Fog May 2000

PROJECT OUTLINE
Developing Fog Harvesting in Namibia

Desert Research Foundation of Namiba, P.O.Box 20232, Windhoek, Namibia
Tel: +264-61-229855; Fax: +264-61-230172; Email: drfn@drfn.org.na

Executive Summary
Capacity should be developed in Western Namibia to harvest fog as a sustainable water resource. As this region is experiencing water shortages, alternatives such as fog harvesting are required. Based on its previous research and engagement with this technology, the Desert Research Foundation of Namibia is planning to initiate pilot applications and to further develop fog-harvesting as a viable water source. The project aims at creating the capacity for know-how and self-sufficiency in the further application of fog harvesting in Western Namibia so as to facilitate human development.
Funds (DM 200 000) are being sought for the following:
(1) Develop and test alternative fog harvesting techniques,
(2) Elaborate one passive, low-input, fog harvesting technique,
(3) Test the passive harvesting technique with the Topnaar community;
(4) Disseminate information to make fog water familiar to potential users and planners.

This project concerning the development and application of fog-harvesting is being done in parallel with another project on fog climatology, where funds are being sought from elsewhere. The development of a spatio-temporal model of Namib fog will improve the predictability of the availability of fog water. This involves the:
(1) Develop a model of fog water formation and distribution,
(2) Integrate the model into Namib climate,
(3) Apply the model to fog water harvesting.

In this project outline we provide a brief background to the status of fog harvesting know-how and describe the experience that the DRFN has already gained in this respect. This places the description of the future plans into context. We describe our objectives, associated activities, as well as intended outputs of the current application. Finally, we describe how this relates to other partner projects that are being formulated. The appendices provide further background to the past experience of the DRFN with the subject of fog and its potential utilisation.

General Background to Fog Harvesting

Namibia is a desert country with a decreasing gradient of rainfall from NE to SW. On the west coast lies the hyperarid Namib Desert with no perennial rivers. The Central Namib Desert receives <22mm of rain and 30-180mm of fog per year. Fog occurs on 60-200 days per year, making it a predictable water source, much more predictable than rain (Pietruszka & Seely, 1985; Seely & Henschel, 1998; Henschel *et al.,* 1998). It is therefore not surprising that it is used by animals and plants (Seely, 1979; Seely *et al.*, 1998), and can be used by humans. Potable water is currently being obtained from groundwater via manually maintained wells, boreholes, while bulk water is being extracted from aquifers in the ephemeral rivers, Kuiseb and Omaruru (Jacobson *et al.*, 1995). Groundwater reserves depend on input from rainfall in the >200km distant interior of Namibia's highlands. In recent years, water abstraction has exceeded input and the groundwater is being depleted. Alternative water supplies will be required. Desalination of sea water is being established, but it will not be available to small settlements and rural communities, and the high expense of desalination prompts other alternatives.

Fog water has the potential to supplement small-scale users and can thereby contribute to alleviating the water deficiency along the Namibian coast. A model case developed in Chile has demonstrated that it is possible to supply a village of 400 people with fog water (Cereceda *et al.*, 1992; Schemenauer & Cereceda, 1994a, b). The fog-water supply scheme is based on a 48-m^2 large collector screen, known as the El-Tofo fog collector. This has since been applied in Peru, Ecuador and Oman. Fog as an alternative water resource is presently gaining attention in several developing countries (Schemenauer & Bridgman, 1998), including South Africa (Struthers, 1995, 1997; Olivier, 1998), and, in the current case, Namibia.

The El-Tofo fog collector is designed for small-scale applications that use simple, passive and low-cost methods to harvest fog. This is, indeed, suitable for developing countries, as it enables self-sufficiency for relatively poor people. Chile and other countries along the west coast of South America, however, quite different from Namibia. The distribution of the people is quite different: many more medium-sized villages exist in South America, whereas the sizeable towns and small settlements in western Namibia are either larger or smaller than places where fog-harvesting has previously been applied. The topography is very different, so that the extensive knowledge on the climatology and spatial distribution of fog in Chile and other South American countries cannot be transferred to Namibia. The very flat and only gently sloping topography of the Namib and the regular occurrence of easterly wind storms are new features in the application of fog-harvesting that require separate experience to be gained.

