IRRIGATION AND WATER

Water allocation for irrigation under the microscope

The precarious state of South Africa's water supply is now a well-known fact, and science-based information regarding how this precious resource must best be used is integral. A recent Water Research Commission-funded study investigated if the largest allocated share of the country's water – to irrigated agriculture – is correct, by comparing crops' water use with water quotas. Petro Kotzé writes for the Water Wheel.

Brand South Africa

The results indicate that some water allocations might be erroneous, but experts warn that though the work is "extremely important", it should be seen as the first step in a way forward that calls for more in-depth investigation.

For the purpose of the study, allocated water quotas were compared with crops' water requirements using SAPWAT4, a progam designed with WRC funding to estimate irrigation water needs. The project was led by agronomist Pieter van Heerden, one of the original SAPWAT developers.

A history of water allocation in South Africa

Under the previous Water Act (Act no. 54 of 1956), irrigation areas were given a water use right as a water quota. The amount was expressed in terms of cubic metres per hectare per annum, for a specified number of hectares. Under the new National Water Act (Act no. 38 of 1998), this has been replaced by a water use right, expressed in total cubic metres of water for a farm or property. However, since the first determinations, and review of some allocation in the first half of the twentieth century when large-scale irrigation development took place, there has been no, or limited revisions and adaptions.

South Africa's water quotas were thus set in ink before sophisticated methods to determine the water requirements of plants existed. The requirements that were known were available to a limited extent, based on a combination of local experience and some research. Irrigation needs were determined by measuring plants' water use, says van Heerden. By adding trees or maize plants to a plot, for example, and then re-measuring water use, an estimate could be made. "This was timeous and expensive research," he says. These methods resulted in advice such as "two irrigations of 3 inches (75 mm) per cutting for lucerne production in the Great Fish River Valley."

Since then, irrigated agriculture has seen major development. Crop growth characteristics and the major crops grown under irrigation have changed. Through the development of shorter growing maize, cotton and potato cultivars, it is now possible to grow two crops in one season on the same irrigated field. More sophisticated water measuring tools have been developed and farmers have learned how to do more with their available water. Irrigation systems have been revolutionised.

Especially over the last few years, van Heerden says, the technology available to calculate more precise water requirements of irrigated crops has improved by leaps and bounds. The South African-developed SAPWAT, in particular, has gained renown for this purpose. The most recent version, SAPWAT4, is commonly used across all southern African countries (except the DRC) and widely to the north of the continent as well. In South Africa, Nic Knoetze, CEO of the South African Association for Water User Associations, says the model is held in such high regard, it was used for calculations when existing lawful water use was registered and is recommended as backup should actual water metering equipment fail.

The model can incorporate soil water characteristics, evaporation parameters, irrigation system efficiency and crop water requirement with data from weather stations and the climate region that the area is located in, to estimate crop irrigation requirements.

It can be applied to a single crop, a field with multiple cropping, a single farm, a group of farms or Water User Association (WUA), for a group of WUAs, or for river basin and basin sub-units. The results are given, where appropriate, in millimetres and cubic metres.

