

## Evaporation Losses from Small Reservoirs

### Authors

*Jens Liebe, Cornell University, Ithaca, NY, USA, and Center for Development Research, University of Bonn, Germany*

*Nick van de Giesen, Delft University of Technology, The Netherlands*

*Tammo Steenhuis, Cornell University, USA*

### Scope

Evaporation losses from small reservoirs affect their water storage efficiency. Because water that evaporates is water that cannot be used, we can also speak of unproductive water losses. Many planners and decision makers feel that small reservoirs are unsuitable for rural water supply because they assume that evaporation losses are extremely high. In a detailed study in the Upper East Region of Ghana we measured evaporation from water bodies in different ways. Observed evaporation losses were moderate.

### Target group

- Decision makers, watershed planners, and development assistance agencies wishing to understand evaporation processes, and likely evaporation rates, in small reservoirs
- Researchers

This study was conducted with custom-built instruments, used in a rather complex setup. Although practitioners can draw on study results, for example, with regard to the positioning of instrumentation, the tool should be adapted to local circumstances in new applications.

### Requirements for application

The study was conducted with a large number of instruments. A wave-stable, self-filling, floating evaporation pan was developed that is controlled by a custom-built data logger. Seven weather stations were also deployed on and around the reservoir to understand how instrument placement affects measurements. The energy budget of the reservoir was calculated using temperature profiles.

Simpler methods are available for practitioners seeking to measure reservoir evaporation. For practical purposes, reservoir evaporation rates are commonly determined with evaporation pans, or calculated from weather station data. For research purposes, a range of additional tools and methods are available, but many of these are expensive and technically complex.

### Description and application

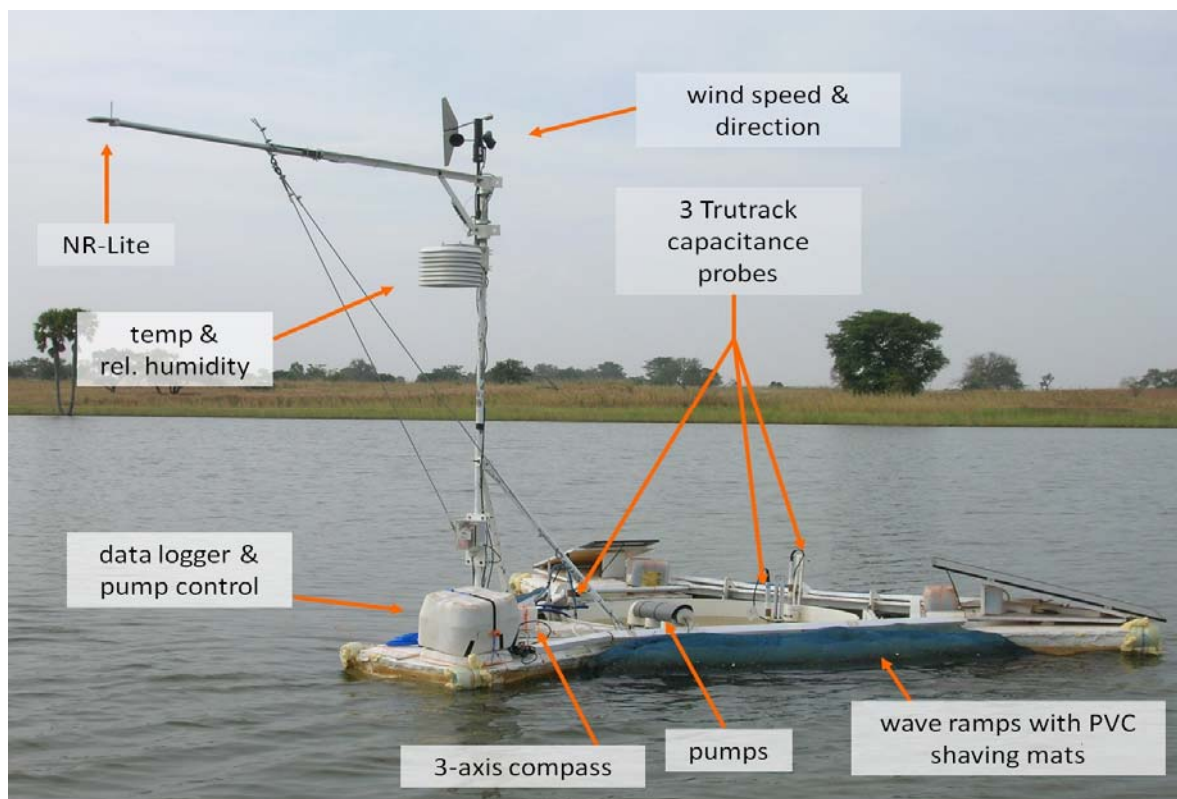
Water bodies in arid surroundings can be subject to high evaporation losses due to the oasis effect<sup>1</sup>. These high rates are due energy advection, or extra energy input from dry surroundings.

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<sup>1</sup> <http://amsglossary.allenpress.com/glossary/search?p=1&query=oasis+effect&submit=Search>

It is often assumed that this leads to high evaporation losses from small reservoirs. Yet, direct evaporation measurements from sub-tropical small reservoirs are rarely available.

