Evaluation of Fog-Harvesting Potential in Namibia

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Abstract: The potential of fog water being collected for domestic purposes by the rural Topnaar community was evaluated in the Namib Desert. This entailed gaining an understanding of climatological, temporal and spatial parameters of Namib fog, determining the water needs and ensuring participation and awareness by potential consumers of fog water. We recommend whether, how and where fog water can be collected to help alleviate the water shortage. The twelve objectives concern the quantity and quality of fog water, the collecting equipment, the water needs, information transfer, the identification of socioeconomic and environmental consequences, the design of a fog water supply scheme, dissemination of information and plans of phases 2 & 3. It was found that the quantity and quality of the fog suffice for a water supply scheme. Strong winds and variations in fog and in the water consumption affect the design. Following the fog water evaluation, a partnership is being formed with the community for the joint development of fog harvesting schemes. Fog water as a resource goes hand in hand with an integrated awareness of all natural resources and the need to manage them sustainably.

1. INTRODUCTION

The Central Namib Desert is an area without perennial rivers, receiving <20mm of rain and 30-180 mm of fog per year. Fog occurs on 60-200 days per year, making it a predictable source of water (Pietruszka & Seely, 1985; Seely & Henschel, 1998) for animals, plants (Seely, 1979, 1998), and humans. Some 100 000 people live in the cities of Swakopmund and Walvis Bay, coastal towns and villages. The latter include small communities of indigenous people, the Topnaar, and the research and training centre at Gobabeb, situated in the desert interior. Potable water is obtained from groundwater via manually maintained wells, boreholes, and the Central Namib Water Scheme based on aquifers in the ephemeral rivers, Kuiseb and Omaruru (Jacobson *et al.*, 1995). Groundwater reserves depend on input from rainfalls in the >200km distant interior of Namibia's highlands. In recent years, water output has exceeded input and the groundwater is being depleted. Alternative water supplies will be required. Fog water has the potential to supplement small-scale users, as a model case developed in Chile has demonstrated (Cereceda *et al.*, 1992; Schemenauer & Cereceda, 1994a). Fog could thus contribute to alleviating the water deficiency along the Namibian coast (Nagel, 1959; Nieman *et al.*, 1978).

Phase 1 of the DRFN's Namfog project entails evaluating the potential for the rural Topnaar community to collect and use potable fog water. The occurrence, water content and climatological parameters of fog were investigated. From this information, the yield of fog water was determined as a fundamental premise to further objectives. Water needs and the social, environmental and economic considerations were taken into account in the preliminary design of a fog-water supply scheme for a Topnaar village to serve as a model for others. The experience gained with pilot schemes in the proposed Phase 2 will facilitate the further application of this technology in Namibia.

In the current paper, we present the results of the first seven objectives of Phase 1 of the Namfog project, namely, quantifying the fog water yield, analysing its quality, testing fog-collecting equipment, assessing the water needs, informing and training potential water users, identifying the social and environmental factors concerning water use, and designing a fog-water supply scheme.

1.1 Quantify fog water yield

Fourteen Standard Fog Collectors (SFC, Schemenauer & Cereceda, 1994b) were placed at six sites near Topnaar villages along the lower Kuiseb River in the Central Namib Desert. SFC orientation was northwest. The SFCs were monitored manually or with data loggers between October 1996 and September 1997. Based on their physical characteristics, three sites near villages were selected for study, namely, Swartbank (altitude 332m amsl; distance from sea: 37km; distance from village: 8km), Klipneus (altitude 340m amsl; sea: 46 km; village: 2km), and Soutrivier (altitude: 387 m amsl; sea: 53 km; village: 0.3km). These villages were chosen because of their need of water.

We found that the annual daily average quantity of fog water collected with SFC's was highest at Klipneus, where it exceeded 1 litre/m^2 of collector/day (Table 1). There was, however, considerable seasonal variation in the frequency and wetness of fog (Figure 1, Table 1).

