# IMPLEMENTATION OF AN OPERATIONAL PROTOTYPE FOG WATER COLLECTION SYSTEM: PROJECT IMPLEMENTATION

J Olivier • J van Heerden

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Water Research Commission

# Implementation of an operational prototype fog water collection system: Project implementation

Report to the Water Research Commission

by

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**Compiled by J Olivier**

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# EXECUTIVE SUMMARY

### Introduction

This project is a sequel to the WRC project (K5/671) conducted from1995 to 1998, which was aimed at determining the feasibility of using fog to supplement existing water supplies in water-scarce parts of the country. A number of small fog water collectors were erected in fog-prone parts of South Africa and the yields monitored over a two to three-year period. The results indicate that fog harvesting is indeed a viable option along the West Coast and in the mountainous parts of the country, specifically in the Soutpansberg and the mountains of the Eastern Escarpment and Western Cape.

The aims of this project were to design, erect and operate a fog water collection system[1] (FWCS) to provide water to a small rural community, and to research the factors associated with water collection at the site. A capacity building and training component formed an integral part of the project.

The research focused on the high elevation regions of the Northern (Limpopo) Province.

### Procedure

The first step was to identify a suitable site for the erection of the FWCS; recipient communities would have to experience a severe shortage of potable water and be close to a site where relatively large volumes of water could be harvested from rain or fog. The previous WRC study (K5/671) revealed that the ideal water collection site would be at or near the crest of a mountain with an elevation of 1 000 m or more, and be exposed to moist fog or rain- bearing winds from the Indian Ocean (Olivier and Van Heerden, 1999). Accessibility, security and community cooperation were also important considerations. As a first step, water-poor communities were identified that were located within 15 km of a suitable water collection site. These were rated according to the severity of the water shortage, the quality of the water available and its accessibility, and the costs involved in implementing such a system. After on-site visits to the short-listed villages, the Tshanowa Junior Primary (JP) School was selected as a suitable site to implement the project.

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[1]A fog water collection system is a vertical structure which collects both rainfall and fog deposition

The Tshanowa JP school is located at the crest of one of the eastern-most promontories of the Soutpansberg in the Northern Province, at an elevation of 1 004 m. The school is exposed to fog-bearing winds from the east, southeast and northeast, and is frequently shrouded in dense mist due to cloud interception. The school population comprises 128 children and four teachers. There are a few houses located near to the school but the majority of the communities live further down the mountain. The closest water sources are a nonperennial spring located 2 km from the school and a dam situated in a valley more than 5 km away.

After obtaining permission from the Northern Province's Department of Education, the traditional leader and the school principal, the FWCS was designed and erected by members of the project team, assisted by members of the community. The system consists of (a) a fog water collector comprising two 36m$^2$ shade cloth nets (forming the collecting screen) attached to three wooden poles and with a gutter suspended at the lower end (the entire structure is anchored by means of a system of galvanized steel cables), (b) a sand filter to remove solid impurities and (c) a 10 000 litre storage tank. A locally designed tipping bucket was installed to measure the volume of water collected. A weather station was also erected to monitor rainfall and wind direction. All data were recorded on a data logger.

Only one water storage tank was initially installed, but it overflowed regularly despite its constant use. Consequently, two more tanks were installed to catch the overflow.

Construction commenced in March 1999 using local labour. The experimental site was visited regularly to read the data, to take water samples and to check for any structural damage.

Research was conducted on the factors affecting the incidence of wet events and analyses were performed to determine the size of the water yield and the factors affecting it. Aspects investigated thus included the synoptic situation and circulation systems prevailing during wet events, the contribution of rainfall and fog to the total water yields and rainfall-fog relationships. Other characteristics of wet events were also studied, such as their seasonal and diurnal incidence patterns and their duration. Chemical and biological analyses were conducted on the collected water as well as on water from the spring and dam.

**Results**

Water collection occurred either during fog or rainfall events. Both are predominantly summer phenomena, although some water collection occurred during the winter months. The synoptic systems causing conditions conducive to wet events at the Soutpansberg site were analysed using synoptic charts. As expected, important controls were tropical and subtropical systems. These systems cause the onshore advection of moist maritime air from the Indian Ocean. On meeting the mountains, the air is forced to rise. During the upward motion, it cools because of adiabatic expansion and condensation takes place at the lifting condensation level (LCL). If the lifting air is humid enough, the cloud base will form below the crest of the Escarpment. If the uplift occurs in stable air, layers of clouds will tend to form in the crests of the standing wave over and against the Escarpment. The mountain wave cloud (fog) formed in this manner remains stationary against and over the mountains. In unstable air, convective (cumulus congestus) clouds may develop out of the stratiform orographic clouds if the orographic uplift provides sufficient vertical velocity for the air to reach the level of free convection.

The major synoptic situations associated with wet events in this project were easterly waves and the Indian Ocean anticyclone. These often occurred in combination with a system of low pressure cells over the interior of the country. On a few occasions, rainfall occurred with northerly winds. This was probably associated with the development of convective clouds that built up ahead of a passing cold front.

A considerable amount of data were lost due to the extreme weather conditions that occurred over the northern part of the country during the early part of 2000. This was exacerbated by the malfunctioning of the locally produced tipping bucket gauge and data logger. The latter resulted in a considerable undercount of the volume of water collected. According to the records available, however, more than 100 000 litres of water were collected between March 1999 and April 2001. This gave an average daily yield of around 2,85 litres per square meter of collecting surface. Maximum daily yields in excess of 3 000 litres were recorded on a number of occasions.

About 75% of the water deposited on the collector originated from rainfall rather than fog. In fact, rainfall was found to be a satisfactory predictor of water collection rates. Other unconventional methods of obtaining water, such as rainfall harvesting, would thus be appropriate for the area. Since rainfall increases with elevation, higher elevation sites would yield higher water collection rates. *It is estimated that the yield at a suitable site with elevation of 2 000m would be about four* times more than that obtained at the school. Paradoxically, the frequency of rainfall and fog water collection were almost the same, since most rain events were preceded and succeeded by fog occurrence, while many wet events were exclusively due to the presence of fog.

Chemical analyses of the water deposited on the fog collector showed that this water was of a much higher quality than that used previously by the children and local community. Although the pH was slightly low, the water contained very few dissolved substances. No disease causing organisms were present and the concentration of heterotrophic bacteria merely reflected that which is normally found in the air. The water was classified as Class 0: Ideal Water Quality.

The cost of a fog water collector (excluding the tank and labour) was just less than R7 000 (1999 prices). When calculated over a 50-year period, the cost of the water amounts to about R3.70 per kilolitre. This is slightly less than the cost of municipal water in Pretoria.

**Capacity building and training**

The project contained a training and capacity building component. Members of the community were trained in the erection and maintenance of the system. Students from the University of Pretoria devised and carried out a short teaching programme on fog and fog collection at the school. It was assumed that information on the project would reach the adults via the children (learners). Information on the project was further disseminated by the inclusion of material into various university courses, publications - both popular and scientific - and conference papers, as well as by means of radio and television interviews.

**Conclusion**

The aims of the project were met in the following ways:

1 The prototype which was designed and erected at the Tshanowa JP School successfully supplied water to the school community and surrounding homes. This design could thus be applied elsewhere. The problems encountered during the course of the research were easily solved - except for those which involved the accuracy of the recording devices. This will, however, not affect the implementation or operation of a FWCS. The water yields, despite being under-recorded, were sufficient to fulfil the needs of the community. The project also showed that harvesting rain and fog water provides a relatively inexpensive source of good quality water in areas where conventional sources are not an option.

2 The meteorological factors associated with water collection episodes were researched. It was found that rainfall values give a good estimation of the yield that can be obtained at high elevation sites.

3 Some training and capacity building took place through direct contact and through the dissemination of information.

The products generated included the actual prototype of an FWCS, a continuous supply of potable water to a water-poor community, an operational manual and new information.

The FWCS has application potential in many areas where water supplies are insufficient. Communities located in the Soutpansberg, the mountains of the Eastern Escarpment and the Cape mountains could derive benefit from implementing an FWCS. The system could also be used for purposes other than supplying water for domestic purposes. It may, for example, be used to provide water for animals or to promote development through agriculture or tourism.

In view of the advantages of this type of system and its application potential in many areas, it is clear that efforts should be made to make the technology available to as many people as possible. The Water Research Commission is in an ideal position to do this. It is, therefore, recommended that

1 the WRC actively promotes the use of fog and rainwater harvesting to relevant organisations such as the Department of Water Affairs and Forestry, Umgeni Water and other water authorities
2 the WRC make recommendations to the proper authorities and funding agencies for bridging finance to maintain the system
3 the WRC supports the acquisition of funding for a larger project or the expansion of the project at the Soutpansberg site.

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# CHAPTER 1
# INTRODUCTION

## 1.1 BACKGROUND

South Africa is an arid country with only 35% of its surface area receiving more than 500 mm rain per year (South African Department of Water Affairs, 1986). Since rainfall decreases from east to west over the country, the West Coast is the most arid of the regions with many places recording annual rainfall totals of 70 mm or less. Few perennial rivers traverse the country, and these surface water sources are often polluted with human, agricultural or industrial waste. Although a number of communities make use of river water either through direct extraction or via pipelines or canals, their main source of water is ground water accessed through either boreholes, wells or springs. Groundwater is, unfortunately, not always available in sufficient quantities and is often contaminated with naturally occurring salts or heavy metals (Toens, Stadler & Wullschleger, 1999). It has been estimated that five out of every 100 children in rural areas die before the age of five from diseases caused by contaminated water (Huntley *et al.*, 1989). Water is often inaccessible even in the wetter parts of the country. Water shortages are thus a common occurrence in large parts of South Africa, especially in rural areas where people are reliant on rivers and ground water sources. This situation is aggravated during periods of drought when the water table drops and wells and springs dry up. During the drought of the early 1990s, more than 12 million South Africans did not have access to adequate supplies of potable water (White Paper on Water Supply and Sanitation Policy, 1994). In view of the high population growth in rural areas, pressures on existing limited water resources will increase in future. It is clear that there is an urgent need to identify alternative sources of potable water.

Fog is one such source of water. Although its water yielding potential is largely ignored by water provision authorities, it was used extensively in more ancient times. The inhabitants of Palestine, for example, built small, low, circular honeycombed walls around their vines so that the mist and dew could precipitate in the immediate vicinity of the plants (Nelson-Esch, nd). Historically, dew and fog were collected in the Atacama and other deserts from piles of stones arranged in such a way that the condensation would drip to the inside of the base of the pile where it was shielded from the day's sunshine (Linacre and Hobbs, 1977). In the Canary Islands, fog drip from trees was the sole source of water for man and animals for many years (Kerfoot, 1968).

During more recent times, a number of projects were initiated which were aimed at supplying fog water to communities. The first was implemented at Mariepskop in Mpumalanga, South Africa, during 1969/70 (Schutte, 1971). It was used as an interim measure to supply water to the South African Air Force personnel manning the Mariepskop radar station. Two large fog screens, each constructed from a plastic mesh and measuring 28 x 3,66 m, were erected at right angles to each other and to the fog and cloud-bearing NE and SE winds (see Fig 1). Two rain gauges, one with a fog cylinder attached to it and the other, standing alone, were erected close to the screens. It was thus possible to differentiate between the water collected during fog and from that collected during rainy periods.

During the 15-month period, from October 1969 to December 1970, the screens collected an average of 31 000 litres of water per month, i.e., approximately 11 litres/m$^2$/day. When yields for only foggy days were taken into account, the mean was 23 395 litres per month - almost 800 ℓ/day. During the entire period, fog/cloud precipitation exceeded rainfall by a factor of 4,6; during certain months, however, it was up to 17 times greater (Schutte, 1971).

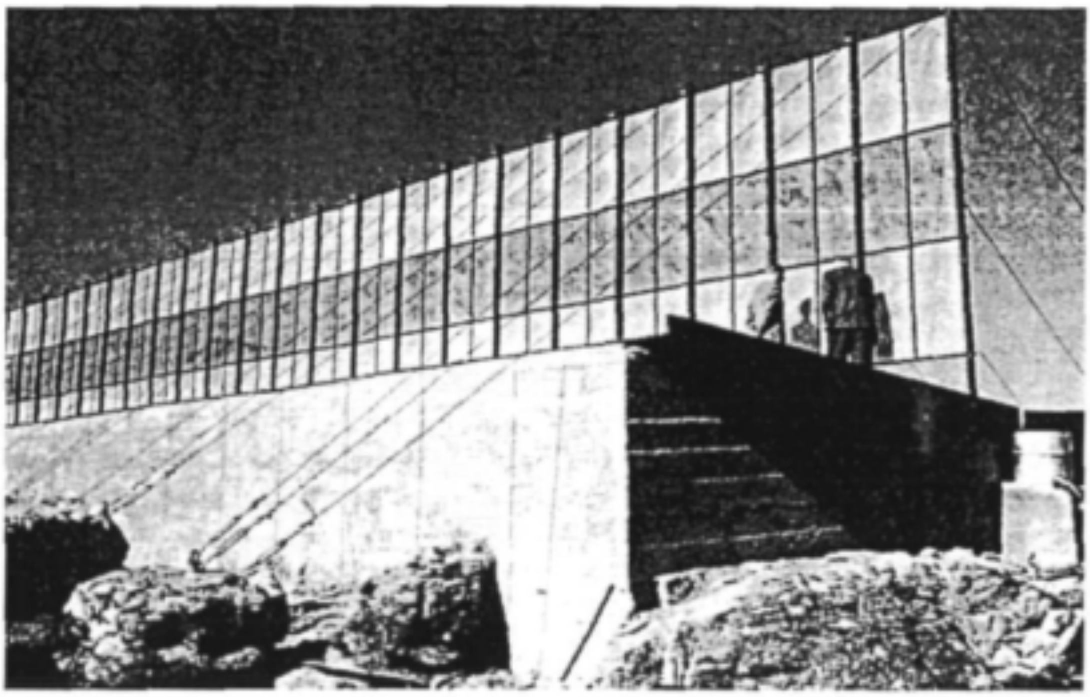

**Fig. 1 Fog water collector at Mariepskop (DWAF, 1986)**

The second and largest fog water collection project to date was initiated in 1987 at a small fishing village in northern Chile by researchers from the National Catholic University of Chile and the International Development Research Centre in Canada. Here, 75 fog collectors - each measuring 12 m by 4 m - were erected on a hill overlooking Chungungo. According to reports, production rates vary from zero on clear days to a maximum of 100 000 litres per day. With the current arrangement, each of the 330 villagers receives about 33 litres of clean water per person per day (Schemenauer and Cereceda, 1991, 1994). In view of the success of this project, similar fog water collection systems have been erected in many other parts of the world, notably in the Canary Islands, Peru, Ecuador and the sultanate of Oman (Schemenauer and Cereceda, 1994).

These experiments clearly indicated the water harvesting potential of fog. In 1995, therefore, the Water Research Commission (WRC) funded a research project in 1995 aimed at investigating the feasibility of using fog water to supplement existing supplies in the rural areas of South Africa (WRC Project No K5/671).

The first steps in assessing the feasibility of using fog water as a supplementary source of water were (a) the determination of the spatial and temporal occurrence patterns of fog in South Africa and (b) the establishment of the relationships between fog water yields and the various factors affecting it.

Analysis of South African Weather Bureau (SAWB, 1986) data revealed that the fog incidence is particularly high in the mountainous parts of the country and along the West Coast (Fig. 2).

During the period 1995 to 1998, a number of pilot fog collectors[2] were erected at various sites in the fog-prone parts of South Africa. The majority of these comprised a 1m$^2$ collecting screen attached to a steel frame. Water deposited on the screen during wet periods, ran downwards under the influence of gravity and was collected in a plastic gutter attached to the lower end of the screen. From there, the water was either channelled to a tipping bucket or collected in a bucket. The volume of the latter was measured by volunteers at each of the experimental sites. The structure of a typical pilot fog collector is shown in figure 3. Water yields, originating from a combination of both rainfall and fog deposition, were thus recorded between 1995 and 1998 (Olivier and Van Heerden 1999).