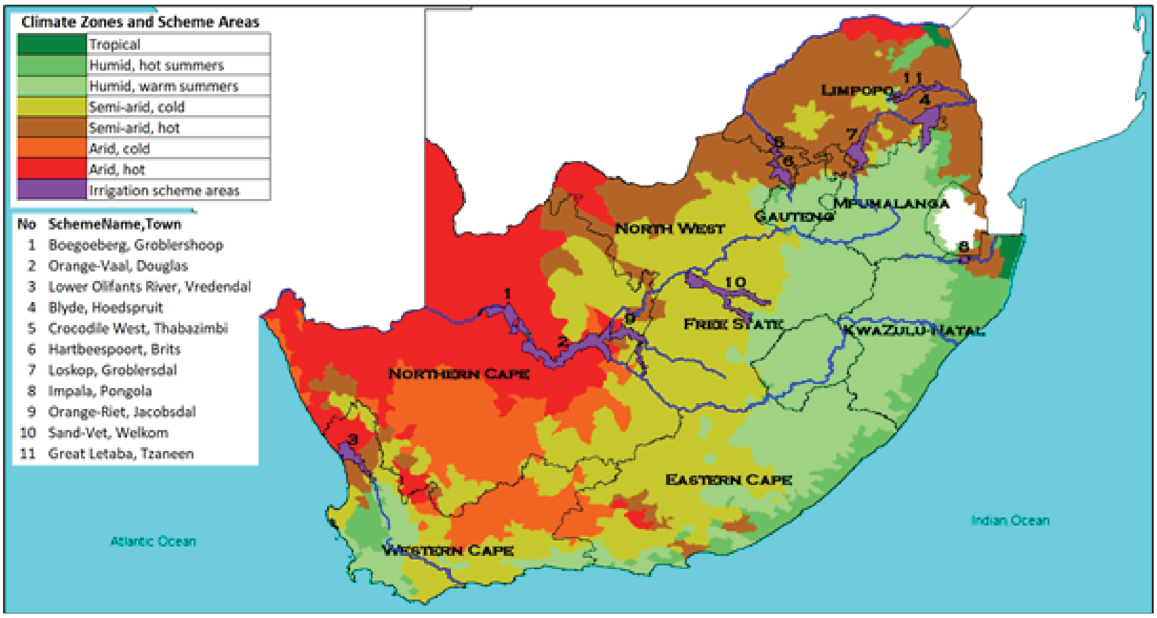
Comparing water needs and allocations

For the purpose of the project, case study areas were selected from across South Africa, in different climatic regions where irrigation takes place.

The research team, Pieter and Gela van Heerden relied on surveys to determine different cropping patterns and soil-, irrigation system and strategies and crop combinations. They also documented which one of the following four irrigation management approaches was used:

Werner Conradie

Irrigation for agriculture remains the largest water user in South Africa.



- Conventional irrigation management, which allows soil water extraction to a level of 50% of readily available soil water, to prevent the development of stress.
- Conservation management, which is applicable when growing large sized seed grain crops, where seeding takes place in the stubble of the previous crop to reduce soil surface evaporation.
- Stress irrigation, which allows for soil water extraction to 100% of readily available water. Water saving through the application of slight stress is a possibility, but estimates indicate noticeable yield losses in more sensitive crops.
- Farmer management: If irrigation management strategies differ from any of the previous three irrigation approaches.

The results show a wide range of deviations between SAPWAT4 estimated crop irrigation water requirements and actual irrigation water quotas of areas.

Specifically, in arid, hot climates, the deviations between the quota and crop requirements are high. In the Boegoeberg, lower-Orange irrigation area water requirements are 165% of the allocated water. The findings showed that the water quotas of five of the eleven WUAs are less than the SAPWAT4 calculated irrigation requirement. At these WUAs the estimated irrigation water requirement ranges from 165% to 113% of the present allocation.

Irrigation area	MAP (mm)	ET_0 (mm d^{-1})	Quota (m3 h^{-1} a^{-1})	Recommended quota (m3 h^{-1} a^{-1})	Change %
Arid, hot climate					
Orange Vaal	288	4.6	10 000	14 426	144
Boegoeberg Middle Orange	215	4.6	10 000	17 009	113
Boegoeberg Lower Orange	215	4.6	15 000	16 534	165
Semiarid, hot climate (winter rainfall)					
LORWUA, Bulshoek Dam downstream of Clanwilliam Dam, Lower Olifants River	260	3.9	12 200	10 025	82
Semiarid, hot climate (summer rainfall)					
Hartbeespoort, Crocodile River downstream of Hartbeespoort Dam	529	4.5	6 200	8 386	135
Crocodile West, Lower Crocodile River	660	4.5	8 000	10 025	109
Impala, Pongola River upstream of Jozini Dam	692	3.9	10 000	7 621	76
Loskop, Olifants River, Loskop Dam	582	4.3	7 700	6 016	78
Blyde, Blyde River, Blyde River Poort Dam	638	4.1	9 900	13 457	136
Semiarid, cold climate					
Orange-Riet, Vanderkloof Dam	486	4.3	11 000	10 750	98
Sand-Vet, Erfenis and Allemanskraal Dams	517	4.1	7 200	5 850	81
Great Letaba, **Humid warm summers**	1 127	3.4	6 620	7 553	114
Great Letaba, **Humid hot summers**	971	3.8	8 920	11 892	133
Great Letaba, **Semiarid hot**	536	4.3	10 900	13 378	123

Present and recommended irrigation water quotas, including climate regions, average annual rainfall and ET_0

Furthermore, two WUAs fall within a 10% deviation of allocation at 109% to 98% of the present allocation. The irrigation water allocation for the remaining four WUAs is more than the SAPWAT4 estimated irrigation water requirement with values that range from 82% to 76% of the present allocation.