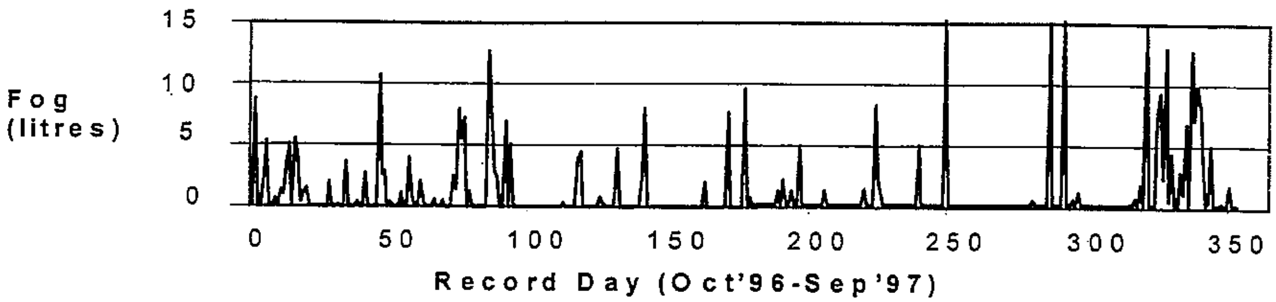

Figure 1: Quantity of fog recorded daily (litres/m^2/day) over the course of 1 year at Klipneus.

Table 1: Fog records with SFC's at three Topnaar villages in the Namib Desert.

Place	Swartbank	Klipneus	Soutrivier
Number			
record days	321	356	273
fog events	108	111	60
Quantity of water collected (litres / m^2) per			
fog event	2.384	3.345	0.437
day: year	0.802	1.043	0.096
day: Aug-Jan	2.720	2.122	0.704
day: Feb-Jul	0.423	0.453	0.084

During the "wet" 6 months (August-January), fog occurred on 45% of the days, and the average daily yield >2 litres/m^2/day. By contrast, from February to July, fog occurred on only 15% of the days, yielding <0.5 litres/m^2/day. Swartbank was similar to Klipneus, but Soutrivier received much less fog.

1.2 Analyse water quality

Water samples were collected from SFCs at Gobabeb and were sent to the Department of Water Affairs for analyses. Although the fog water is quite pure and of neutral pH (Eckardt, 1996), the SFC screen accumulates dust and wind-blown salts that get washed off by the fog water. The initial rinse off the SFC after a non-foggy period yielded turbid, brackish water (1630 mg $NaCl.l^{-1}$) that was only marginally fit for human consumption, but could be used for livestock. The subsequent water was considerably cleaner and of lower salt content (<1000 mg $NaCl.l^{-1}$). Equally good quality fog water has been analysed by Rössing Uranium Mine (Coetzee & Mulder, pers.comm.).

1.3 Test fog collecting equipment

The test screens were observed during and after dry, strong storm winds that occur during winter. Such winds, with average hourly speeds exceeding 12-16 m/s, gusting at an estimated 24-32 m/s, occurred on twelve occasions during 1997. Several SFCs were damaged during winter storms and were strengthened with additional supporting structures. Some of the plastic logger equipment did not withstand this weather, resulting in data loss. We conclude that the fog collectors should be designed to withstand gusts of at least 35 m/s coming from an easterly direction (at right-angles or from the opposite direction to the fog).

1.4 Assess water needs

During winter and the summer school holidays we interviewed people at the three Topnaar villages Swartbank, Klipneus and Soutrivier concerning their water sources and requirements and obtained information on the population size of village and associated domestic animals. We also recorded the water management system and estimated the volume of water from the size of the containers used to fetch or store it at the homes.

The water sources are traditional, hand-dug wells of 5-15 m depth in the riverbed. In addition, there is a wind pump at Klipneus and a diesel pump at Soutrivier, both of them installed and maintained by the government. However, the pumps become unreliable when they are a few years old. The Swartbank people fetch a considerable proportion of their water with donkey carts from the 20-km distant Ituseb school that gets its water from the municipal supply of Walvis Bay. The current water supply is not conducive to keeping gardens.

The village populations fluctuate (Table 2). Residents are occasionally joined by job commuters to town and school children, who spend 10-25% of their time at the villages. People use between 11 and 68% of the total water consumed, and most goes to domestic animals, with cattle requiring about half of the water (Table 2). The consumption fluctuates least at Klipneus (47%), and most strongly at Soutrivier (137%). The total volume of water consumption is highest at Swartbank, where the need for a scheme to supplement the hand-dug wells and donkey-drawn water carts is highest. The water requirements could be halved by excluding cattle.

Table 2: Daily water consumption (litres) at three Topnaar villages.