Fog water was found to contribute a significant proportion to the total volume of water collected.

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[2]Fog collectors are vertical structures which collect both rainfall and fog

The results thus indicated that fog water harvesting[3] might be successfully applied along the West Coast and in the mountainous parts of the country, particularly those exposed to moisture bearing winds from the sea.

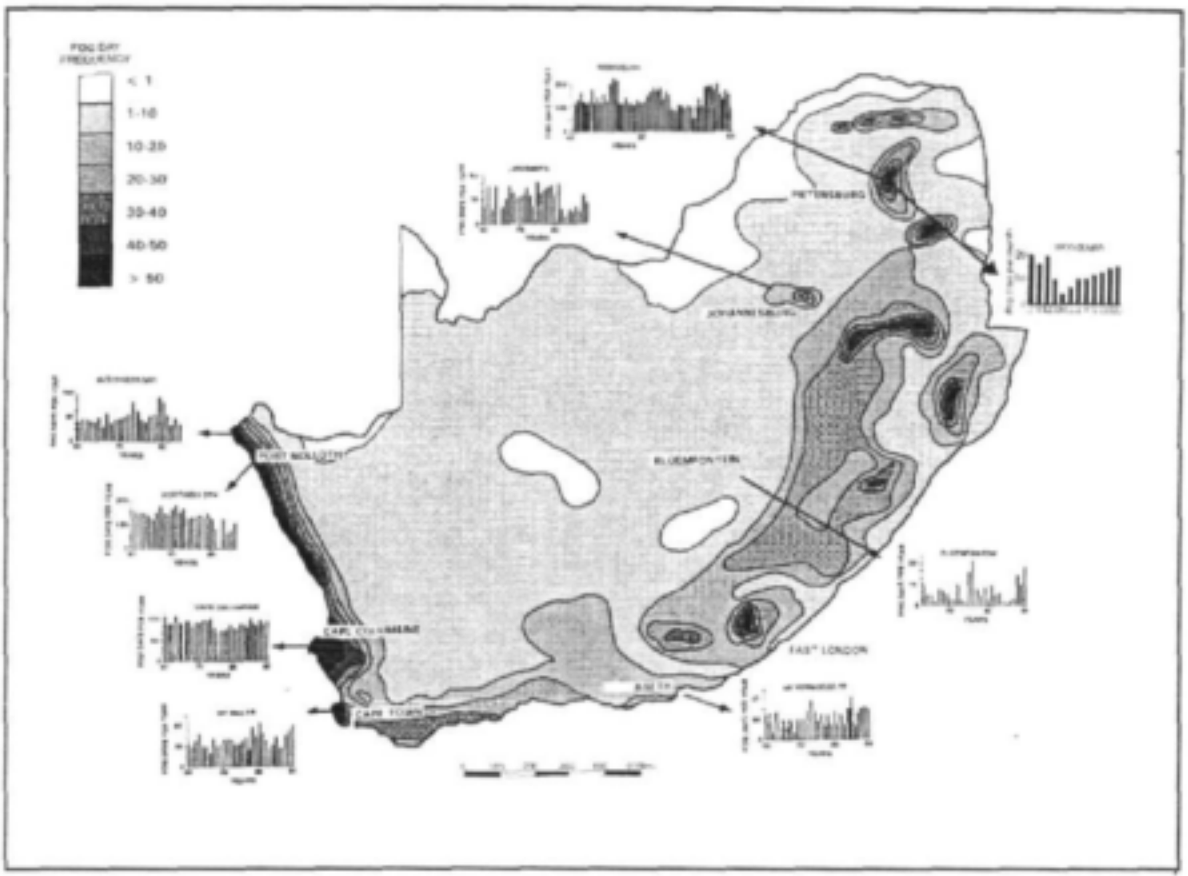



**Fig 2 Spatial distribution of fog in South Africa**

[3] The term "fog water harvesting" is used to denote the combined volumes of water harvested by rainfall interception as well as fog deposition on a vertical fog collector. A fog collector thus collects both rainfall and fog.

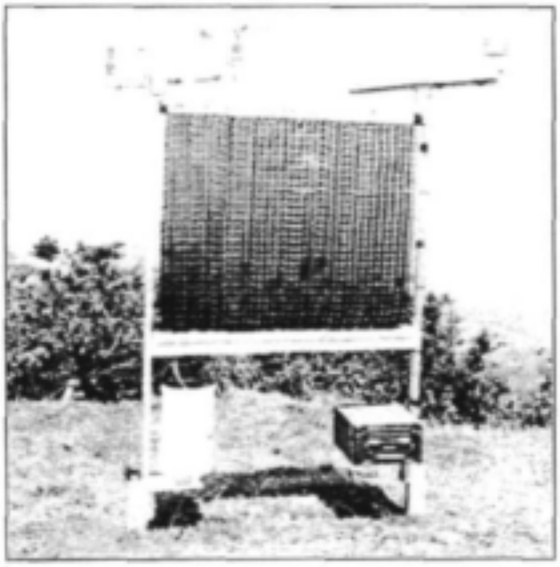


***Fig. 3 A pilot fog water collector used during the 1995 - 1998 WRC project***

Clearly, the only way of determining the efficacy of fog water harvesting was to implement a fully operational fog water harvesting system (FWCS). Two such projects were initiated. The Water Research Commission funded an operational FWCS at a high elevation site in the Northern (Limpopo) Province, while SANPAD funded a project on the West Coast of South Africa. These projects were aimed at establishing a fog water collection system which could serve as a prototype for similar projects in other parts of the country. This report focuses on the high elevation regions of the Limpopo Province.

## 1.2 AIMS AND OBJECTIVES

The aims of this project were as follows:

1 To design, erect and operate a small prototype of a fog water collection system to provide potable water to a small rural community.

2 To research the meteorological and geographical conditions associated with the incidence of rainfall and fog at the site in order to determine the most efficient design and operational procedures.

3 Training and capacity building. This involved training members of the local community to

operate and maintain the system, providing training materials so that members of other communities or other interested parties could erect similar fog water harvesting systems, and informing as wide an audience as possible of the feasibility, techniques and advantages of fog harvesting.

## 1.3 LAYOUT OF THE REPORT

Chapters 2 and 3 deal with the first of the project's objectives mentioned in section 1.2. Chapter 2 describes the selection of the experimental site, while chapter 3 focuses on the design and erection of the fog water collection system. Problems encountered with the design and their solutions are also discussed in this chapter. The results obtained with respect to water yields, factors affecting yield, water quality and cost are discussed in chapter 4. This addresses the second project aim. Chapter 5 deals with the third project aim, namely, training and capacity building. The report culminates in chapter 6, which provides a summary of the project and presents suggestions and recommendations for future activities.

A do-it-yourself instruction manual is presented as Appendix 1 of the report.

# CHAPTER 2
# SITE SELECTION

Four main factors should be taken into account when determining a suitable site for a fog water collection system, namely the potential for collecting large volumes of water; the proximity of a water-poor community, terrain features and accessibility. Other aspects such as security, land tenure and the willingness of the community to participate also play a decisive role.

## 2.1 PREREQUISITES

### 2.1.1 Water Yield Potential

The total amount of water collected on a fog water collector consists of a combination of rainfall and fog deposition. Fog water yield is dependent on a high fog occurrence frequency, the persistence of fog episodes, high fog moisture content and the presence of fog-bearing winds (Fuentes, 1995). During the 1995 to 1998 WRC project (K5/671), a comprehensive study was conducted to determine the spatial and temporal occurrence patterns of fog in South Africa. This was used to identify areas with high fog water potential. In order to determine the actual water yields that could be collected, small $1m^2$ pilot fog collectors (see Fig. 1) were erected at the following five high elevation sites: Medingen, Hanglip and Pypkop in the Limpopo Province, near Sabie in Mpumalanga and in the Groenland mountains in the Western Cape. Water collection rates were monitored over a two to three year period.

Average daily yields of between 1,3 and 12,2 litres of water were recorded per square metre of collection surface.

The relationship between water yields and various meteorological (rainfall, wind speed, wind direction), geographical (topography, micro-relief) and collector-related (collector height, type of collection material) factors were determined in an attempt to identify those with the greatest impact on yield. A number of these, such as rainfall and wind speed, are a function of altitude. It was not, however, possible to determine the nature of the yield-altitude relationship using only data from five stations. Fortunately, information on fog water collection rates was obtained during experiments performed at a number of high elevation sites in the former Transvaal during the 1960s and 1970s (Schutte, 1971). In these experiments, small wire fog cylinders were mounted over rain gauges so that all water - albeit from rain or fog - could be measured on the rain gauges. The amount of precipitation was monitored over an eight to twelve month period.

Using this information, a quasi-linear (S-shaped) relationship was obtained when mean monthly precipitation (converted to litres) was plotted against elevation of the site. This is illustrated in figure 4.

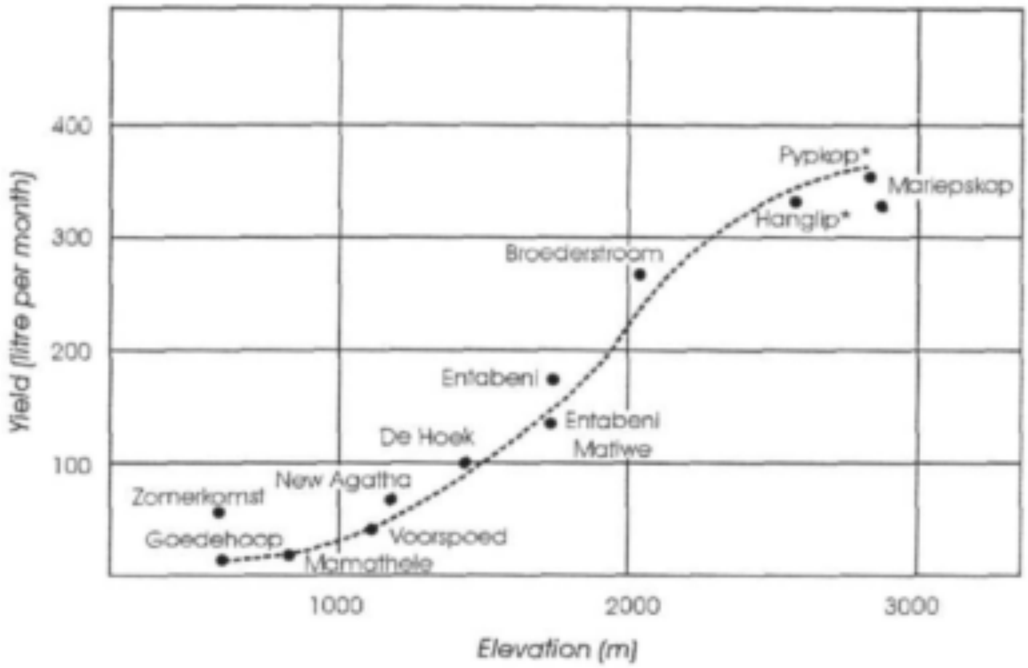



**Fig 4. Relationship between elevation (m) and fog cylinder yields (l) at 10 fog collection sites in the former Transvaal (From Schutte, 1971).**
*** Experimental sites. The dotted line indicates the power function.**

Fortunately, simultaneous measurements of fog water collection rates from the wire fog catcher and large vertical fog screens (see Fig. 1) were made at Mariepskop during 1969 and 1970 (Schutte, 1971). These indicated that for each 1 mm of water collected by the fog catcher, 75 litres were collected by a 90,2 $m^2$ screen. Assuming this factor to be constant, it was a simple matter to convert the fog water collection rates measured at the Transvaal sites to give expected water collection rates from fog collectors.

The coincidence between predicted yields (dotted line on Fig. 4) and those actually obtained at Pypkop and Hanglip , serves to indicate that figure 4 can be used to estimate fog water collection rates at different elevations. Table 1 gives these values for elevations exceeding 1 000m.

**TABLE 1: ESTIMATED WATER YIELD FROM FOG COLLECTOR AT SPECIFIED ELEVATIONS**

| ELEVATION (m) | ESTIMATED WATER YIELD ($l/m^2/day$) |
|---|---|
| 1 000 | 2,3 |
| 1 100 | 2,7 |
| 1 200 | 3,5 |
| 1 300 | 4,0 |
| 1 400 | 5,0 |
| 1 500 | 6,0 |
| 1 600 | 7,2 |
| 1 700 | 8,5 |
| 1 800 | 9,5 |
| 1 900 | 10,0 |
| 2 000 | >10 |

Assuming that the lower threshold yield value for an economically viable fog water harvesting is 2 litres/$m^2$/day, it is clear that *the elevation of the site should exceed 1 000m.*

Another important consideration was that *the site should be exposed to moisture bearing winds.*

These criteria were met at high elevation sites in the Soutpansberg of the Limpopo Province, the mountains forming the Eastern Escarpment of the country and those in the south western Cape (Olivier & van Heerden,1999).

### 2.1.2 Identification of a Suitable Community

The proximity of a water-poor community to a high elevation water source is the second prerequisite for the implementation of a fog water collection system.

A preliminary investigation was carried out in the preceding project (K5/671), aimed at identifying suitable recipient communities for a fog water collection system. This selection was based on (a) the water need of the community and (b) the costs involved in supplying water from a fog water collection system. The following procedure was employed to identify such communities:

1 A list of water-poor communities (in the Limpopo Province) was obtained from the Departments of Environmental Affairs (Provincial) and the Department of Water Affairs and Forestry (National). It comprised 770 villages where less than 15 litres of water was available per person per day. The list was compiled during the drought of the early 1990s. This information was supplemented by field trips to the area and information obtained from AFRICON in Pietersburg.

2 As a preliminary step, those water-poor villages located within 25 km of a high elevation (>1 000 m) site were identified using topographical maps. A total of 62 such communities, comprising 84 270 inhabitants, were thus identified. Most of these were located in the immediate vicinity of the Soutpansberg or the Eastern Escarpment near Magoebaskloof and Tzaneen.

3 These villages were then prioritized in terms of the severity of their water shortage, the proportion of the community experiencing severe (<15 l/c/d) water shortages, the quality of the water and its accessibility. A simple rating scheme was devised to achieve this. Forty-eight of the original 62 villages were identified as experiencing severe water problems.

4 The size of the community and its distance from a potential fog water collection site obviously play a decisive role in the cost of the project. The distance over which the water had to be transported was estimated as being the sum of the vertical and horizontal distances between the village and the closest, highest site. Topographical maps were used to determine these distances.

5 A short-list was drawn up of those villages located within 15 km of a potential water harvesting site. Thirty-seven villages were identified in this manner. These are listed on page 133 of Olivier and Van Heerden (1999).

The above-mentioned villages were thus selected on the basis of the extent of the water shortage and the estimated cost involved in supplying fog water. However, for the final selection of a suitable community, other factors, such as terrain features, accessibility, security, land tenure and community involvement had to be assessed at each site. Detailed examination of the area was thus essential. This could only be carried out by means of an on-site investigation of the villages.

Since only a prototype fog water collection system was to be erected, it was decided to limit the operational system to a single fog water collecting unit. The recipient community for the prototype thus had to be relatively small - ideally either a school or a clinic. Nevertheless, the distance over which the water had to be conveyed had to be as small as possible to limit costs.

The following three trips were undertaken in 1998: to the Soutpansberg region, to the more easterly sections of the Wolkberg, and to the Drakensberg in the vicinity of and to the south of Woodbush and Tzaneen.

It was found that a number of the villages where a water-shortage was said to exist, did if fact have a source of water in the immediate vicinity. In some cases, taps had already been installed in the villages. Although the quality of the water was not determined, it was assumed that this would be acceptable. It can only be surmised that some of the villagers exaggerated their situation so as to place pressure on the Department of Water Affairs to install taps in all erfs or inside the dwellings. At the most suitable site (at Jack), the Department of Water Affairs was busy laying pipes and constructing a reservoir.

Although a number of communities were identified as potential recipients, the Tshanowa Junior Primary School in the Soutpansberg (Venda), was found to best meet the criteria. Consequently, it was selected as a suitable site for project implementation.