DRFN Experience with Fog Harvesting

The DRFN gained first-hand experience of the Chilean model when two of its staff visited Chile in 1996. It then continued with a pilot study in Namibia, and could demonstrate that Namib fog is sufficient to warrant the development of fog-water supply schemes in western Namibia (Henschel *et al.*, 1998; Mtuleni *et al.*, 1998).

It was found that during each fog event at a suitably fog-exposed site, an average of more than 3.5 litres of potable water is collected per square metre of collecting material. Fog occurs throughout the year, but varies with season; if the supply and consumption is managed appropriately, this source of water is available throughout the year. In 1998, the DRFN and the Namibian Embassy of the Federal Republic of Germany assisted the Topnaar community with the establishment of a small fog-water supply scheme at a homestead at Klipneus. This scheme supplements their water and enables the community to become familiar with this new water source. It is thus a test case for the development of a larger fog-water supply scheme for an entire village. While the overall costs of fog water are similar to that of ground water with a wind pump, fog is a more sustainable and environmentally friendly water source in the desert and its development is therefore greatly encouraged.

Information transfer between the DRFN and the Topnaar community concerning water management has been initiated. The Topnaar community expressed their interest in becoming more involved in fog harvesting to alleviate their dire water shortage. The operation of this kind of technology, as demonstrated by their Klipneus pilot scheme, was welcomed by the Topnaar community as being socially acceptable and within their own capacity to manage. Members of other communities, such as urban Swakopmund, or organisations, such as the Department of Water Affairs, have also expressed their interest in fog harvesting. Given adaptation of the technology to various requirements, fog harvesting has a high potential for its application for several purposes.

The DRFN's initial experiments indicated that further development of the technology is required to fully adapt it to Namibian requirements and conditions. For example, the effects of storm winds need to be incorporated into the design; the El-Tofo model did not incorporate this in the design, as Chile does not normally experience storm winds of the kind regularly encountered in Namibia. The flat topography and variable winds currently makes it difficult to predict the movements of fog clouds on different days, so that the yield varies dramatically on different fog days. Enhanced technology may be required to enhance the capture of marginal fog, when the centre of the cloud is either lower or higher than the fog-collector screens. Such improvements could, for instance, benefit the water supply of Gobabeb, lying near the margin of the main fog belt. Enhanced technology should also improve the overall cost-efficiency of fog as a water source, and thereby increase its potential application in western Namibia.

The DRFN has gained sufficient experience to coordinate a project with the goal of making fog-harvesting a viable water source in Namibia. Such a project would fit the DRFN's mission to: "dedicate itself to creating and furthering awareness and understanding of arid environments and developing the capacity, skills and knowledge to manage them appropriately."

Project Proposal
In order to develop fog-harvesting technology for Namibian applications it will be necessary to improve the technology for local requirements and climatic conditions so as to improve the cost-efficiency. This will involve making appropriate designs, testing their fog-harvesting yield, and testing their application with consumers. First-hand experience with water-supply schemes, as well as information dissemination will be necessary to make this source of water familiar and attractive to potential consumers and water planners / managers.

Specifically, the project involves the following:
(1) Develop and test alternative fog harvesting techniques,
(2) Elaborate one passive, low-input, fog harvesting technique,
(3) Test the passive harvesting technique with the Topnaar community;
(4) Disseminate information to make fog water familiar to potential users and planners.

(1) Develop and test alternative fog harvesting techniques
Fog-harvesting technology needs improvement in order to optimise cost-efficiency. Relatively high capital costs for relatively low water yield may currently still be seen as a hurdle for the general acceptance of fog as a water source. This hurdle can be overcome by exploring the condensation rates on collectors under various conditions, e.g. cool surfaces, electrical fields. The technical aspects represent a challenge for environmental engineers, materials scientists, and do-it-yourself inventors and the DRFN intends to collaborate with them. It is planned initially to conduct experiments at or near Gobabeb. The development of the infrastructure at the Gobabeb Training and Research Centre, involving the design, application, and display of appropriate technology, should serve as a test case.