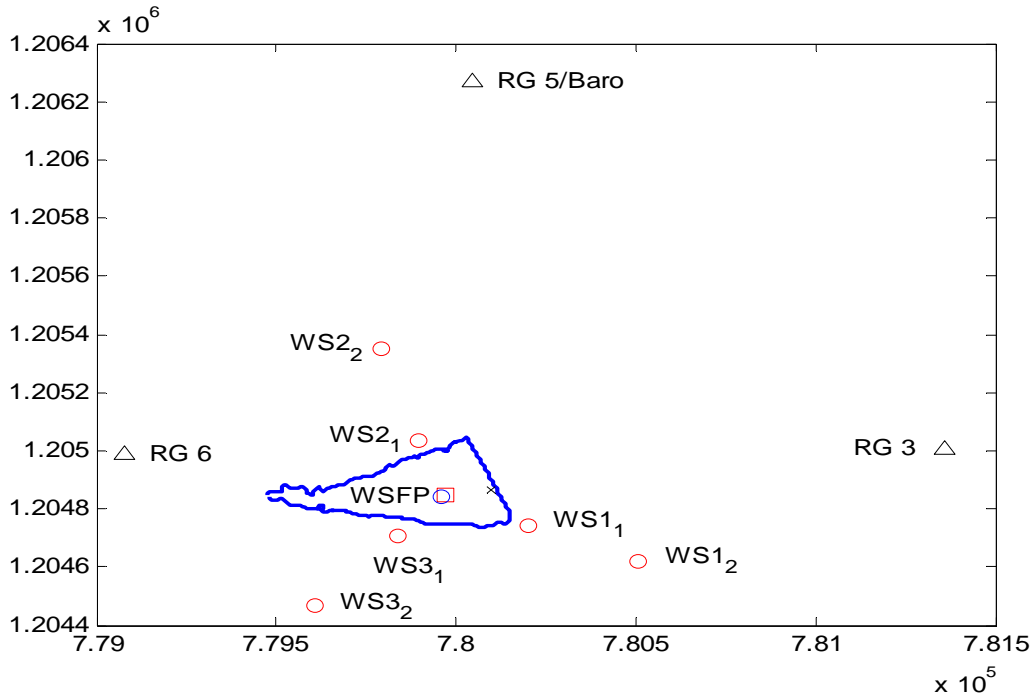
The objective of this research was to compare direct and indirect methods to determine evaporation losses from a small reservoir, and to evaluate local effects that influence such evaporation. For direct measurements, a newly designed floating evaporation pan (Figure 1) was operated on a small reservoir in the Upper East Region of Ghana (10°53' 20"N, 0°26'20"W). Indirect evaporation estimates were determined from the reservoir energy balance, and potential evaporation after Penman. The Penman evaporation was determined at seven locations on and around the reservoirs to evaluate local effects (Figure 2).



**Figure 1:** Floating Evaporation Pan and instrumentation

It was found that in the dry months from November 2005 to March 2006, during the season when evaporation is relatively high, mean monthly evaporation losses were in the range of 4.9 to 6.4 mm per day. In the wet season, mean monthly evaporation losses were below 5 mm per day. During the months of December 2005 through March 2006, the energy budget suggests a weak oasis effect.

The arrangement of weather stations showed that general circulation patterns play a major role in determining evaporation losses. During much of the year, the southeast monsoon is the prevailing circulation pattern. These air masses often arrive at the reservoirs with a high relative humidity, which keeps evaporation losses low. During the dry season, when the Upper East Region is affected by the northeast trade winds, the approaching air masses are very dry (relative humidity often below 10%) and can absorb a lot of water from the reservoirs.



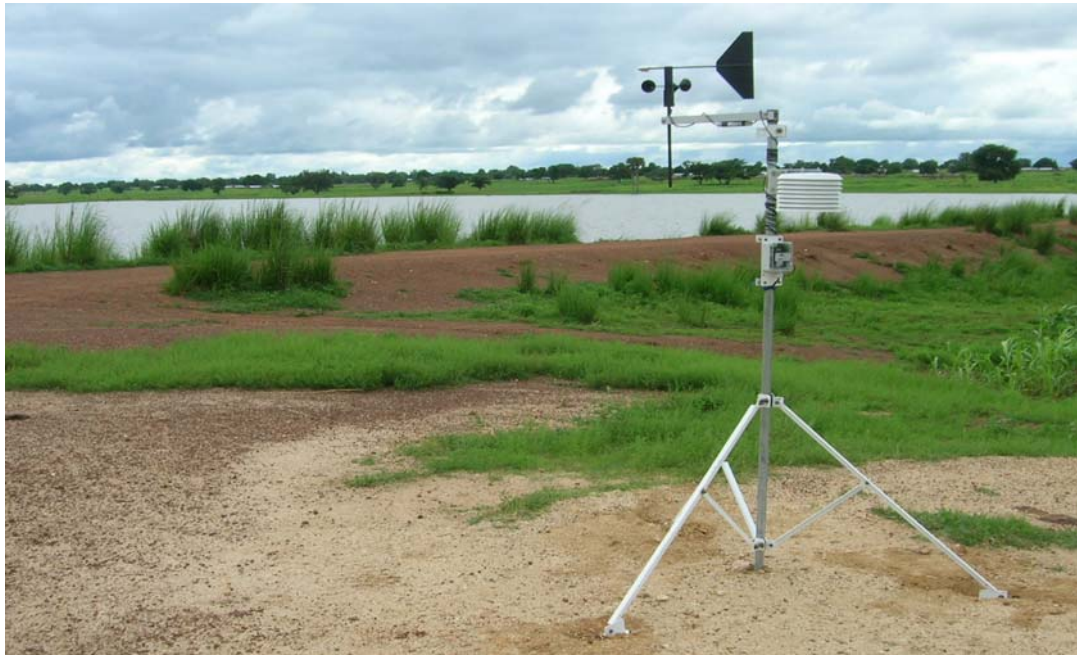
**Figure 2:** Evaporation study setup with six land based weather stations (WS<sub>1</sub><sub>1</sub> to WS<sub>3</sub><sub>2</sub>), and a floating weather station (WSFP)