## 2.2 CHARACTERISTICS OF SITE

The Tshanowa JP school is located at an elevation of 1 004 m, at the crest of one of the eastern-most promontories of the Soutpansberg in the Limpopo Province. The school is exposed to fog bearing winds from the east, southeast and northeast. According to the principal, the area is frequently shrouded in dense mist due to cloud interception. This was corroborated by the presence of a thick layer of lichens on the trunks of trees in the vicinity of the school and the growth of moss on the eastern and southern walls of the school building. The school population comprises 128 children and four teachers. There are a few houses located near the school, but the majority of the communities live further down the mountain.

Although the area has a high rainfall (> 800 mm), there is no water available at the school. The closest natural water sources are a non-perennial spring located 2 km from the school and a dam situated in the valley more than 5 km away. Although a reservoir was built close to the school by the Department of Water Affairs and Forestry, this water is not available to the school or the villages in its vicinity, since the reservoir is located at a lower elevation than the school. Moreover, the pumps and taps were broken a considerable time ago and have not yet been repaired: there is thus no water available at the school or at any of the villages in the vicinity. The terrain is extremely rugged and steep, and it is difficult and time-consuming for the inhabitants of the area to obtain sufficient quantities of water for domestic purposes. Since most water sources in the Province are contaminated with the bilharzia parasite, the quality of the dam water is suspect. In the past, children had to fill bottles at these sources and carry them to school with them. Not only was the volume of water inadequate, but it might have carried waterborne diseases.

An indication of the location of the experimental site is shown in Figure 5

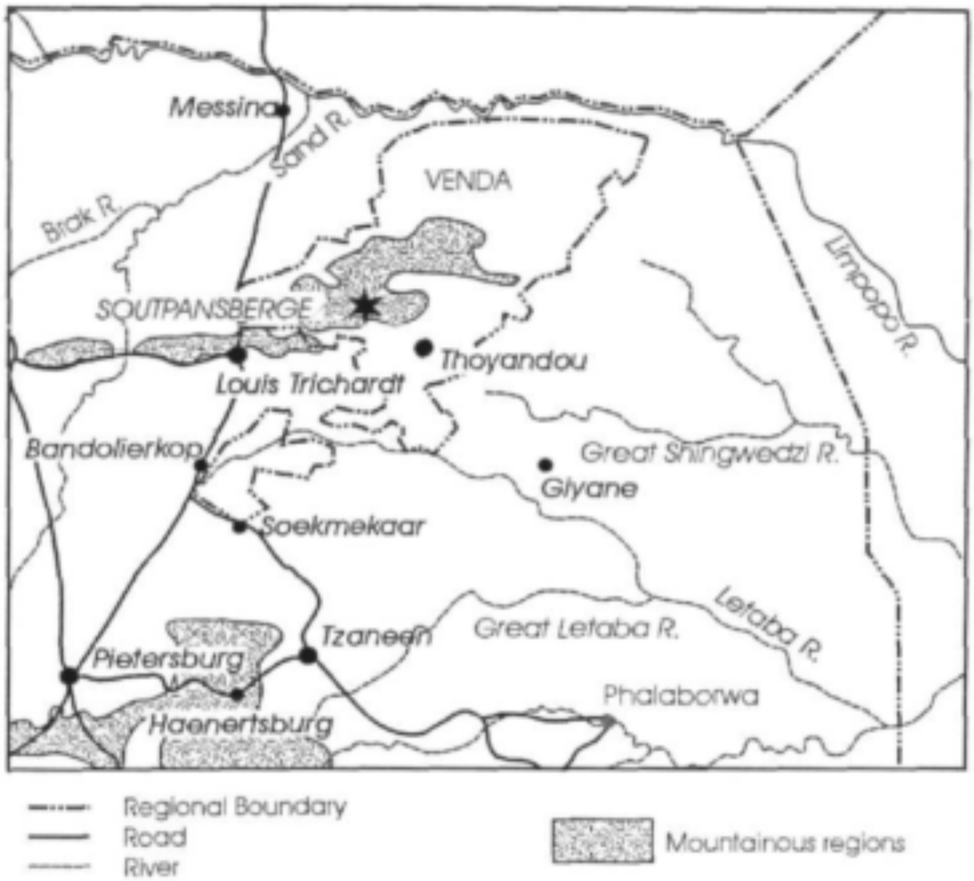



**Fig 5 Map showing the location of fog water collection site* (Juta's Springbok Atlas, 1988)**

Two of the criteria for a suitable site for fog water collector were thus met and they are

- elevation (Although the elevation is relatively low, it does exceed the minimum of 1 000 m.)
- a community which experiences severe water shortage

*Additional positive factors include the following:*

- Terrain features. There was a large piece of flat vacant land immediately adjacent to the school.
- Accessibility. Two roads - albeit in relatively poor condition - give access to the site.
- Community cooperation. Discussions were held with the school principal, who was very enthusiastic about the project.
- Approval from local and regional authorities. The Northern (Limpopo) Province's Department *of Education was approached for permission to erect a fog water collection system on the* school premises. Fortunately, the Director-General of Education was familiar with the Chilean fog project and permission was granted without delay.

  On request, the principal of the school, Mr M Netshifhefhe, organised a meeting with the traditional leader of the region, Mr Vondo. This was held early in December 1998 and was attended by Mr Vondo, two of his sons, a few other members of the local community, Mr Netshifhefhe, Profs Van Heerden and Van Rensburg, and myself. Permission was granted *and a piece of land, approximately 2 000 $m^2$in size, was set aside for the fog collector. The* only proviso was that local labour should be hired to help with the construction.
- Security. A fence was erected around the plot so as to ensure security. In addition, the school and teachers are on site most of the day. Not only do they implement strict access control, but they regularly arrange sessions where the vegetation in the plot is cleared, especially during times when conditions are conducive to veld fires.

# CHAPTER 3
# DESIGN AND IMPLEMENTATION OF THE WATER COLLECTION SYSTEM

## 3.1 DESIGN AND STRUCTURE OF THE FOG WATER COLLECTION SYSTEM

Following a visit to El Tofo (Chungungu) and discussions with the Chilean team, the fog water collector was designed by Prof Van Heerden and assisted by Prof Ben van Rensburg of the Department of Civil Engineering, University of Pretoria. The design of the collector was based on the one used in Chile (Schemenauer *et al.* 1988; Schemenauer and Cereceda 1991, 1992, 1994) and is similar to it in a number of respects. Slight modifications were, however, made to suit local climatic conditions. A schematic diagram of the design is presented in Figure 6.

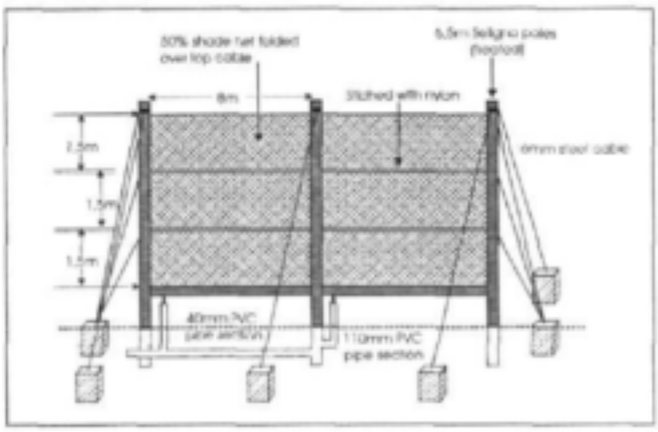



**Fig 6 A schematic diagram showing the structure of the fog collector**

The fog collector consists of three 6 m high wooden (Saligna) poles mounted 9 m apart. Galvanized steel cables anchor the system to the ground. Double sets of horizontal galvanized steel cables anchor the poles to each other and support the screen. The screen consists of two 9 m x 4 m sections of 30% shade cloth netting that are draped over the top net support cable and threaded through the space between the two middle and the two lower net support cables. The nets are secured below the lower cables by bolting them together using sections of perforated aluminium flat bars. A gutter is attached to the lower end of the net along the lower net support cable.

During foggy conditions, water droplets collect on the screen, flow downwards and drip into the gutter. The latter is tilted slightly so that the water is channelled to a sand filter. This empties into a 1,1 litre tipping bucket connected to a data logger. From there, it flows through a 40 mm PVC pipe to a 10 k▾ storage tank located downslope. Originally, a single tank was installed, but two additional tanks 10 k▾ tanks were installed to collect the overflow from the first.

A complete CR10 automatic weather station - consisting of Campbell and RM Young temperature, wind speed and direction sensors and a rain gauge - was installed at the fog water collection site. For purposes of verification, two channels were used to collect data from the 1,1 litre tipping bucket - one recorded every tenth tip and the other, every $20^{th}$ tip. These are referred to as the 10 and 20 tip records, respectively.

The structure of the completed construction and water storage tanks are shown in figures 7 a and b respectively, while details of various components of the system are illustrated in Figure 8.

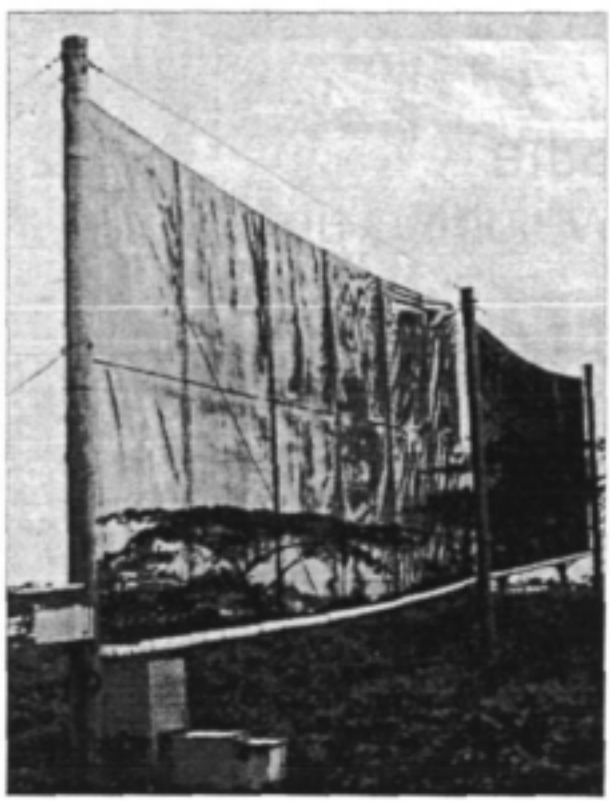
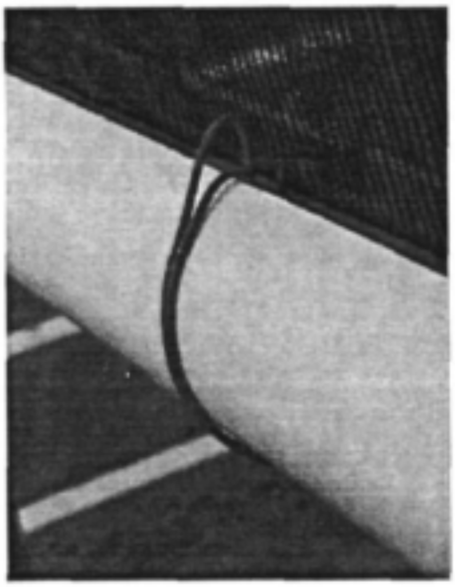


**Fig. 7 a The fog water collector at the Tshanowa Junior Primary School site**

**Fig 7 b 10 000 litre water collection tanks**

(a)



(b)

(c)

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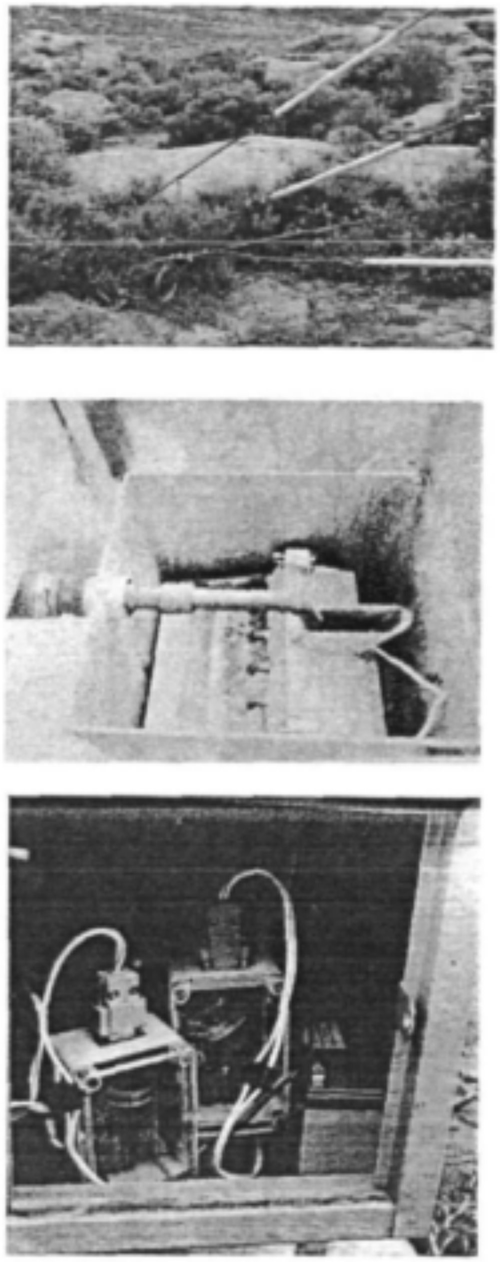


**Fig 8 Various components of the fog water collection system. (a) Galvanized steel hangers supporting the gutter (b) turnbuckles to adjust cable tension (c) tipping bucket and (d) data logger and batteries**

## 3.2 ERECTION OF SYSTEM

Local inhabitants were employed to assist with the erection of the fog water collector. The construction phase commenced in February 1999 and was completed during the first week of March.

## 3.3 DESIGN PROBLEMS AND SOLUTIONS

A few problems were encountered with the structure, which necessitated a number of subsequent modifications. These are listed below.

- *All the brass hangers used to support the gutter failed due to metal fatigue.*
  *Solution:* The hangers were replaced by ones made of 3 mm galvanized wire (see Fig. 8a).

- Problems also arose at the join between the gutters attached to the two sections of the screen.
  This problem was rectified by using a 110-50 mm reducer which was PVC welded to the gutter. However, the 110 - 50 mm reducers around the center pole developed leaks due to stress and lateral movement caused by strong winds.
  *Solution:* A possible remedy is either to funnel water from only one half of the collector to the data logger - with the other emptying directly into the tank or to slope the two gutters towards the center so that each empties separately into the tipping bucket/filter system.

- During windy conditions, the nets moved to-and-fro along the upper support cables. The resultant friction caused the nets to fray and tear.
  *Solution:* This problem was reduced by fixing the sides of the net to the poles.

- The nylon string which was used to attach the net to the poles started to cut into the net, causing it to fray.
  *Solution:* This problem was rectified by sandwiching the sides of the net between two 20 x 30 mm aluminium flat bars and tying these to the poles by means of galvanized wire.

- The 5 mm supporting cables stretched, causing the nets to fill during windy conditions. This placed enormous pressure on the system and resulted in the loss of water. It is essential that the cables be very taught, especially in regions with high wind speeds. Failing this, the nets rub against the cable, which causes them to fray and eventually tear.

  *Solution:* This problem was rectified by attaching turnbuckles (Fig. 8 b).

- The sand filter required more maintenance than was previously anticipated. The screens collected dust during dry periods, with the result that the sand had to be replaced at least once a month.

  *Solution:* An U-tube with a tap at the lower end was fitted to the pipe. This can be opened periodically to flush out accumulated dust and dirt.

- Some vertical cracks appeared at the top of the poles.

  *Solution:* A bitumen sealer was applied and appears to have solved the problem.

- The major problem was associated with the tipping bucket and data logger. For instance:
  - Battery failure due to infrequent site visits.