(2) Elaborate one passive, low-input, fog harvesting technique
Proven technology, such as a modification of the El-Tofo design, can initially be used for the construction of fog-water supply schemes at remote places, such as Topnaar settlements. Our tests have, however, shown that some adaptations to Namibian conditions are required. The El-Tofo design, which serves as our model of a passive collector, has been designed based on practical considerations, such as low cost with readily-available materials, and ease of construction and maintenance, but too little attention has been paid towards structural stability, especially in terms of wind. We intend to refine the design.

(3) Test the passive harvesting technique with the Topnaar community
The Topnaars requested that fog-harvesting be applied to their remote settlements. In addition to designing, constructing and monitoring fog-water supply schemes, the project entails the involvement of the Topnaar consumers to manage the supply and use of fog water and to gain experience. The project should also involve management of other resources, such as limiting livestock within the carrying capacity of the browse despite the increase in water, or increasing the harvest of Nara fruit by watering, or expanding the livelihood basis by marketing fog water. The project involves a partnership between the DRFN as catalyst to the self-development of the community in this regard.

(4) Disseminate information to make fog water familiar to potential users and planners.
Fog water is a new resource and its application depends on adoption by consumers, developers, and managers of water infrastructure. Information on the opportunities of the new resource will be made known to a wide audience by training, reports, publications, making of a video, and by conducting workshops and community meetings and market surveys. Opportunities for direct experience with the technology should promote acceptance and initiate self-development. Potential users, developers, marketers, and water managers in western Namibia will be targeted.

Activities

The planned project duration is for one year of field work, followed by six months of analyses and completion of information dissemination. The project will be carried out by DRFN staff, field staff of target groups such as Topnaars, students, collaborative researchers, and consultants. It will involve the following activities:

(1) Develop and test alternative fog harvesting techniques

- *find material with optimal properties in terms of condensation and run-off*: test condensation and run-off on hydrophobic & hydrophilic materials; test surface textures ranging from smooth to rough; test effect on condensation of thermal properties of surfaces.
- *test the influence of net configuration on yield and durability*: study aerodynamics of nets of different structures (micro-structure), sizes, and shapes of collection screens; design aerodynamically stable structures
- *design active fog collectors (requiring energy input)*: cooling to increase condensation; electrical charge to attract droplets; funnelling and compression; energy via appropriate technology, such as wind generators
- *supplement Gobabeb water with fog as a model case*: design roof-top and active harvesters as components of a water plan that incorporates different sources

(2) Elaborate one passive, low-input, fog harvesting technique

- *optimise yield, cost and durability of a passive fog collecting unit for a water-supply scheme on open ground*: conduct tests in the field, wind-tunnel, and computer simulations to improve the aerodynamics of the El-Tofo model
- *re-design a full-scale fog-collecting unit*: incorporate the above considerations, while avoiding complex designs; incorporate the needs for low cost, ease of construction and simple management with ordinary tools.

(3) Test the passive harvesting technique with the Topnaar community

- *further the partnership with the Topnaar community concerning sustainable resource management*: train field staff, facilitate the formation of water committees, initiate monitoring and evaluation
- *assist with the planning, construction, operation and maintenance of a communal fog water supply scheme at a Topnaar settlement*: involve Topnaars and other water managers in planning; guide construction; assist with the monitoring of water quantity & quality as well as hardware condition; guide self-maintenance by the community
- *guide water management*
  - *in households and gardens and for livestock*: quantify and qualify current use, facilitate identification of alternative uses
  - *watering Nara*: study progression of drip water; test plant cultivation procedures in the field; supplement water to old Naras; product development and marketing
  - *other uses, such as bottling and marketing of fog water*: assist the Topnaars with the identification of alternative livelihood improvements based on natural resources.

(4) Disseminate information to make fog water familiar to potential users and planners

- *train field staff, potential future appliers and businesses*
- *publish*: inform press; generate information for decision-makers; produce posters and exhibits; draft reports and scientific papers
- *produce a video for national and international viewing*: plan production with film producers for a DRFN (or allied) product; advise film-makers and photographers
- *convene and attend workshops and community meetings*
- *conduct a survey and preliminary tests towards the wider potential of fog harvesting in western Namibia*: villages and remote settlements (e.g. Henties Bay, Möwe Bay); urban households (e.g. Swakopmund); bulk-water suppliers (e.g. Namwater)