Though the study is a good starting point, Knoetze says more robust research is necessary to verify the findings before the results can be used by policy makers.

For accurate output, accurate input is necessary

Their dependence on WUA managers to provide information such as crop areas planted via questionnaires impacted on the accuracy of the data for some areas, van Heerden says. "Along the Olifants River they take a satellite image every year, so that area's results are tremendously accurate." At the Orange-Vaal irrigation area, the crop patterns are regularly documented, which also results in accurate results, he says. In other areas where such detailed data is not available, the accuracy of the findings are thus affected.

The interpretation of satellite images could be an improvement of the situation, provided that satellite images of spring, summer, autumn and winter cropping patterns are utilised. To obtain long-term cropping patterns, such surveys should be repeated regularly to keep up with changes in climate, cropping patterns and markets.

As for the performance of SAPWAT4, further tweaking could include updating the model's crop coefficient values, as newer varieties have different growing patterns than those currently included. Van Heerden points out that some crops that are coming into production because of market pressure, such as macadamia and blueberries, are not sufficiently researched in terms of crop coefficients yet. "This is also very relevant in the case of subtropical crops, where spring, summer, or autumn growth flushes effects the mid-season crop coefficients."

Last, the quaternary drainage region climate data should be updated and imported into SAPWAT4. Currently ranging from 1950 to 1999, updating these would also enable the SAPWAT4 user to compare short period climate differences as experienced lately.

Insights into on-farm farming operations

The research team found that farmers made very efficient use of rainwater, using it to partially supply their crops' water requirement and reduce the need for irrigation. However, in low rainfall areas, the occurrence of rain is often very erratic and its contribution is usually very low. The general impression is that the farmers know about good irrigation scheduling strategies and that they do apply these as far as possible.

In areas where study results indicated that less irrigation water is received than what the crops require, farmers have adapted short-term crop production strategies. These include planting smaller areas; irrigating higher value crops at the expense of lower value crops; pulling up less profitable orchards and vineyards; pruning tree and vine crops to smaller sizes or to just main and frame stems to reduce irrigation water requirement. Although good strategies, the researchers point out, these are only short-term solutions and are not economically viable.

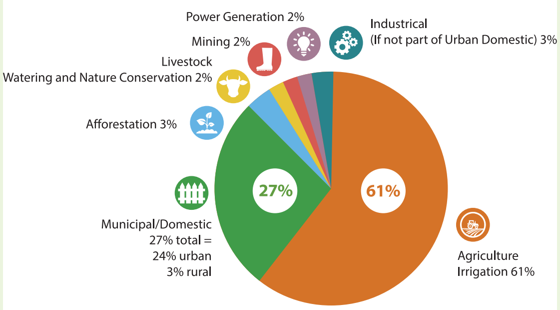
Moving forward

"The project findings are interesting," Knoetze says, "but cannot be accepted as gospel without a follow-up study to produce more reliable figures, especially from on-farm operations." Knoetze was part of the project's reference group, a model applied by the WRC to allow for broad and cross-sectoral consultation of research project methodologies and study results.

Still, van Heerden says that ideally, irrigation water allocations should be adapted from time to time based on the climate and the crop pattern. "The water quota has to be based on the crop's water need," he says. This has to be reviewed every three or four years as cropping patterns and markets change, irrigation systems are upgraded, the climate changes and shorter growing cropping varieties emerge.

In a water scarce country like South Africa, we cannot afford to play irresponsibly with our available water, van Heerden says. Part and parcel of that, is to ensure that an agricultural area receives the correct water quota based on the specific farming practices applied there.

South Africa's water allocation



How we use our water resources in South Africa

According to South Africa's Water and Sanitation Master Plan (2018) agriculture is the country's largest water use at 61% of total water use, followed by municipal use at 27% (including industrial and commercial users provided from municipal systems), with power generation, mining and bulk industrial use, livestock and conservation and afforestation jointly making up the remaining 12%.