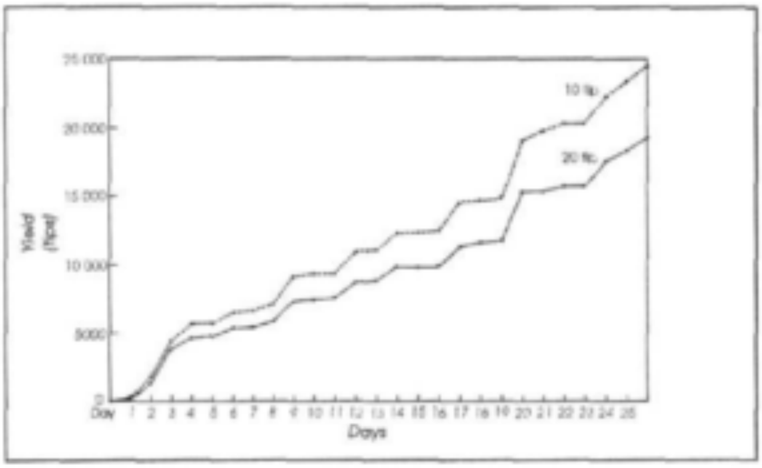
  *Solution:* A solar panel was connected to ensure that the batteries remained fully charged.

  - Tipping bucket malfunction.
    - It was found that the tipping bucket did not empty completely resulting in some water being scooped back on the return tip.
    - Due to the incorrect placing of the reed switches, every tip was not recorded. This error is compounded over time, as illustrated by the increasing deviation between the 10 and 20 tip records in figure 9(a). Malfunctioning of the reed switch led to the loss of 20 tip data during 2000. The available (10 tip) record for the corresponding period could thus not be verified.
    - During heavy rain, the stream of water falling onto the tipped bucket delayed its up-tip and large volumes of water flowed directly to the tank without being recorded. In fact, when the rainfall exceeded 50 mm per hour, the entire box housing the tipping bucket, became filled with water - preventing it from tipping. Figure 9(b) clearly illustrates the undercount during heavy rain.

  *Solution:* As an interim measure, a water flow meter was inserted into the pipe near its connection with the tank. Daily readings of the volume of water harvested were recorded by the teachers and learners. However, this gave rise to inaccurate records and gaps in the data record, especially over weekends and during school holidays. In addition, only daily data were available instead of hourly data.

The original tipping bucket was replaced. It is, however, still unsatisfactory and will have to be replaced by some other measuring device. Some means of recording flow volumes electronically will have to be found since the manual recording of the data is unreliable.

(a)




(b)

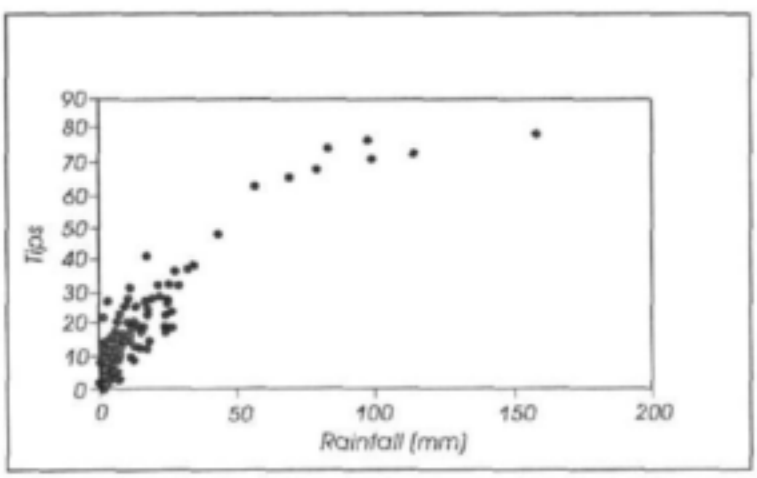



**Fig 9 (a) 10 and 20 tip data logger readings for the same events (b) influence of rainfall on recording accuracy**

## 3.4 COST OF THE FOG WATER COLLECTOR

Table 2 shows the costs of erecting the fog water collector. Expenditure of materials amounted to approximately R6 600 during 1999. The entire system, as implemented at the Soutpansberg experimental site and including the costs of equipment such as ladders and that of the water tank, amounted to approximately R 11 000. This does not include the cost of labour.

**TABLE 2: COST OF FOG COLLECTOR**

| MATERIALS | COST (R) |
|---|---|
| 1 roll 30% shade cloth | 700 |
| 175 m of 6 mm galvanized cable, turnbolts, eye nuts, cable clamps, threaded bolts | 2 500 |
| Gutter and gutter hangers | 600 |
| 100 m of 40 mm PVC pipe and fittings | 200 |
| Other nuts and bolts, aluminium strips | 700 |
| Cement for anchors | 400 |
| 3 x 6,5 wooden poles | 300 |
| Sand filter | 1 000 |
| Sundries - sealants, chlorine | 200 |
| **TOTAL** | **6 600** |

# CHAPTER 4
# DATA ANALYSIS AND RESULTS

## 4.1 INTRODUCTION

The mountains of the eastern Escarpment experience some of the highest fog incidence frequencies in the country (see Fig. 1). Figure 10 indicates that the rainfall values are also relatively high in the region.

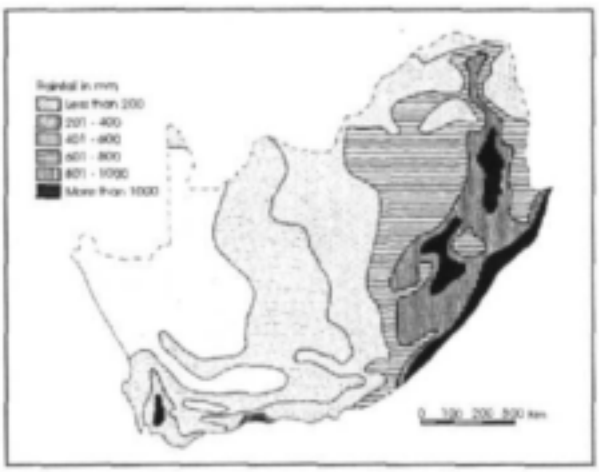



**Fig 10 Mean annual rainfall map of South Africa (Liebenberg, 1992)**

Fog and rainfall occurrence are controlled by prevailing synoptic conditions since they determine both wind speed and direction as well as the moisture content of the air. According to Preston-Whyte and Tyson (1988), wet conditions long the Eastern Escarpment arise due to the advection of moist maritime air from the Indian Ocean. Onshore airflow is associated with two main synoptic situations. (a) Under the influence of the South Indian Ocean anticyclone (SIA), onshore winds advect warm, moist air inland. Under stable conditions, this northeasterly flow may cause gradual upslope flow which may result in the formation of orographic fog. Alternatively, clouds may form if conditions are unstable. Here rain and fog will result from cloud interception. (b) A ridging anticyclone to the south of the country will result in extensive onshore air movement and cloud along the eastern coastal and adjacent areas. Both rainfall and fog may result from these clouds.

The experimental site in the Soutpansberg is located slightly to the north west of the Escarpment and will thus also be influenced by the systems described above. However, the extent of this influence and the resultant yields obtained from rainfall and fog water harvesting could only be ascertained by analysing the data logger records.

## 4.2 DATA ANALYSIS

The tipping bucket data record was analysed in order to obtain data on daily and hourly water yields as well as on the times and dates of wet events. The former was achieved by noting the number of tips recorded during hourly time periods and multiplying this value by 1,1 to obtain the hourly yields in litres. These were summed to obtain daily and monthly totals.

The hours (days) on which deposition were recorded are referred to as *wet hours* (days). Data from the rain gauge were used to distinguish between rainfall and foggy hours (days). Those periods during which water was collected but no rainfall was recorded on the rain gauge, were designated *fog hours* (days). All precipitation deposited on the collector was deemed to have originated from fog alone. Conversely, *rain hours* (days) occurred when rainfall was recorded on the rain gauge during any hourly time slot. It was assumed that all deposition occurring during a rain hour was due to rainfall alone. The data record spans the period 9 March 1999 to 18 April 2001.

## 4.3 FACTORS AFFECTING THE INCIDENCE OF WET EVENTS: SYNOPTIC CONTROLS

Daily weather charts obtained from the South African Weather Services in Pretoria were analysed to determine the dominant macro- and mesoscale controls associated with the collection of water at the Soutpansberg experimental site. Synoptic charts were studied for those days when water collection was recorded on the data logger during the period spanning March 1999 to April 2001.

Figure 11 shows the nine typical synoptic situations associated with wet events at the Soutpansberg site.

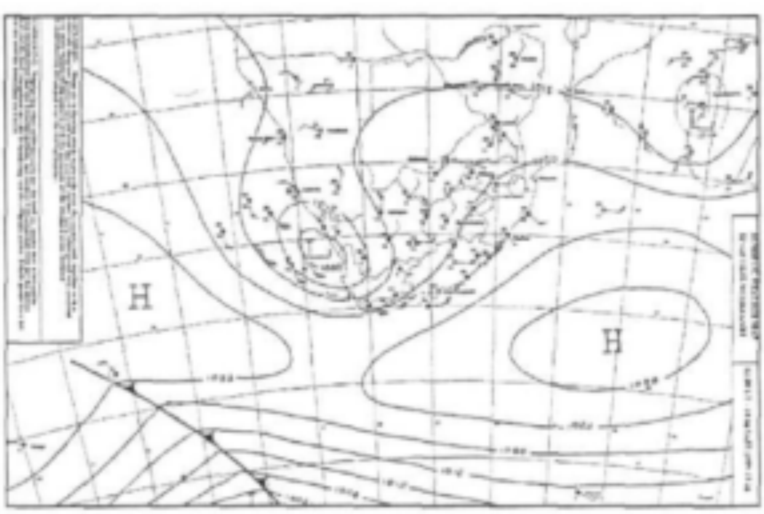
During the majority of wet events at the Soutpansberg site, waves in the equatorial easterlies were located over or just to the north of the area. These waves were either associated with troughs of low pressure (Fig. 11a) or contained embedded lows (Fig. 11b). The positions of the low pressure systems varied but were usually located over Botswana and over Madagascar or the Mozambique Channel. Wet events arising from deep easterly troughs occurred during the autumn whereas those associated with circulation around tropical lows, were mainly summer phenomena. A number of wet events were associated with the presence of cyclonic conditions over the country (Fig. 11c). Often a number of low pressure cells were arranged in a north-south alignment from the tropics into the temperate zones. These tropical temperate troughs either extended over the Indian ocean or were truncated, terminating at the coast. Although these systems are the most common rain-bearing systems in the summer rainfall region (Preston-Whyte and Tyson, 1986), they were associated with less than 22% of wet events at the Soutpansberg site.

Cold fronts accounted for 11% of wet events in the Soutpansberg (Fig 11d). Contrary to expectation, these events were not exclusively winter phenomena, but occurred most often between October and January.

The presence of the Indian Ocean high produced precipitation at the experimental site on about 10% of the time - mostly during the March to June period (Fig 11e). Often, however, wet events were associated with the combined impact of this subtropical system and the tropical easterlies. Winds at the school were then exceptionally light causing relatively little precipitation. These conditions prevailed from spring to late autumn. A more complex situation, comprising the combined impacts of the equatorial easterlies, a system of low pressure cells over the country and the circulation around the Indian ocean high, occurred during 5% of wet events in the Soutpansberg (Fig. 11f).

Another synoptic situation which occurred during was associated with wet events - albeit only rarely - was associated with a ridging South Atlantic anticyclone (Fig. 11g). On rare occasions, the SA Anticyclone ridged in over the continent from a position on the west coast or from far to the south of the continent.

(a)



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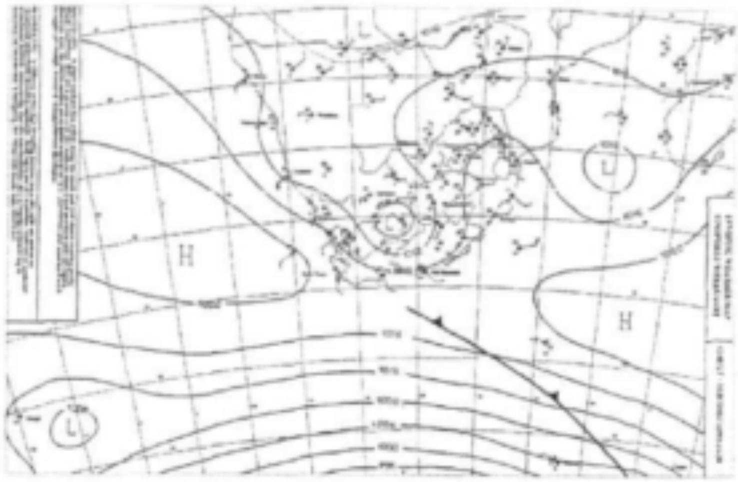


(c)

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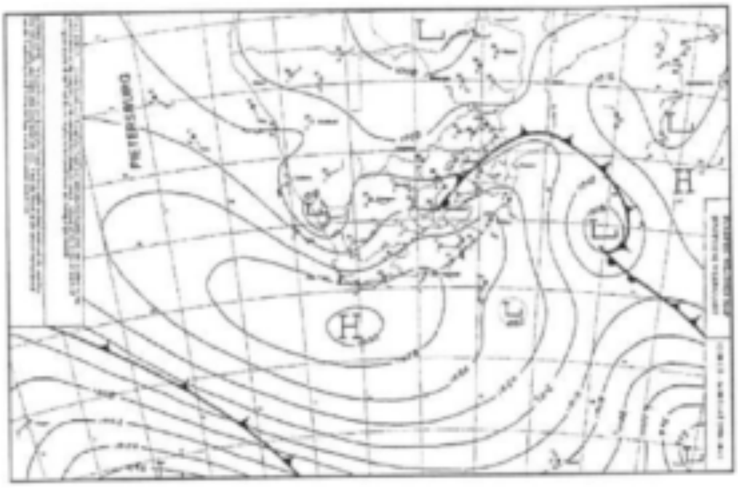
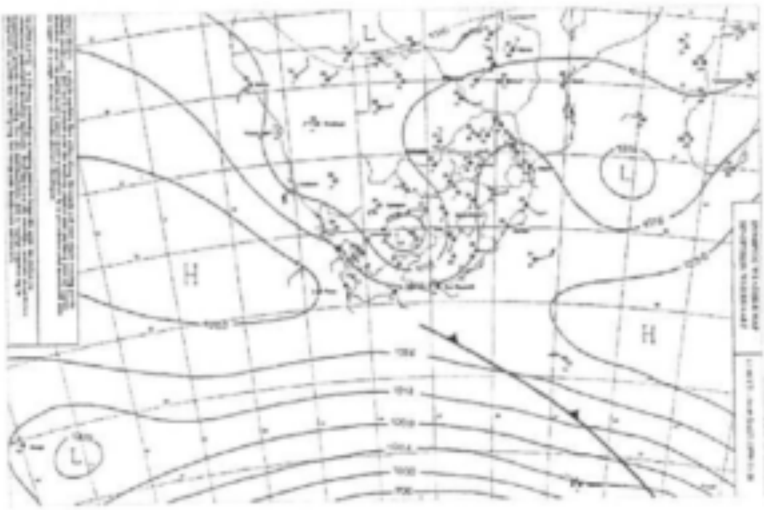
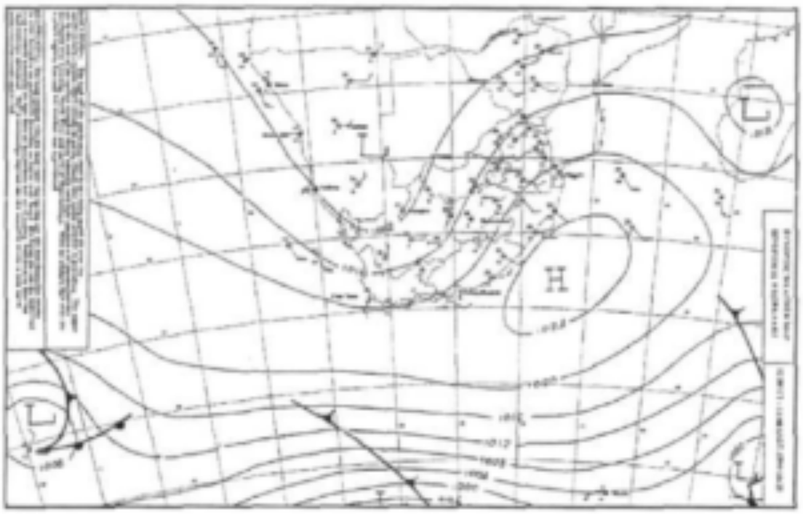


