirements for the new mapping framework, SANBI also tested tool operations and robustness during their development, while guiding implementation rationale.

Comparing mapping approaches

Collins employed topographic mapping to different reference sites and tracked the time spent on mapping tasks. The first approach involved rapid topographic mapping, while the second approach focused on topographic mapping with increased mapping effort. The third approach included on-screen mapping, which was used to supplement the results of the second approach.

"A key advantage of this alternative framework is that it does not require any training or reference data."

In addition, Collins compared the accuracy of the existing national wetland map (NMW5) to the same reference data. He did this to determine how the topographic mapping approaches using variable mapping effort compared with the reference sites and NMW5.



Above and top: An example of improved wetland mapping that can be obtained using a topographic mapping approach. The blue polygons (top image) are wetland areas in the latest national wetland map (National Wetland Map 5). In terms of topographic mapping, the black areas (bottom image) are potential wetland areas.

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The new approach is flexible enough to accommodate different scales and levels of accuracy, making it suitable for anyone who wants to map wetlands

Collins assessed mapping accuracy and performance at two sites, one in the Northern Cape and the other in KwaZulu-Natal. He says the mapping accuracies of the three approaches can, at best, be described as moderate to good. "Wetland maps that are created [with these approaches] may not be completely accurate, but they are still an improvement to the national wetland map," he says. "If the priority is efficiency, the first approach [rapid topographic mapping with minimal mapping effort] should be used. However, if accuracy is the main concern, the third approach [topographic mapping supplemented with on-screen mapping] should be pursued.

"The difference between the reported accuracies of multispectral image mapping and the international state of wetland inventorying is striking," he remarks. Collins says that no mapping approach by itself can create a comprehensive wetland map for South Africa. He considers the best solution one that incorporates multiple mapping approaches.

"One of the major challenges when mapping using multispectral images is the need for specialised knowledge and resources," he says. "Unfortunately, this expertise is not commonly found within government institutions in South Africa. As a result, previous attempts at mapping wetlands have been unsuccessful in creating an accurate inventory that can be used confidently at a national level."

Multispectral imaging is a collection of a few image layers of the same scene, each acquired at a particular wavelength band. "These images are created by detecting frequencies, including and other than what our eyes can see. It is a complex and expensive process requiring much technical know-how."

It is also important to note that multispectral wetland mapping has limitations. "One of the major challenges is that it cannot detect and map transformed wetlands," he says. "As a result, their omission from the national wetland map undermines its accuracy. Therefore, we must continue to develop new methods for mapping wetlands to ensure a more comprehensive understanding of these important ecosystems."

Collins says that multispectral image analysis alone still needs to successfully create a comprehensive wetland mapping for South Africa and that the best solution is one that incorporates multiple mapping approaches. "Instead, it might be better for South Africa to explore alternative mapping methods more suitable for its needs. In our context, it would make sense to apply an approach which requires minimal expertise, skill, and funds, with the ability to track change over time."

"Given the past poor accuracies when using multispectral imagery analysis to detect wetland vegetation for large-scale wetland mapping in South Africa, the topographic position is considered the only other viable alternative for large-scale and cost-effective mapping.

According to him, both multispectral and topographic mapping approaches are by themselves unsuitable for wetland mapping, and especially the smaller and narrower wetlands. Both approaches are inaccurate at mapping wetland boundaries. Instead, he says on-screen mapping is the preferred method to achieve more precise results.

With minimal data, Collins' approach can map existing and historic wetland extent over large regions more accurately

than what has been achieved thus far. Furthermore, it requires minimal to no data preparation and basic geographic information system skills.

Framework offers flexibility

Collins' framework allows for flexibility that integrates other mapping technologies and approaches.

Collins says an ideal mapping approach for South Africa is one where those technologies and approaches most capable of satisfying mapping requirements can integrate available information into a single mapping structure. He achieved this by developing a conceptual mapping framework, which can combine the use and abilities of on-screen, multi-resolution topographic mapping, and other mapping approaches, which, except for monitoring, can collectively satisfy wetland mapping requirements.

He says the achieved accuracies are better than those of the national wetland maps, which along with the improved mapping extent, represents "a meaningful improvement". "This is especially the case when considering that these improvements were achieved at a fraction of the cost and time spent during the more than 20 years of national wetland mapping," he points out.

"A key advantage of this alternative framework is that it does not require any training or reference data. However, in the absence of reference data, and especially when mapping an unfamiliar area, it may be necessary to first relate the imagery to actual wetland occurrence through in-field or other forms of verification."

Although not part of Collins' study objectives, mapping the spatial extent of wetlands while simultaneously accounting for and including existing descriptive data is an additional benefit of his approach not offered by other approaches where attribute data has to be dealt with as a post-mapping exercise.

While Collins concluded that the proposed mapping framework offers a practical solution for large-scale wetland mapping in South Africa, he acknowledges that his approach also has some limitations. His approach has a different consistency and repeatability than other more automated approaches. Inconsistent results can be expected when the same area is mapped by different persons or by the same person using different imagery. Accuracy is also influenced by terrain topography and climatic factors such as mean annual precipitation and evaporation.

On the plus side, the ability of his alternative approach to map existing and historic wetlands has the potential for improved estimates of wetland loss by determining the difference between the wetland potential map and a map of transformed land cover. Such information is essential for monitoring purposes.

One major advantage of the low technical requirements for mapping wetlands is that it allows individuals who are not GIS or remote-sensing experts to participate in the mapping process.

Unlike other mapping models that incorporate different earth observation technologies and approaches at the onset, the open structure of the proposed mapping framework allows for any earth observation technology or other mapping approaches to be added at any time of the mapping process. This can be achieved without the technical skills that are usually required to edit and adapt such modelled approaches.

"With this approach, anyone can easily create maps of wetlands in any area, incorporating both spatial and descriptive data," he says. "The best part is that it is flexible enough to accommodate different scales and levels of accuracy, making it suitable for anyone who wants to map wetlands."

Collins found that this mapping framework can be implemented in incremental steps as it doesn't require data collection, model development, or complex data preparation. This flexibility also means that certain areas, like strategic water source areas, can be prioritised for a greater mapping effort within the same mapping project. Other approaches, such as predictive modelling, do not allow for this kind of prioritisation for large-scale mapping, as the training data are applied equally to the entire area being modelled.

"The results demonstrate that mapping technologies and approaches other than what has been used thus far to create the South African national wetland map can produce wetland maps with improved accuracy and representation, and at significantly reduced time and cost," he says. "Even though the accuracies achieved are considered modest and unsuitable for detailed wetland assessment such as is required for environmental impact assessments, they are considered suitable for large-scale management and conservation planning purposes."

While the proposed alternative mapping approach and conceptual framework for wetland mapping may not represent or include the most current technologies and methods, Collins considers it better suited for developing countries.

Even though the accuracies achieved during this study may not satisfy what can be considered to be the minimum mapping accuracy required for national wetland mapping and inventorying, Collins says they still represent "a marked improvement" to the existing national wetland map. "There is no silver bullet option for mapping wetlands in South Africa," he says. "The differences in accuracies and efficiencies achieved for the different reference sites suggest that what will be the most accurate mapping approach in one area will not necessarily be the most accurate in another. The ability of the mapping framework to incorporate such different mapping approaches that are suitable for different areas makes it suitable for mapping large and heterogeneous areas.

"To manage wetlands effectively and efficiently, we must be able to assess and prioritise them for a range of different objectives and values. Achieving this aim requires many data inputs, of which my study addresses only one."