The research described is helpful in understanding the fundamentals of small reservoirs in their surroundings, but it is beyond the scope of what is typically suitable for practitioners, who are likely to find that evaporation pans or weather stations are more appropriate for their purposes. Pan evaporation is usually determined with standardized pans. The U.S. Weather Bureau Class A Evaporation Pan is the most commonly used. The Class A pan is 1.2 m in diameter and 250 mm deep. It is installed 150 mm off the ground on a wooden platform. The normal operating water level is specified at 175 - 200 mm of water depth.

To determine potential evaporation rates from weather stations (Figure 3), a number of sensors are required. Determining evaporation rates after Penman (1948) requires measurements for temperature, relative humidity, saturation deficit, wind speed, net radiation, and ground heat flux. Low cost weather stations are available from a number of sources, for example, Onset ([www.onsetcomp.com](http://www.onsetcomp.com)), while a low cost net radiation sensor (NR-Lite) is available from Kipp and Zonen ([www.kippzonen.com](http://www.kippzonen.com)). For practitioners, Allen et al. (2005) provide an excellent overview of evaporation measurement from both crops and water surfaces.

### Lessons learned

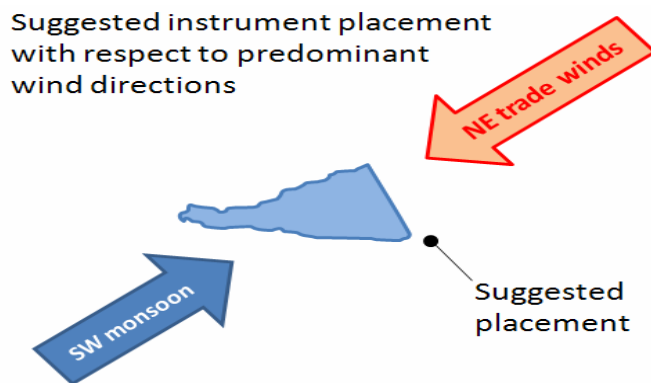
Our direct measurements with the floating evaporation pan have shown that the actual evaporation from reservoirs was below the potential evaporation rate. Evaporation losses are therefore lower than often assumed. A mild oasis effect was observed in the driest months (December 2005 until March 2006), which can lead to increased evaporation rates.



**Figure 3:** Weather station, equipped to measure temperature, relative humidity, saturation deficit, wind speed, and wind direction.

## Recommendations

The placement of evaporation instrumentation (evaporation pan or weather station) can have an effect on the accuracy of measured evaporation rates. If predominant wind directions, such as SW monsoon and NE trade winds, can be identified in the region of interest, it is advisable to position the evaporation instrumentation such that it is close to the reservoir, but rarely downwind of it. This is achieved by placing it next to the reservoir, parallel to the predominant wind direction. In the example in figure 4 below, this placement ensures that, regardless of which of the two predominant wind directions predominates, air reaching the evaporation instrumentation has not already taken up water from the reservoir. If a land based evaporation pan is chosen to measure evaporation it is essential to use a pan coefficient (often a multiplication factor on the order of 0.7, Linacre & Geerts, 1997). Land based pan evaporation measurements usually exceed lake or reservoir evaporation significantly due to the extra energy a pan receives through its sides and bottom (Jones, 1991).



**Figure 4:** Suggested positioning of a weather station in areas with predominant wind directions.

## Limitations

Evaporation pans are initially cheaper, but require daily attention and careful maintenance.

## References

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## Contacts and links

Jens Liebe, Center for Development Research, University of Bonn, Germany: [jliebe@uni-bonn.de](mailto:jliebe@uni-bonn.de)

Nick van de Giesen, Delft University of Technology, The Netherlands, [c.vandegiesen@tudelft.nl](mailto:c.vandegiesen@tudelft.nl)

Tammo Steenhuis, Cornell University, USA, [tssl@cornell.edu](mailto:tssl@cornell.edu)

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