Village		Swartbank		Klipneus		Soutrivier	
Consumer	Individual Needs	Population	Consume	Population	Consume	Population	Consume
People	22-30	15-42	330-1260	6-13	132-390	14-37	308-1110
Goats	2-4	96	192-384	50	100-200	53	106-212
Donkeys	16-18	44	704-792	20	320-360	16	256-288
Cattle	40-50	26	1040-1300	16	640-800	0	0
Dogs	2-3	6	12-18	7	14-21	10	20-30
Chickens	0.1	34	3	30	3	20	2
TOTAL			**2281-3757**		**1209-1774**		**692-1642**

1.5 Inform and train potential fog water users

The attitude of the people towards fog as a potential water source is as important as providing the ability to access this source. In preparation to managing fog-collecting schemes, the people of Swartbank, Klipneus and Soutrivier gained access to information and possibilities for hands-on training and experience concerning this technology. We worked with the Topnaar leaders towards a fully participatory relationship addressing fog harvesting as a component of sustainable resource management. The possibilities of forming water committees for each village, as is also promoted by the Department of Water Affairs, were discussed and these are in an early planning stage. Those residents who assisted actively in the project helped to explain the process to other villagers so that the technology is by now familiar to many Topnaars.

1.6 Identify social and environmental aspects of collecting, supplying and using fog water

People living along the lower Kuiseb River are in need of alternative water sources. However, following years of Government dependency, they seem to have accepted their daily struggle with the existing system as a way of life: they walk long distances to hand-dug wells that require much maintenance, while they wait patiently for a Government technician to arrive to fix a pump. On the other hand, they have expressed interest in a reliable system that they can maintain themselves with little effort. However, they currently have limited funding and do not intend to invest this towards a new water scheme, a service always provided by Government in the past. The means to afford to run the fog harvesting technology would need to be developed through a lengthy participatory process parallel to and integrated with that of the Department of Water Affairs which is focused on fostering self-responsibility for the management of this resource.

Given a more reliable source of water, the Topnaars could diversify their activities, for instance to include gardens or to attract tourists. This should improve their living standards. On the other hand, people indicated that if they obtained more water, they would keep more goats. This could increase the impact that these animals would have on the environment. However, the need for careful management of fog water may mitigate this change. Integrated water and range management is also an objective of the Department of Water Affairs.

1.7 Design a fog-water collection and supply scheme

The above points were taken into consideration in designing a pilot fog collecting and supply scheme. The suggestion that the first experimental fog water supply scheme be constructed at Klipneus has been discussed by the Topnaar community, although a final decision is awaited. The lessons from this scheme would facilitate planning for the more complex situation at Swartbank. In the meantime, we have made a preliminary design for the Klipneus conditions based on the model at Chungungo in Chile (Cereceda *et al.*, 1992, 1996). This design assumes that fog water will become the only water source, but a hybrid system may be more realistic.

The following factors were taken into account for the design: a) seasonal variation in fog water availability, b) the effect of the storage capacity on water availability, c) the consumption rate that can be sustained without running the storage tank dry, and d) the ability to vary the consumption rate. The optimal magnitude of each factor was calculated. Most importantly, due to the intervals between fog events, the reservoir can frequently run empty unless the consumption is managed. Ideally the water will be rationed, i.e. an adequate quantity be made available each day, which cannot be exceeded if a tap is inadvertently left open. The resulting design comprises the following elements:

- enough fog collecting units of 48 m^2 each (modified after Cereceda *et al.*, 1996) to supply the average daily water requirements

- pipes and sedimentation tanks
- a reservoir to sustain the consumers for up to 3 weeks without fog
- a tank to contain the daily ration of water for households as well as domestic animals other than cattle
- another tank for the daily water ration for cattle at times when the main reservoir is over half full; cattle require alternative water when the reservoir is less than half full.

1.8 Conclusions and Recommendations

Fog has the potential of providing potable water to villages of indigenous people in the Namib Desert. This is possible only at places located <50 km from the Atlantic Ocean, where the average daily yield is >1 litre/m^2/day. In partnership with the Topnaar community, an experimental pilot plant should be built and managed at a village such as Klipneus. Important factors that influence the construction are the seasonal fluctuations of fog water supply and of its consumption as well as the occurrence of dry storm winds. It is very important that the water consumers adopt the idea that fog is a resource that they can use sustainably.

Other methods of fog collection are being examined at Gobabeb (Shanyengana, pers.comm.) and elsewhere in the Namib (DWA; Coetzee & Mulder, pers.comm.) as possible alternatives to the Conaf design used at Chungungo, Chile, that serves as our initial model. Fog harvesting should be considered in conjunction with other water sources and hybrid systems may be better than specialised ones.

Other uses of fog water should also be considered. For instance, if the indigenous !Nara plant is supplemented with water, it may increase the harvest of melons for the Topnaars (Dausab & Henschel, 1997). People in the coastal town of Swakopmund are investigating the possibility of watering vegetables with fog water (Coetzee & Mulder, pers.comm.). Indeed, fog water could turn out to be a valuable supplementary water source to help alleviate the water shortage along the Namibian west coast.

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