(e)



(f)



(g)

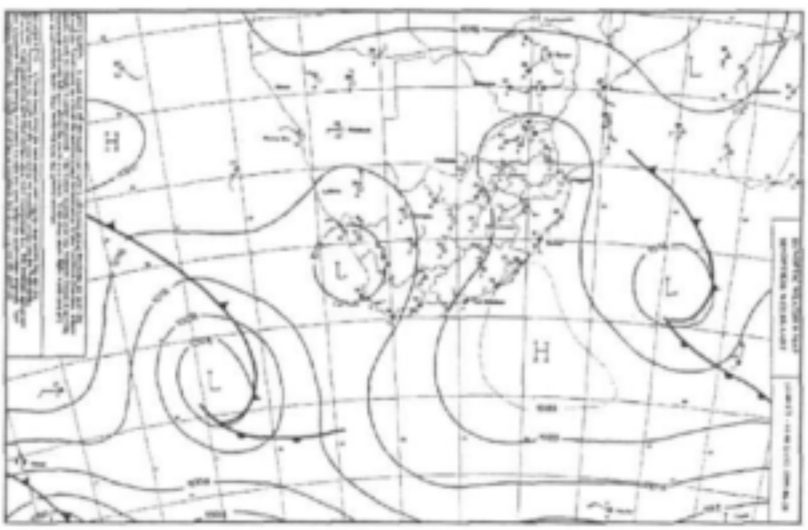


Fig 11 Synoptic situations associated with wet events at the Soutpansberg experimental site (a) an easterly wave (b) combination of easterly wave and lows (c) combination of low pressure systems (d) cold front (e) Indian Ocean high (f) combination of an easterly wave and the IOH (g) South Atlantic anticyclone

Table 3 lists the synoptic systems that prevailed during wet events at the experimental site and gives the associated occurrence frequencies and seasonality.

**TABLE 3 SYNOPTIC SITUATIONS ASSOCIATED WITH WATER COLLECTION AT THE TSHANOWA JP SCHOOL FOG COLLECTOR (March 1999 - April 2001)**

| SYNOPTIC SYSTEMS | | | % | MONTHS |
|---|---|---|---|---|
| TYPE | CIRCULATION | SYSTEM | | |
| TROPICAL | Cyclonic | Easterly wave | 14 | Oct- Mar |
| COMBINATION: TROPICAL & SUB-TROPICAL | Cyclonic | Easterly wave with low pressure cell | 13 | Oct - Jan |
| | Cyclonic | Multiple lows | 22 | Oct - Jan |
| | Complex cyclonic & anticyclonic | Easterly wave + IOH | 25 | Oct - May |
| SUB-TROPICAL | Anticyclonic | IOH | 10 | Mar - Jun |
| | Anticyclonic | South Atlantic H to south | 2 | Mar - Jun |
| | Anticyclonic | South Atlantic H to west | 2 | Jan, Jun |
| | Anticyclonic | Continental high | 1 | Jun |
| MID-LATITUDE | Cyclonic | Cold front | 11 | Oct - Jan |

It thus appears that the study area is dominated by tropical and subtropical circulation systems, with the major synoptic conditions associated with wet episodes being either:

*Tropical systems* comprising easterly waves and tropical lows or

*Subtropical systems* in the form of anticyclones - either manifest as a continental high pressure cell or as the Indian Ocean anticyclone located to the east of the country, or even as a ridging Atlantic high from the South Atlantic anticyclone located relatively far to the south of the continent.

*Mid latitude systems* as reflected by the passing of a cold front over the area play a lesser role in the incidence of rainfall and fog at the site.

The tropical and sub tropical systems cause the onshore advection of moist maritime air from the Indian Ocean. On meeting the mountains the air is forced to rise. During the upward motion it cools because of adiabatic expansion and condensation takes place at the lifting condensation level (LCL). The LCL in turn, is a function of the maritime air's temperature and dew point at the foot of the Escarpment. If the lifting air is humid enough, the cloud base will form below the crest of the Escarpment. If the uplift occurs is stable air, layers of clouds will tend to form in the crests of the standing wave over and against the Escarpment. The mountain wave cloud (fog) formed in this manner remains stationary against and over the mountains. In unstable air, convective (cumulus congestus) clouds may develop out of the stratiform orographic clouds if the orographic uplift provides sufficient vertical velocity for the air to reach the level of free convention.

## 4.4 CHARACTERISTIC OF WATER COLLECTION EPISODES.

### 4.4.1 Annual frequency of wet events

No long term weather data are available for the experimental site and the relatively short records available from the data logger are not sufficient to give an overall picture of the incidence of wet events at the experimental site. The mean annual rain day frequency can possibly be estimated from those recorded at nearby Weather Bureau stations. Levubu, for example, is located to the south of the experimental site at an altitude of 706 m above MSL The mean annual rain day frequency there is 100 days. According to Fig. 1, its fog day frequency should exceed 50 days per annum.

The total number of wet days per year is not simply the sum of the rain day frequency and the fog day frequency since both rainfall and fog may occur on the same day. It can be assumed that the total wet day frequency lies between the estimated mean annual rain day frequency and the sum of the rainfall and fog days i.e. between 100 and 150+ days.

Since the experimental site's altitude is greater than that of Levubu, higher RDFs And FDFs can be expected. Analysis of the data logger record indicates that during the 490-day recording period, 271 were wet. Extrapolated to a year, this amounts to 200 wet days. This appears to be a good reflection of the true WDF.

### 4.4.2 Seasonality of wet events

The school is located in a predominantly summer rainfall region. Once again, the seasonality of the rainfall can only be estimated from that of nearby Weather Bureau sites. Likely scenarios are given by Fig. 12 which shows the monthly rain day frequency at Levubu and the monthly fog day frequency at Woodbush (SAWB, 1986).

Although the latter values are probably higher than that experienced at the Soutpansberg site, the pattern would remain essentially the same. It can therefore be assumed that most deposition can be expected during the summer months, although some water collection should occur during winter. Analysis of the data logger records reveals that this is indeed the case (see Table 4, column 7).

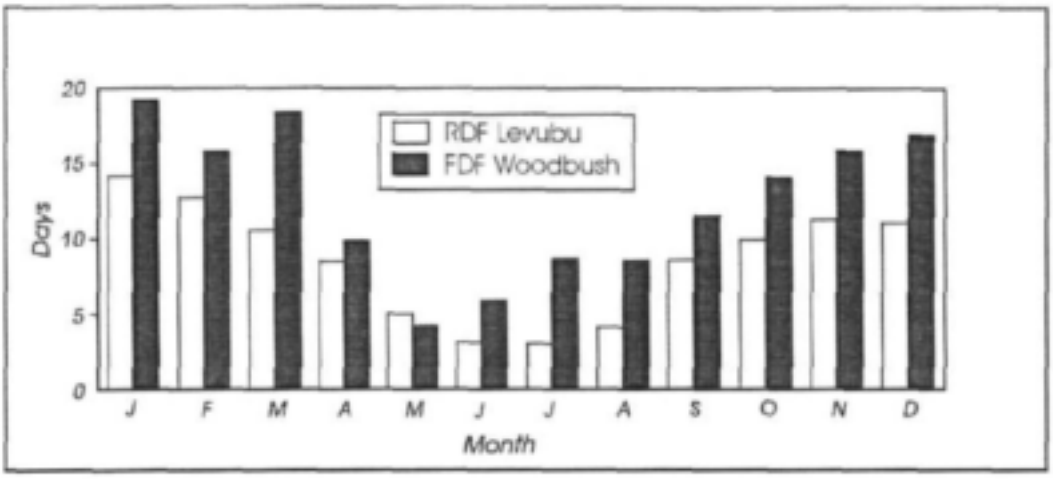



**Fig 12 Seasonal incidence of rainfall at Levubu and fog at Woodbush**

### 4.4.3 Diurnal incidence and duration of wet events

Analysis of the data logger records reveals that most water was collected during the early morning hours, notably between 02:00 and 09:00 in the Soutpansberg (Fig. 13). Both rainfall and fog can occur during any time of the day or night. During the 1999- 2001 period, the deposition occurring between 23:00 and 06:00 was mostly due to fog while water from rain made up the largest part of the total yield during the daylight hours.

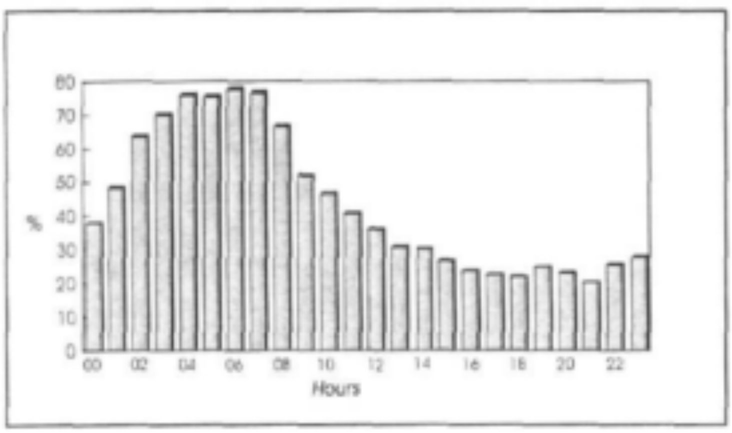



**Fig 13 Diurnal incidence of wet events at the Soutpansberg site**

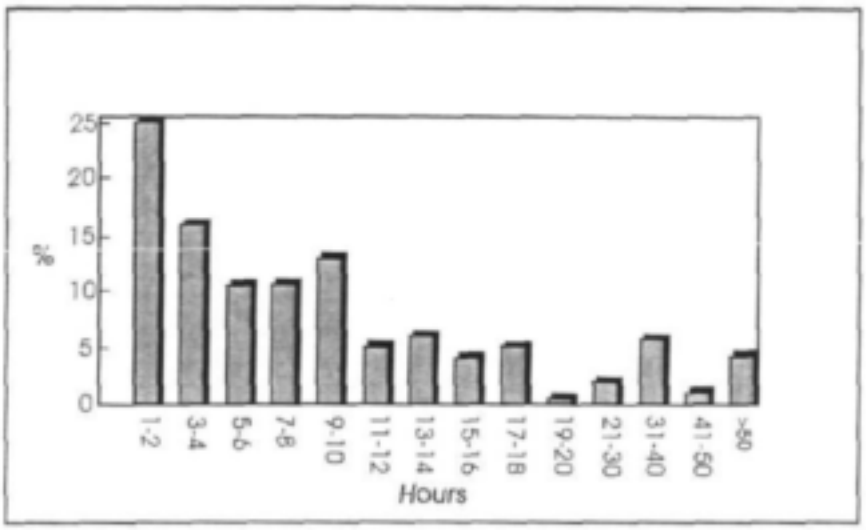



**Fig 14 Duration of wet events at the Soutpansberg site**

Figure 14 depicts the duration of wet events. Around 72% of all wet events lasted for one up to 10 hours. However, the duration of the majority of these was less than three hours. The longest episode recorded during the study period lasted for 112 hours and occurred between 2 and 6 February 2001 when 1 211 litres of water were collected.

## 4.5 WATER YIELDS

The construction of the fog collector was completed on Thursday, March 5, 1999. The first wet event occurred on 9 March and since then, water collected on the fog screen has been consumed on a daily basis by school children and members of the local communities.

### 4.5.1 Factors affecting data record

Unfortunately, not all the data were captured on the data logger. As explained previously, this was due to problems encountered with various parts of the system. Further data were lost due to adverse weather conditions. Most data loss occurred during the February to May 2000 period when one of the worst floods in living memory hit the Limpopo Province and Mozambique. This was due to an intense tropical low followed by tropical cyclone Eline during February. These phenomena caused widespread devastation, changing streams into torrents, collapsing bridges and washing away the majority of the roads in the mountains. Although an attempt was made to collect the data during this period, roads were impassable until May 2000. Fortunately no structural damage resulted from strong winds during these wet periods. Table 4 gives an indication of the excessive rainfall recorded in the Limpopo Province during February 2000.

**TABLE 4 RAINFALL (mm) AT SELECTED SITES IN THE LIMPOPO PROVINCE DURING FEBRUARY 2000 vs NORMAL CONDITIONS** (information supplied by CJdeW Rautenbach)

| STATION | RAINFALL 5-9 FEB. | RAINFALL 22-26 FEB | TOTAL FEB. 2000 | MEAN FEB. RAINFALL | FEB 2000 AS % OF NORM |
|---|---|---|---|---|---|
| PIETERSBURG | 59 | 82 | 188 | 72 | 261 |
| PHALABORWA | 59 | 231 | 338 | 85 | 398 |
| MARA | 95 | 136 | 274 | 65 | 422 |
| LOUIS TRICHARDT | 245 | 268 | 669 | 126 | 531 |
| TZANEEN Grenshoek | 278 | 440 | 1163 | 147 | 791 |

### 4.5.2 Water collection rates

The first results were extremely gratifying. Table 5 gives a summary of the monthly water yields collected from the Soutpansberg site during the period March 1999 - April 2001.

During this period, a total of over 100 000 litres were recorded. The actual volumes collected exceeds this since large gaps occur in the data collection record. For instance, data were only available for the first five days of February 2000 (the month with the highest rainfall during the study period). According to Table 4, the total February rainfall for those areas affected by tropical cyclone Eline, was between two to eight times that recorded up to the 9th of the month. It is thus highly probable that more than 10 000 litres of water could have been collected on the fog collectors during February 2000, instead of the 3000 litres recorded for the month.

According to the existing records (Table 5) , most water was collected during January 2000 and March and November 1999. The highest mean wet day yields were recorded during June 2000 (9,3 $\ell/m^2/d$ and 2 007 $\ell/m^2$/wet day). The highest daily yields were recorded on the 5th of June 2000 and the 20th November 1999 when 3883 and 3 179 litres of water were collected, respectively. Yields of more than 1 000 litres were recorded on 17 other occasions. Hourly values in excess of 500 litres were collected between 01:00 and 02:00 on 24/03/99 and between 09:00 and 10:00 on 20 November 1999. The average recorded collection rate during the data collection period was just less than 3 $\ell/m^2/d$.