Budget
DM 200 000 ~ N$ 666 000

Personnel	
Project manager (50%)	N$ 90 000
Research assistant (50%)	N$ 45 000
Researcher – appropriate technology (20%)	N$ 25 000
Namibian Student (100% of time)	N$ 24 000
Namibian Volunteer (100% of time)	N$ 12 000
Volunteer Counterpart (100% of time)	N$ 6 000
Field Staff (100% of time)	N$ 18 000
Data management (100 %)	N$ 30 000
Other, incl. consultants	N$ 50 000
	N$ 300 000
Equipment	
Experimental structures and tests	N$ 30 000
Topnaar water collectors	N$ 50 000
Topnaar water storage and delivery system	N$ 50 000
Monitoring instruments	N$ 20 000
	N$ 150 000
Travel	
Domestic 40 000 km @ N$2.75/km	N$ 110 000
	N$110 000
Information Dissemination	
Publication & Brochures Production	N$ 30 000
Workshops & meetings	N$ 5 000
Literature	N$ 5 000
	N$ 40 000
Administration	
Communication	N$ 6 000
Bench Fees	N$ 18 000
Overheads (10%)	N$ 62 000
	N$ 86 000
	N$686 000

Appendix A

Summary of Workshop: Topnaars with DRFN
@ Gobabeb on 9 May 1998
compiled by Joh Henschel

From October 1996 until present, the quantity of fog that can be captured with established technology (vertical netting over a frame) was investigated at several sites in the Namib Desert. These sites were located near Topnaar settlements along the Kuiseb River. The Topnaars and the DRFN collaborated since the beginning of the project. On 28 April 1998, a public Fog Information Day was held at Gobabeb. This was followed on 9 May 1998 with a Workshop at Gobabeb at which the Topnaar Community and the DRFN participated.

At the workshop, 56 Topnaars, 13 DRFN staff and volunteers, and 3 visitors were present. 20 Topnaars came from Swartbank, Klipneus and Sout Rivier, and the rest were evenly divided between elsewhere along the river and Walvis Bay. During the morning, some of the project participants explained various aspects of rural water management and demonstrated pertinent points concerning fog water collection. After lunch, the Topnaars divided into two groups, women and men, with a facilitator and two scribes participating in each. The aim of the group sessions was to gauge the attitude of the Topnaar community in terms of water management and to find out whether they felt that fog water could meet their needs.

To the question of where and how the people expect to get water in the future, answers included all possible sources and methods, but many people were unsatisfied with the present status and would like to try fog-harvesting. Over-extraction by the bulk water system was felt to be the major problem, so that even the hand-dug wells run dry. There was a unanimous expression that the fog-harvesting should be demonstrated, while some people went so far as to recommend it as the sole water source of the future.

The opinion was repeatedly expressed that the community was capable of maintaining its water sources and that the role of the water committee should be to assist this process. As to the question of ultimate responsibility, opinions ranged from "everybody", to the Government, the community, to particular persons in each settlement (several volunteers named themselves). This question requires further clarity.

It was not yet clear as to how a reliable source of fresh water would change people's lives. Some thought it would bring "more of the same" (livestock), or enable them to begin gardening or help their neighbours overcome water shortages. The opinion of "seeing is believing" and "then we plan what to do" would sum up the general opinion. This point requires further attention.

The community expressed their readiness to become involved in maintenance, construction of water systems, and being trained in the management of water systems. Support and advice was expected of the community leaders and Government, while the DRFN was requested to guide the planning process, assist with the drafting of proposals and to provide equipment. The DRFN was explicitly requested to demonstrate the technology of fog-harvesting by providing the opportunity of first-hand experience. The community decided that an initial fog-harvesting screen should be put up at Klipneus for this purpose.

REFERENCES

Cereceda, P., R.S. Schemenauer, & M. Suit, 1992: An alternative water supply for Chilean coastal desert villages. *Water Resources Development* 8, 53-59.

Henschel, J.R., 1997: Fog harvesting. *Namib Bulletin* **14**: 8-9.

Henschel, J.R., V. Mtuleni, N. Gruntkowski, M.K. Seely & S.E. Shanyengana, 1998: Namfog: Namibian Application of Fog-Collecting Systems, Phase I: Evaluation of Fog-Water Harvesting. Desert Research Foundation of Namibia, Occasional Paper No. 8, 81 pp.