**TABLE 5 WATER YIELDS FOR DATA COLLECTION PERIOD**

| YY | MM | YIELD (*l*) | DAYS* | *l* /day | *l* /m²/d | WET DAYS | *l*/wd | *l*/m²/wd |
|---|---|---|---|---|---|---|---|---|
| 1999 | 03 | 13 035,0 | 28 | 465,5 | 6,5 | 23 | 566,7 | 7,9 |
| | 04 | 566,5 | 3 | 188,8 | 2,6 | 3 | 188,9 | 2,6 |
| | 05 | 4 834,5 | 24 | 201,4 | 2,8 | 7 | 690,6 | 5,6 |
| | 06 | 3 492,5 | 29 | 120,4 | 1,7 | 6 | 582,1 | 8,1 |
| | 07 | 6 688,0 | 31 | 215,7 | 3,0 | 15 | 455,9 | 6,2 |
| | 08 | 3 674,0 | 31 | 118,5 | 1,7 | 5 | 734,8 | 10,2 |
| | 09 | 2 937,0 | 22 | 133,5 | 1,9 | 6 | 489,5 | 6,8 |
| | 10 | 2 656,5 | 19 | 139,8 | 1,9 | 9 | 295,2 | 4,1 |
| | 11 | 10 428,0 | 30 | 347,6 | 4,8 | 19 | 548,9 | 7,6 |
| | 12 | 1 105,5 | 21 | 52,6 | 0,7 | 13 | 85,0 | 1,2 |
| 2000 | 01 | 24 343,0 | 31 | 785,3 | 10,9 | 31 | 785,3 | 10,9 |
| | 02 | 3 146,0 | 5 | 629,2 | 8,7 | 3 | 1 048,7 | 14,6 |
| | 05 | 51,5 | 11 | 4,7 | 0,1 | 3 | 17,2 | 0,2 |
| | 06 | 8 029,0 | 12 | 699,1 | 9,3 | 4 | 2 007,3 | 27,9 |
| | 10 | 1168,0 | 24 | 48,7 | 0,7 | 14 | 83,4 | 1,2 |
| | 11 | 2 730,0 | 30 | 91,0 | 1,3 | 19 | 143,7 | 2,0 |
| | 12 | 1 505,0 | 31 | 48,6 | 0,7 | 16 | 94,1 | 1,3 |
| 2001 | 01 | 685,0 | 31 | 22,1 | 0,3 | 15 | 45,7 | 0,6 |
| | 02 | 6 829,0 | 28 | 243,9 | 3,4 | 24 | 284,5 | 4,0 |
| | 03 | 1 840,0 | 31 | 59,4 | 0,8 | 24 | 76,7 | 1,1 |
| | 04 | 877,0 | 18 | 48,7 | 0,7 | 12 | 73,1 | 1,0 |
| **TOTAL** | | **100 648,0** | **490** | **205,4** | **2,85** | **271** | **371,4** | **5,2** |

*** Total number of days on which data were collected**

As previously mentioned, it is more than likely that the water collection rate is considerably higher than 2,85 litre per m² per day. At Lepelfontein on the West Coast, an identical system was erected. According to the data logger records, only 1,02 litres of water were collected per square metre per day, while in actual fact it was closer to 4,6 litre/m²/day. The malfunctioning of the tipping bucket would probably affect the readings to a greater degree at the Soutpansberg site where the rainfall is higher and larger volumes of water are collected in short periods of time, thus magnifying any errors and flooding of the tipping bucket housing more often.

Since the size of the community varies over time, it is not possible to obtain accurate figures of the number of people using the water. It is therefore not possible to express the above volumes in terms of the number of litres of water available per person per day.

#### 4.5.3. Rainfall - fog relationships

In order to determine the relationship between rainfall and fog water deposition, hourly water collection and rainfall data were analysed. It was assumed that whenever rain was recorded on the rain gauge, all the water deposited on the collector originated exclusively from rainfall. On the other hand, if no rain was recorded, all the water collected was assumed to have originated from fog alone. Although this technique underestimates the contribution by fog, it does give some indication of the relative contributions of fog and rainfall to the total volume of water collected.

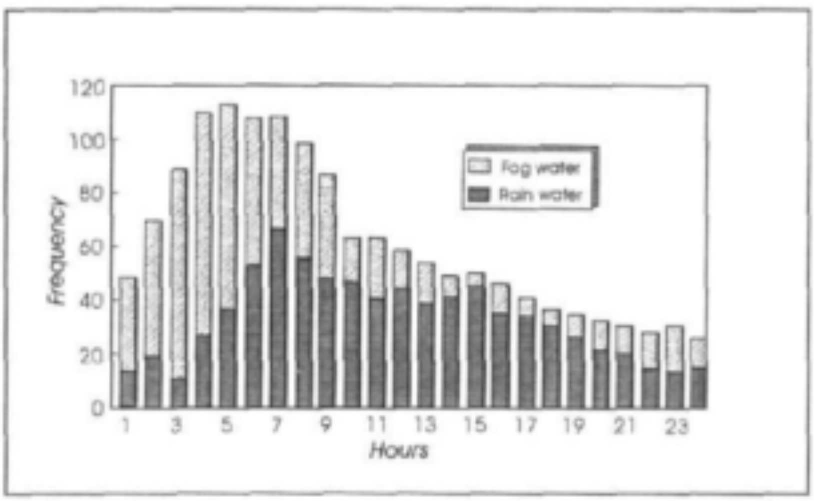
Hourly water collection records were compared with the corresponding rain gauge measurements in order to distinguish between 'rain-hours' and 'fog-hours'. The volume of water collected during each of these two sub-sets was summed to obtain daily and monthly totals. Table 6 gives the summary of the contribution of fog to the total volume of water collected during specific months for the period October 1999 to April 2001.

It was found that only about 25% of the water yields were due to fog while rainfall contributed the bulk of the water. This is illustrated in by figures 15a and b, which show the relative contributions of rainfall and fog on hourly and daily scales. For the former, hourly water collection and rain gauge data were used for the period between the 7$^{th}$ of October 2000 until 4 April 2001. By subtracting the total volume of water collected during fog hours (rainfall = 0 mm) from the total volume of water collected during the same hourly time period, the volume of rain water could be determined. Figure 15b illustrates the volume of rainfall and fog water deposited during the period October 11 to 31, 2000.

TABLE 6 CONTRIBUTION OF FOG TO TOTAL WATER YIELD

| MONTH | TOTAL YIELD (*) | FOG-HOUR YIELD (*) | % FOG |
|---|---|---|---|
| OCT 99 | 2 656,5 | 1 222,0 | 46,0 |
| NOV 99 | 10 428,0 | 1 668,5 | 16,0 |
| DEC 99 | 1 105,5 | 693,1 | 62,7 |
| MAY 00 | 51,7 | 51,7 | 100,0 |
| JUNE 00 | 8 029,0 | 1 702,2 | 21,2 |
| OCT 00 | 1 168,0 | 552,5 | 47,3 |
| NOV 00 | 2 730,0 | 761,7 | 27,9 |
| DEC 00 | 1 505,0 | 635,1 | 42,2 |
| JAN 01 | 685,0 | 356,2 | 52,0 |
| FEB 01 | 6 829,0 | 901,4 | 13,2 |
| MAR 01 | 1 840,0 | 671,6 | 36,5 |
| APR 01 | 877,0 | 362,2 | 41,3 |
| **TOTAL** | **37 904,7** | **9 578,8** | **24,5** |

(a)



(b)

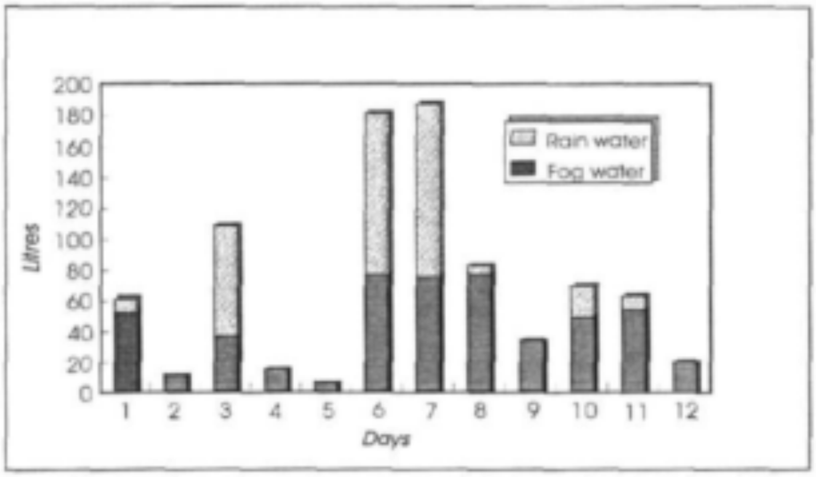
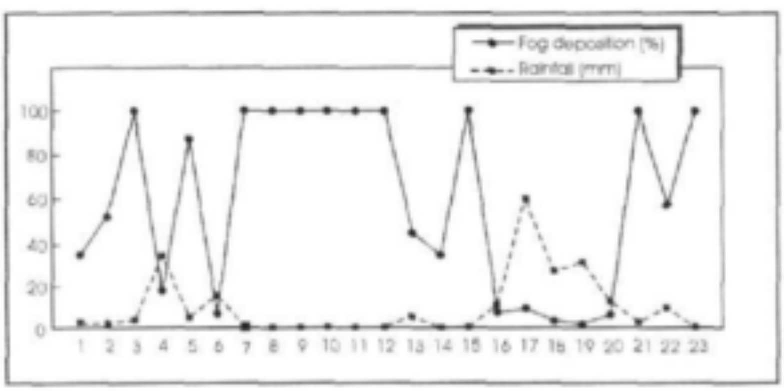



**Fig. 15 (a) Hourly and (b) daily rainfall and fog water yields**

Figures 16 a and b illustrate the proportion of fog water collected, together with the corresponding daily and monthly rainfall values. The former is depicted using data for wet days during October and November 1999. As expected, most fog was deposited during low rainfall events and vice versa $r_{\text{rainfall vs fog collection}}$ = -0,67).

(a)



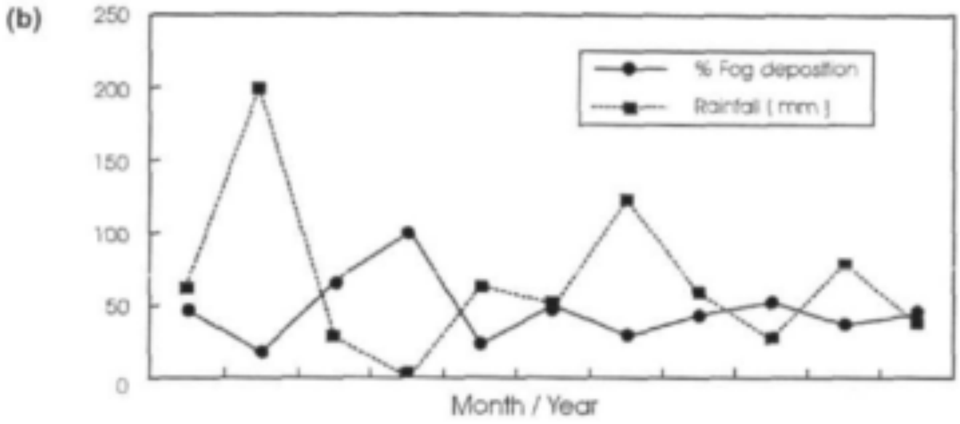



**Fig 16 Fog yield (expressed as percentage of total yield) and corresponding rainfall on a (a) daily and (b) monthly basis.**

Although rainfall contributes significantly more water to the total *volume* collected, *the number of hours* during which fog and rainfall were collected, was almost the same. During the period May and June 2000, for example, fog occurred 55% of the time, whereas during the October 2000 to April 2001 period, this dropped to 46%. Over the entire seven month period, fog was deposited for 731 hours as opposed to the 825 hours of rainfall collection. Fig. 17 illustrates the frequency of fog and rainfall collection during part of 2000 and 2001.

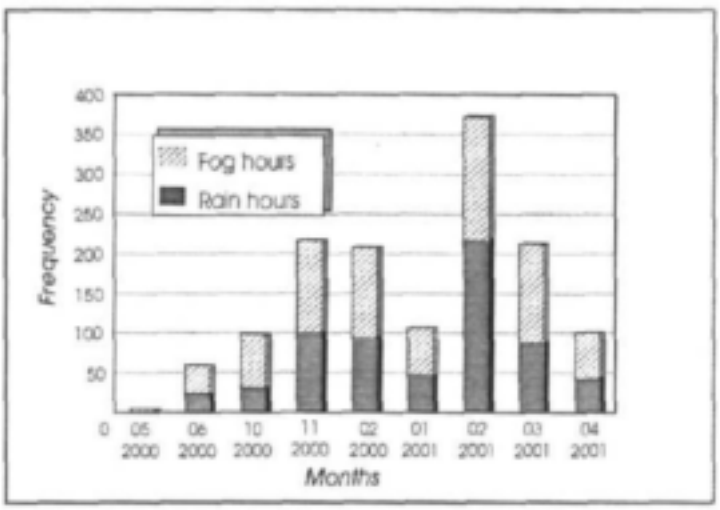



**Fig. 17 Hourly frequencies of rainfall and fog collection during 2000 and 2001**

A wet episode usually commenced with a period during which fog alone occurred, followed by the rain event and ending again with a foggy period. A typical wet event is illustrated in figure 18, showing times during which rain and fog were recorded on 26/10/2000.

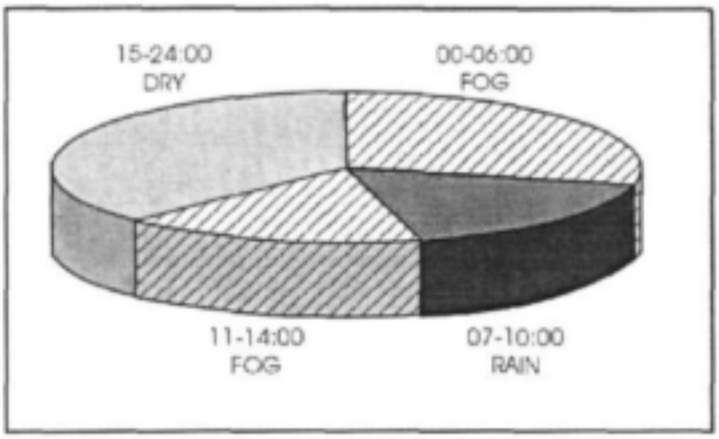



**Fig 18 Occurrence of rainfall and fog during a wet event (26 October 2000)**

## 4.6 FACTORS AFFECTING WATER COLLECTION RATES

In addition to the frequency and duration of wet events, the moisture content of the air, wind speed and direction and various site and collector characteristics also affect the magnitude of the water yield.

### 4.6.1 Wind

#### *4.6.1.1 Wind direction*

The direction of the wind plays an important role in cloud water harvesting since maximum yields are obtained with winds at right angles to the screen. For this reason, as much information as possible on the characteristics of fog and rain bearing winds were obtained from the local inhabitants prior to the erection of the fog collector. This was supplemented with indirect evidence of the direction of moisture bearing winds, such as the position of lichen and moss growth on trees and walls. This information was used to determine the optimal orientation of the fog collector.

The data logger records were analysed to determine the directions of the winds prevailing at the school. These are illustrated by means of Table 7 and the straw diagram presented as Figure 19.

**TABLE 7 PREVAILING WIND DIRECTIONS AT THE TSHANOWA JP SCHOOL (Oct 1999 - Jan 2000)**

| Bearing | Percentage occurrence |
|---|---|
| 0-45 | 7,2 |
| 45 -90 | 12,1 |
| 90 - 135 | 36,2 |
| 135 - 180 | 27,3 |
| 180 - 225 | 1,4 |
| 225 - 270 | 1,3 |
| 270 - 315 | 5,2 |
| 315 - 360 | 9,3 |

The straw diagram shows hourly wind speed and direction for the period 15/10/99 to 1/1/2000. The length of each "straw" reflects the wind speed while the wind direction is indicated by the direction in which the straw leans. Straws drawn below the horizontal line thus indicate winds from the south whereas those drawn above the line represent winds originating from the north. The upper part of the diagram gives an indication of when wet events occurred.

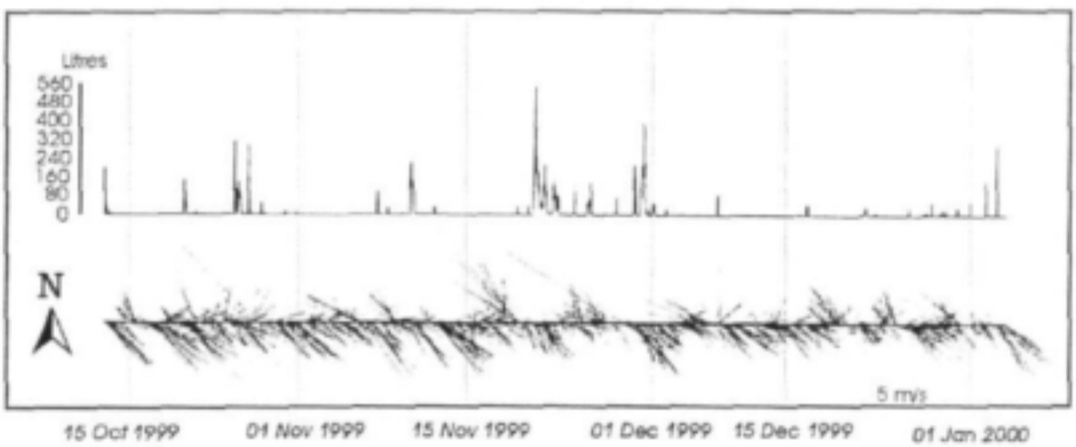
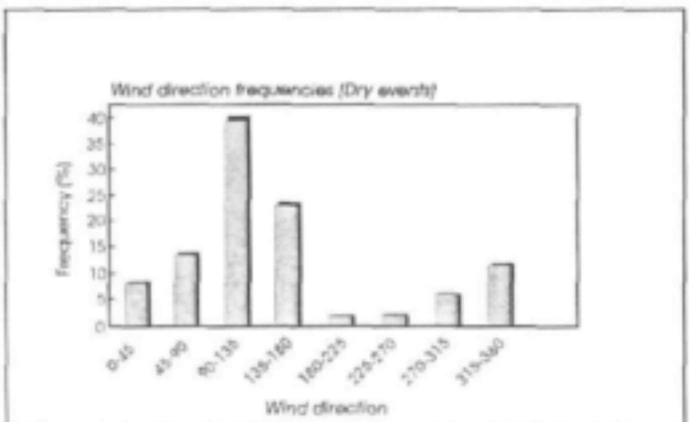



**Fig 19 Straw diagram showing the direction of prevailing winds during the period 15 Oct 1999 - 1 Jan 2000**

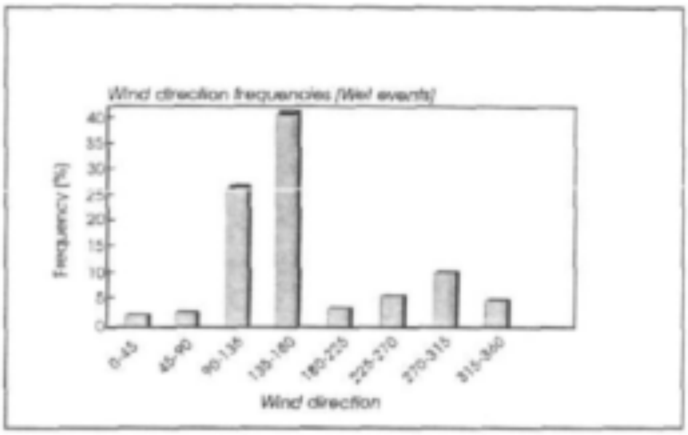
It is clear that the winds blow mainly from the south easterly quadrant: 36% from the ESE (90 - 135$^0$) and 27% from SSE (135 - 180$^0$). Interestingly, the dominant wind directions vary during wet and dry conditions (Fig. 20a and b). During dry conditions, winds are variable with about 38% originating from the ESE, about 20% from the SSE, lower proportions from the northern quadrant and virtually no winds from the south westerly quadrant. Rain-bearing winds, however, blow mainly from the south south east (135 -180$^0$) while the ESE winds are slightly less important. Some rainfall occurs when winds blow from the north. The latter is probably associated with the development of convective clouds that tend to build up ahead of a cold front. Little or no rainfall is collected from winds originating from any other direction. Winds from the north, south and west were consistently associated with low yields. It was also found that a slight deviation of only one or two degrees beyond the optimal direction resulted in a marked decrease in deposition. This emphasizes the importance of obtaining accurate information on the characteristics of fog bearing winds prior to erecting a fog water collection system.

Fog water collection is even more sensitive to wind direction than rain water collection, as indicated by figure 20c. As with rainfall, the major fog bearing winds originate from the south easterly quadrant. Winds from the other directions are of considerably less importance with respect to fog water harvesting.

(a)



(b)




(c)

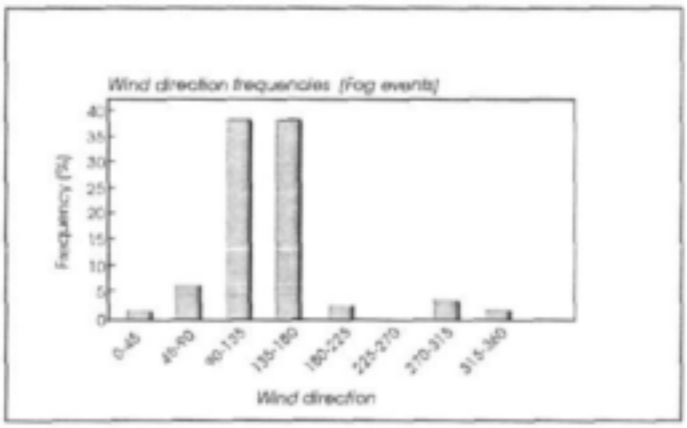
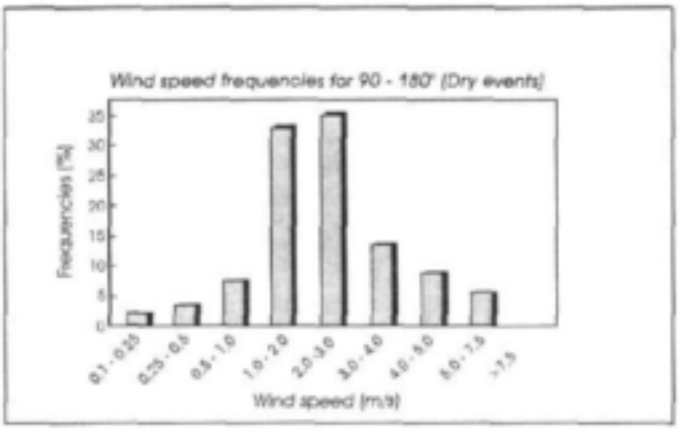



**Fig 20 Direction of prevailing winds during (a) dry conditions (b) wet conditions and (c) fog episodes.**

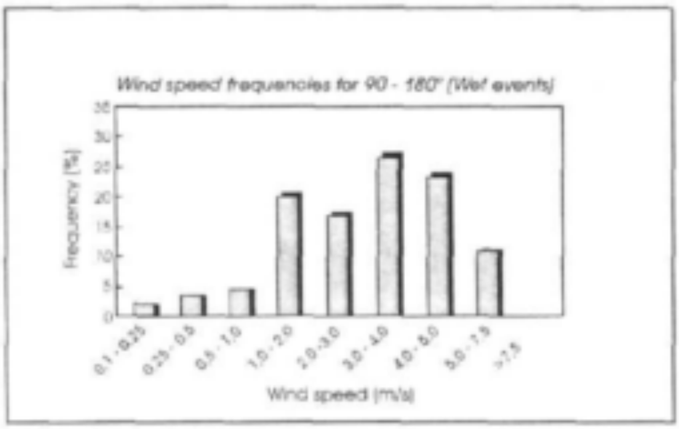
#### *4.6.1.2 Wind speed*

Wind speeds at the school are generally light, varying between zero and around 7,5 m/s (Fig. 21a). Water collection is usually associated with the stronger winds (Figs. 21 b & c). In fact, little or no water is collected with wind speeds of less than 1 m/s. Contrary to expectation, no statistically significant relationship was found between hourly wind speeds and water yields - irrespective of whether total yield were used or only rainfall or fog water yields. These results are probably (in part) due to the fact that wind speed and direction are recorded only once per hour. Wind speed is extremely variable and it is unlikely that the records accurately reflect the wind speeds during the preceding hour. The results are also in contradiction with those obtained from research done at Birdhouse near Grabouw in the Western Cape, when it was found that yields peaked with wind speeds of around 2,6 m/s in summer and 2,2 m/s in winter, decreasing with both increasing and decreasing wind speed (van Wyk 1991). The initial low deposition rates were ascribed to low volumes of moist air passing through the gauze while evaporation and splash were thought to account for the decrease at higher wind speeds. The slight difference between summer and winter peak speeds may have been due to the difference in moisture content of the air in the two seasons. Although not strictly comparable, Cereceda and Schemenauer (1993) found that a wind speed of 6 m/s was optimum for fog water collection at El Tofo in Chile. The difference in water content of coastal fog vs cloud probably accounts for the discrepancies between Birdhouse and El Tofo.

(a)




(b)



(c)

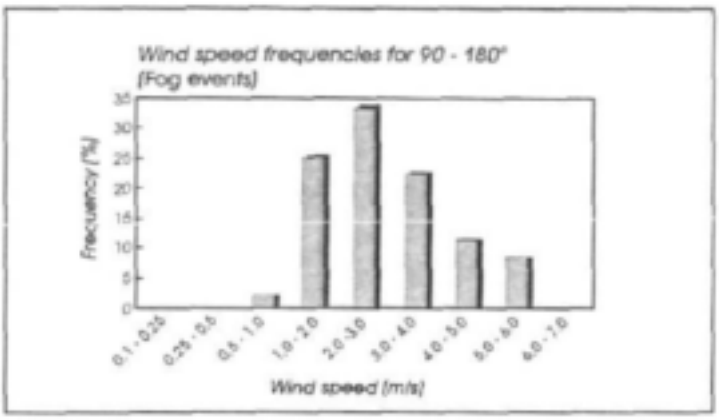



**Fig. 21 Wind speeds during (a)dry, (b) wet and (c) foggy conditions**

### 4.6.2 Water collection rates vs rainfall

The coincidence of high yields with periods of heavy rainfall (section 4.5.3) suggests that there may be a linear relationship between the variables. Comparison of *hourly* rainfall values and yields appeared not to confirm this supposition. The correlation (Pearson's Product Moment) between hourly water yields and rainfall during the October to December 1999 period, for example, gave a value of only 0,2 (Fig. 22). It appears that the water yield associated with very low rain gauge readings is extremely variable. This variability could be caused by a number of factors such as variable wind speed and direction. A further complication could arise from the difference in size and sensitivity of the measuring devices. The tipping bucket tips when 1,1 litres of water has drained into it whereas the rain gauge requires only 0,1 mm before recording a tip. It is thus possible that water deposited on the screen at or near the end of one hour, was only recorded at the beginning of the next while the rain gauge would have recorded the rainfall during the relevant hour. Another factor to be taken into account is the possibility that very low rain gauge values were, in fact, due to fog and not rainfall. It was therefore decided to use a threshold value of 0,2 mm/hr to distinguish rainfall from fog precipitation.

Upon re-analysing the data set using rainfall values exceeding 0,2 mm, a correlation coefficient of 0,66 was obtained.

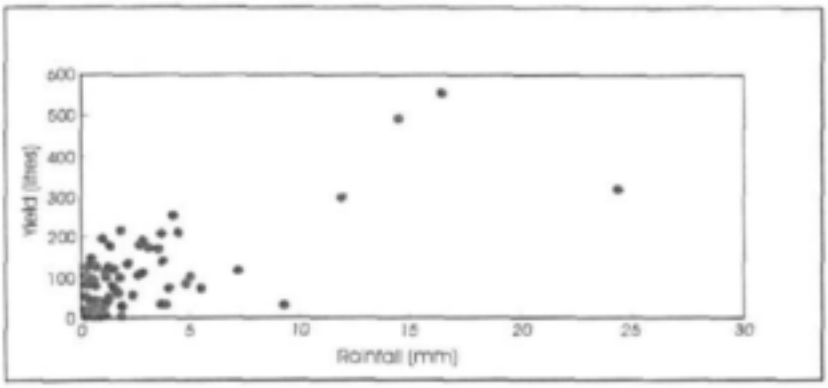



**Fig 22 Relationship between hourly rainfall and water collection rates (Oct - Dec 1999)**

Comparisons on a *daily* scale also showed a positive linear relationship between rainfall and water harvested. Figure 23 indicates this relationship during the October to December 1999 period r = 0,79; sign. at the a = 0,01 level).

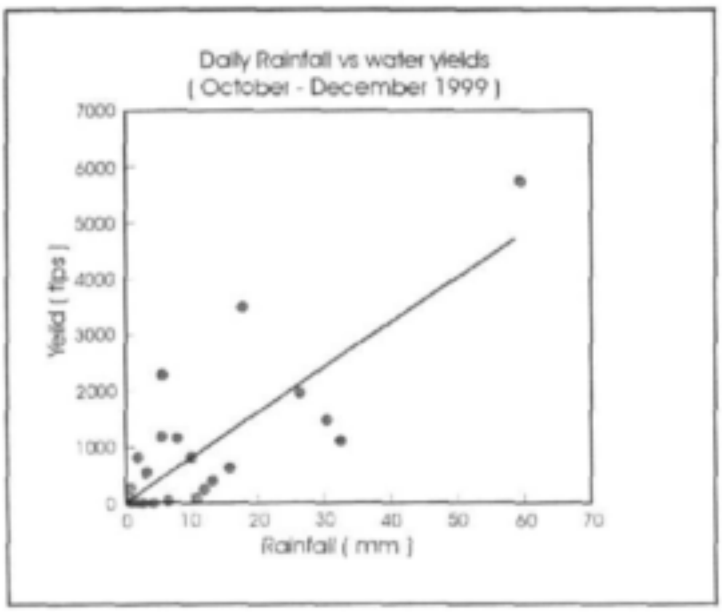



**Fig 23 Relationship between daily rainfall and water collection rates (Oct - Dec 1999)**

### 4.7 WATER QUALITY

Water quality is of vital importance when supplying children with drinking water. As previously noted, an estimated five out of every hundred children die from water related diseases. Since the water collected was to be used for drinking purposes, steps had to be taken to ensure its potability. Since the quality of the water was not initially known, it was decided to add a small piece of dry chlorine to the water in the tanks so as to ensure that it would not cause ill health. While effectively destroying all the microbes, it also served to increase the concentration of sodium, calcium and chloride ions (column 2 of Table 8). Fortunately, the levels of these ions were within allowable limits and hence did not constitute a health threat. However, the water was found to be acidic and corrosive. This caused it to be classified as Class II - "Marginal water quality."

Since the chlorinated tank water did not reflect the quality of the water collected by the fog collectors, an U-shaped tube with a tap was installed just before the inlet into the first storage tank. It was assumed that samples taken from the U-tube would give an accurate indication of the water quality of the fog/cloud water.

In addition, in an attempt to remedy the low pH, a layer of marble chips was placed inside the sand filter. This appeared to achieve the desired effect - as shown in column 3 of Table 8. The high iron concentration in the second sample was due to rust from a metal cover of the sand filter. The cover was subsequently replaced with a plastic one. The presence of iron in the water also resulted in a class II water quality grading of the sample collected on 29/10/99.

Column four on Table 8 gives the results of the latest chemical and microbial analysis and adequately reflects the quality of the water collected on the fog water collector. No substances were added either to the contents of the tank or to the sand filter but the former probably contains some remnants of chlorine which had been added to the tank by mistake during the winter months (which explains the presence of magnesium and chloride ions). It is obvious that the water is very pure - having very low concentrations of sulphate, calcium, sodium and potassium ions. No iron, manganese or nitrates were present. As expected, no disease-forming bacteria were present in the water. The few heterotrophic bacteria present in the sample merely reflect those occurring naturally in the atmosphere. Hence, according to the guidelines laid down for the assessment of the quality of domestic water supplies, by the South African Department of Water Affairs and Forestry, the Department of Health and the WRC, the water was classified as Class 0: Ideal water quality.