Jacobson, P.J., K.M. Jacobson, & M.K. Seely, 1995: *Ephemeral rivers and their catchments: sustaining people and development in western Namibia*. Desert Research Foundation of Namibia, Windhoek, 167 pp.

Mtuleni, V., J.R. Henschel & M.K. Seely, 1998: Evaluation of fog-harvesting potential in Namibia. *1st International Conference on Fog and Fog Collection, Vancouver, Canada*, pp. 179-182.

Olivier, J., 1998: A high elevation fog water collection experiment in South Africa. Schemenauer, R.S. & Bridgman, H. (eds.), Proceedings of the 1st International Conference on Fog and Fog Collection, 19-24 July 1998, Vancouver, Canada, p. 441-443.

Pietruszka, R.D. & M.K. Seely, 1985: Predictability of two moisture sources in the Namib Desert. *South African Journal of Science* 81, 682-685.

Schemenauer, R.S. & H. Bridgman, 1998: Proceedings of the 1st International Conference on Fog and Fog Collection, 19-24 July 1998, Vancouver, Canada.

Schemenauer, R.S. & P. Cereceda, 1994a: Fog collection's role in water planning for developing countries. *Natural Resources Forum* 18, 91-100.

Schemenauer, R.S. & P. Cereceda, 1994b: A proposed standard fog collector for use in high-elevation regions. *Journal of Applied Meteorology* 33, 1313-1322.

Seely, M., 1979: Irregular fog as a water source for desert dune beetles. *Oecologia*, Vol. 42., 213-227.

Seely, M.K. & J.R. Henschel, 1998: The climatology of Namib fog. *1st International Conference on Fog and Fog Collection, Vancouver, Canada*, pp. 353-356.

Seely, M.K., J.R. Henschel & M. Robertson, 1998: The ecology of fog in Namib sand dunes. *1st International Conference on Fog and Fog Collection, Vancouver, Canada*, pp. 183-186.

Struthers, M.J., 1995. *Pilot fog study at Kleinzee - Progress Report: July 1995 to October 1995*. Division of Earth, Marine and Atmospheric Science and Technology, CSIR, Stellenbosch, South Africa.

Struthers, M.J., 1997. *Water from fog study on the Cape West Coast progress report: December 1995 to May 1997*. Reprint, No. CSIR ENV/S- I 97018, Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch, South Africa.

Namibian Fog-Harvesting Calender

January 1996: DRFN applies to the IDRC to fund an evaluation of fog harvesting in Namibia, application was granted
May 1996: International fog expert (Prof. Pilar Cereceda) visits from Chile on behalf of the IDRC to provide advice
June 1996: the Topnaar community assents to cooperate and to monitor fog near their villages
July 1996: monitoring of fog water with Standard Fog Collectors begins at 10 places in the Namib Desert with the assistance of Topnaars (!Narib & Cloete)
August 1996: DRFN staff (Mtuleni & Henschel) learn fog-harvesting concept and technology in Chile
September 1996: DRFN staff (Henschel) learns ecosystem restoration with fog in Peru
June-December 1997: water use and awareness assessments with the Topnaars
December 1997: fieldwork for the current analyses stop (monitoring continues on a long-term basis)
December 1997: data analyses and report production (Mtuleni, Henschel, Gruntkowski, Seely, Shanyengana)
January 1998: initiate testing of the water pyramid (with Norsk-Hydro)
24-25 April 1998: construction of first big fog collector at Gobabeb
26 April 1998: fog information day
24-26 April 1998: filming of Namfog project activities for use in a future video
9 May 1998: fog workshop with the community at Gobabeb
12-14 May 1998: oral presentation of project in Harare, Zimbabwe (Mtuleni)
18 May 1998: follow-up meeting with residents at Topnaar settlements
26-29 May 1998: construction by the Topnaars of their first big fog collector connected to a Topnaar settlement (Klipneus)
1 June 1998: opening of the fog collector at Klipneus
June 1998: publication of fog evaluation report, generation of visual and printed material
19-24 July 1998: 3 oral presentations on Namib fog by 2 DRFN staff (Seely & Mtuleni) in Vancouver, Canada
August-October 1998: feedback from Vancouver conference
November 1998: initiate preliminary study of fog-water chemistry (with Weathers & Baker, New York)
December 1998-October 1999: review existing structures, future planning