**TABLE 8 CHEMICAL ANALYSES OF FOG WATER, TSHANOWA JP SCHOOL 1999 - 2001.**

| ANALYSIS | SAMPLE | | | | |
|---|---|---|---|---|---|
| | 16.04.99 | 29.10.99 | 28.08.01 | SPRING | DAM |
| pH | 4.46 | 5.97 | 5.29 | 5.17 | 5.29 |
| Conductivity mS/m | 8.1 | 3.7 | 5.4 | 91.1 | 176 |
| TDS mg/l | 51 | 16 | 37 | 571 | 901 |
| Sulphate mg/l | 3 | 1.5 | 2.9 | 50.5 | 79 |
| Nitrate : N mg/l | 0 | 0 | 0 | 7.58 | 2.21 |
| Chloride mg/l | 18.6 | 3 | 8.9 | 230.5 | 470.6 |
| Fluoride mg/l | 0.01 | 0.05 | 0.01 | 0 | 0.08 |
| P-Alkalinity | 0 | 0 | 0 | 0 | 0 |
| M-Alkalinity | 7.8 | 7.8 | 12.6 | 11.2 | 201.2 |
| Carbonate | 0 | 0 | 0 | 0 | 0 |
| Bicarbonate | 9.5 | 9.5 | 15.4 | 13.6 | 245.3 |
| Calcium mg/l | 6.4 | 2.6 | 2.7 | 16 | 64.4 |
| Magnesium mg/l | 0.4 | 0.7 | 3.1 | 13.8 | 31.7 |
| Sodium mg/l | 9.1 | 1 | 3.4 | 142.6 | 282.8 |
| Potassium mg/l | 0.22 | 0.16 | 1.09 | 6.91 | 12.39 |
| Iron mg/l | 0 | 0.25 | 0 | 0 | 0.259 |
| Manganese mg/l | 0 | 0 | 0 | 0 | 0.61 |
| Sum Cations | 0.75 | 0.25 | 0.56 | 8.31 | 18.48 |
| Sum Anions | 0.74 | 0.27 | 0.57 | 8.32 | 19.1 |

| ANALYSIS | 16.04.99 | 28.08.01 | SPRING |
|---|---|---|---|
| Total Viable Organisms /ml | 4 | 6 | 169 |
| Total Coliform Organisms /100ml | <1 | <1 | 62 |
| Faecal Coliform organisms /100ml | <1 | <1 | <1 |

The last two columns indicate the quality of the spring and dam water. Women congregate around the spring to wash their clothes. Water for drinking purposes is also collected from it. The high levels of sodium and chlorine ions clearly reflect contamination by soap. Water was also collected from the dam in the vicinity of the bridge, where people go to collect water for domestic purposes. During the dry season, when the spring dries up, this is also the main site for collecting drinking water. Unfortunately, no bacterial analysis was performed on the dam water. Both samples are clearly contaminated and were classified as Class II - Marginal water quality.

The quality of the water collected by the fog collector is clearly a vast improvement on that previously used for domestic purposes.

## 4.8 COST OF WATER

It is difficult to gauge the cost of this method of water collection, if not compared to some standard. It was therefore decided to use the price of water supplied to residents in Pretoria for comparison purposes.

When calculating the price of reticulated water in cities, it is not the cost of the water *per se* which taken into account, but the cost of the infrastructure needed to collect and treat the water and to distribute it to the consumer, as well as running costs. Clearly, not only must these costs be recovered but such an enterprise should be profitable. Although the greatest cost is incurred before the water reaches the consumer, it would not be feasible to attempt to recover the costs over a short period of time such as one or two years. Rand Water, which supplies water to Johannesburg and Pretoria, uses a 50-year period to recover the costs of major plants and pipes (Personal communication: Mr Hans Ott, Rand Water).

The cost of 'fog' water is thus also calculated for a 50-year period.

It has been shown that a fog water collection system (including the tank) cost a total of about R11 000 in 2001. During a 50-year period, the screen should be the only part of the system that would require to be replaced. As the shade cloth is guaranteed for a period of 10 to 15 years, it can be assumed that the screen will have to be replaced three times during a fifty-year period. With inflation, the total cost should not exceed R14 000.

With an average yield of 2,85 litre/m$^2$/day, the total volume of water collected by the 72 m$^2$ collector over a 50-year period is:

$$2,85 \times 72 \times 365 \times 50 = 3\ 744\ 900 \text{ litres.}$$

At a cost of R14 000, this amounts to 0,37c/litre or R3,70/kl.

The Pretoria city council supplies the first 6 000 litres of water free of charge. Thereafter it costs R4,28/kl. (Incl. 14% GST).

*It is clear that the price of fog water at the Soutpansberg site compares favourably with that of* municipal water in Pretoria. This cost is probably considerably less in view of the fact that the volume of water actually collected during the study period, exceeds the recorded values.

# CHAPTER 5
# CAPACITY BUILDING AND DISSEMINATION OF INFORMATION

In the previous section, it was established that fog water collection is economically viable. However, if information on this method of water collection is not disseminated, the effort involved in implementing the system successfully and the money spent during the project would, to a large extent, be wasted. It is also important that the people involved in the project as well as the recipient communities should be capacitated - either in terms of research and skills training or in terms utilizing the knowledge gained, so that as many people as possible are empowered to make use of the technology. In order to maximize the benefits resulting from fog water collection, two further aspects thus need attention. These are: (a) capacity building and (b) dissemination of information. These were achieved by direct training, inclusion of material into various educational programmes and publicizing the project as widely as possible.

## 5.1 TRAINING AND CAPACITY BUILDING

Capacity building takes place when people are empowered to use information in order to benefit themselves and others. This is brought about by education and training. In the course of the project, this was achieved in a number of ways, namely, by:

(a) involving members of the community in the implementation of the project
(b) teaching the children at the Tshanowa JP school about the project
(c) incorporating information about fog water harvesting into the curriculum of higher education courses
(d) informing decision-makers about the relevant technique.

### 5.1.1 Community involvement

The community was directly involved in the project in the following ways:

- A number of local community members were hired to assist with the erection of the fog collector and the water tanks.
- The principal and teachers were intimately involved in collecting data and maintenance and repair.

#### 5.1.2 The teaching programme: The 'Fog Catchers' project

Ms L Dyson, the lecturer in charge of the community outreach programme of the Department of Meteorology, University of Pretoria (UP), suggested that a community training programme be conducted at the Tshanowa JP school. This was extremely opportune since it was felt that, by teaching the children about the project the adults of the community would also be reached.

Details of the trip, the activities at the Soutpansberg site, and the report-back to the students and staff of various departments at the UP (eg. Departments of Geography, Geoinformatics and Meteorology, Geology, Civil Engineering), the Agricultural Research Council and the South African Weather Service staff are contained in the "*Fog Catchers*" report included as Appendix II.

#### 5.1.3 Further training and capacity building

In addition to the above, a number of other initiatives were embarked on to involve people in the project and to supply information on the techniques used in the project to tap this unconventional source of water.

- Students from the University of the North assisted with the analysis of the results while students from the University of Pretoria assisted with repairs.

- A competition was launched to involve students - preferably engineering students - in the project. One of the problems initially foreseen was that relatively low water yields would be obtained due to low wind velocities during fog events. It was therefore decided to give a prize for anyone who could design a more efficient fog collector. During 1999, forms were sent to the HODs of the 21 Engineering Faculties at tertiary institutions in South Africa. Unfortunately, there was no response. During 2000, the exercise was repeated, but this time, the Directors of Research at the 28 tertiary institutions in the country were targeted. Only two people responded, but neither submitted a design.

- The National Community Water and Sanitation Training Institute was approached to include information on fog water harvesting in their modules on water resources. They agreed to incorporate information on the FWCS in the new B.Sc programme on Water and Sanitation, which was introduced at the University of the North in 2002. The Department of Geography is responsible for teaching the "South African Water Resources" course at first year level. The material which was submitted to them, has been incorporated into the course. The first intake of students numbered 250 students.

- Information on the fog project has been included in UNISA's GGH301 (3rd year) and the Hydrogeography honours lecture notes.

A DIY training brochure describing how a fog water collection system can be erected, was drawn up by Prof. van Heerden. It is envisaged that the brochure will be used to train other interested communities. It will be distributed to the Department of Water Affairs and Forestry, the National Community Water and Sanitation Training Institute and the Water Research Commission.

- Mr Molemisi, of the Community Water division of the Department of Water Affairs in Louis Trichardt was invited to visit the construction at the experimental site. He is in a position to inform and train other communities of this source of water and how to tap it. Unfortunately, due to bad weather and other circumstances beyond our control, this meeting has not yet taken place. Arrangements have been made to have discussions at the Tshanowa school at a later date.

- Mr Tim Madgewick of Umgeni Water and the Department of Water Affairs and Forestry's Water Resource Management section will be approached to disseminate information to all workers concerned with water resource management. This could result in capacity building of communities located throughout South Africa.

Table 9 gives a summary of the number of staff and students who were directly involved in aspects of training and capacity building or who recipients thereof.

**TABLE 9 PARTICIPANTS INVOLVED IN THE FOG WATER PROJECT**

| PARTICIPANTS, CONTACTS % RECIPIENTS | | NUMBER |
|---|---|---|
| UNISA | Project leader | 1 |
| University of the North | Lecturers: (Mr Ramudzuli, Mrs Burger) | 2 |
| | students | 4 |
| University of Pretoria | Lecturers: (Prof. van Heerden, Dr Rautenbach, Prof van Rensburg, Ms Dyson | 4 |
| | Students | 13 |
| Tshanowa JP school | Community: Assistants | 2 |
| | School: teachers | 3 |

## 5.2. DISSEMINATION OF INFORMATION

During preparatory discussions with the principal, Mr Netshifhefhe, and teachers of the Tshanowa School; the traditional leader, Mr Vondo; and the Director of Education of the Limpopo Province, detailed explanations were given of the mechanisms involved in cloud water collection, the results obtained in the preceding study (WRC K5/671) and the Chilean fog water collection project, the aims and objectives of this project, the methodology to be used and the potential benefits of project implementation.

Initially, all the water was used exclusively by the school. Strict control was kept of the amount of water used and the children were only allowed to fill their containers from the tank twice a day. With the addition of the second and third tanks, however, sufficient water is available for use by the whole community. The taps are locked and the key kept by the principal to ensure that water is not wasted. Since the size of the community varies over time, it is not possible to obtain accurate figures of the number of people using the water. Nevertheless, at least 50 members of the community make use of the water on a regular basis. They were informed of the project by the teachers and principal of the Tshanowa school. In addition, 128 school children were involved in the 'Fog Catcher' project. It is assumed that they would also inform their parents and other community members of the project.

Great interest was generated by the construction and news of the project travelled to some of the remotest parts of the province. This facilitated the purchasing and delivery of the Saligna poles and the water tanks and led to a number of newspaper articles and radio and TV interviews.

Forty people attended the 'Fog Catcher' report-back session at the University of Pretoria. A fully illustrated report of this project is available on the web at:
http://www.up.za/academic/geol/meteo/fogproject.htm.

Information on the fog water project was further disseminated by means of publications in popular and scientific journals and at conferences.

A list of publications, conferences and media interviews are listed below.

#### 5.2.1 Publications:

***Popular:***

Olivier J 1998: Fog water harvesting in South Africa. *Strategic Insights, Environmental Issues*, **3**(2). Institute of Futures Research, University of Stellenbosch, Bellville.

Engineering News: "SA can now drink its fog" March 26 - April 1, 1999, Vol. 19 (11), pp 1, 6.

Farmers Weekly: "Water out of thin air." Nov 27, 2001, pp 22-24.

Scientific America' web page: "Fog for a thirsty planet." March 19, 2001. (http://www.sciam.com/explorations/2001/03190 fog/

***Scientific:***

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### 5.2.3 Radio and TV

Three TV interviews (one was Canadian) and two radio interviews (1 Canadian, 1 South African) were given where this project was described. The project appeared as an item on SATV 1's local news on three different occasions. Another video was shown as part of a popular science program for children on TV2.

## 5.3 SUMMARY

A serious attempt was made to use this project as a means to capacitate people through education, training and the dissemination of information. In addition to the list of people involved directly with the project, a wide audience of many hundreds of people must have been reached by the articles, interviews and conferences.

# CHAPTER 6
# DISCUSSION AND CONCLUSIONS

## 6.1 SUMMARY

The aim of the project was to design, erect and operate a small fog water collection system (FWCS) to provide potable water to a small rural community in the mountainous parts of the Limpopo Province of South Africa.

Other objectives were:

- To research the meteorological and geographical conditions associated with fog occurrence and water yields at the site
- To determine the most efficient design and operational procedures
- To train the local community members and staff in the operation and maintenance of the system and to develop research capacity

The site selected for implementation of the fog water collection system was located at the Tshanowa Junior Primary school in Venda. The school is located at an altitude of 1 004 m on the easternmost promontory of the Soutpansberg and is therefore exposed to fog and rain bearing winds. It is also accessible by means of a road; is secure, it is immediately adjacent to a water-poor community and the community members were eager to participate in the project since their closest water source was located more than 2 km away. All the criteria needed for a suitable fog water collection site are thus fulfilled.

After obtaining permission from the local educational authorities and the traditional leader, the FWCS was designed by Profs van Heerden and van Rensburg and erected by team members from the University of Pretoria, assisted by members of the community. The system consisted of (a) a fog water collector comprising two 36m$^2$ of shade cloth nets (forming the collecting screen), attached to three wooden poles and with a gutter suspended at the lower end. The entire structure was anchored by means of a system of galvanized steel cables (b) a sand filter to remove solid impurities and (c) three 10 000 litre storage tanks. A tipping bucket was installed to measure the volume of rain and fog water collected. Data was captured on a data logger. A weather station was also erected to monitor rainfall and wind data.

Research was conducted on the factors affecting the incidence of wet events and the characteristics of these events. Analyses were also performed to determine the size of the water yield and the factors affecting it. Attention was thus given to the synoptic situation and circulation systems prevailing during wet events and the contribution of rainfall and fog to the total water yields. Other characteristics of wet events were also studied, such as the diurnal incidence patterns and their duration. Chemical and biological analyses were performed on the collected water as well as on the water from the local spring and dam. The results of the above analyses were presented and discussed in chapter 4 of this report.

Water collection occurred during either fog or rainfall events. While rainfall occurred at any time of the day, fog was mostly confined to the cooler hours. The moisture needed for the formation of fog and rain originates over from the Indian Ocean and is transported inland by means of onshore breezes. Orographic lifting takes place and fog or clouds are formed, depending upon the stability of the air. The synoptic systems causing conditions conducive to wet events at the experimental site were analysed by means of synoptic charts. As expected, important controls were the tropical easterly waves and the circulation around the Indian Ocean anticyclone. The South Atlantic anticyclone ridging to the south of the subcontinent was also associated with wet conditions. Less often, a cold front passes over the region, bringing rain. The presence of a trough of low pressure over the interior was also shown to create conditions conducive to the formation of rain and fog. These systems were mostly associated with winds originating from the south east. Wind directions during wet events thus varied markedly from those blowing during dry periods.

Many of the problems encountered were associated with the mechanical malfunctioning of the tipping bucket or the inability of the electronic system to capture the data accurately. The volumes of water collected by the screen were too small for conventional hydrological measuring devices, too large for meteorological instruments, and operate at too low pressures for municipal water measuring devises. This resulted in large gaps in the data record and an undercount of the volume of water collected. Unfortunately, the project funding was insufficient to develop proper measuring equipment.

During the period March 1999 to April 2001, a mean daily water collection rate of 2,85 litres of water per square meter of collecting surface was recorded. Maximum yields exceeded 3 800 litres per day. The actual volume of water collected was undoubtedly considerably higher than that recorded, since a number of problems were encountered with the recording of the data.

The quality of the water is excellent, and is a considerable improvement on that previously used by the community. Despite these relatively low volumes, the cost of the water compares favourably to that being paid in Pretoria (R3,70/kl compared to Pretoria's R4,20/kl).

Although the contribution of fog to the total volume of water collected is underestimated at around 25%, a considerable amount of the water originated from rainfall. Other unconventional methods of obtaining water, such as rainfall harvesting from roof runoff, would thus be appropriate for the area.

In addition to providing water to the school and local inhabitants, the project also included a training and capacity building component. This is described in chapter 5 of the report. One member of the community was trained in the construction and maintenance of the FWCS. Students from the University of the North and the University of Pretoria were involved in the project. Staff and students from the University of the North visited the site and assisted with some of the analyses. The University of Pretoria students had the opportunity to do practical, community-orientated work during the 'Cloud Catcher' exercise. This was an invaluable experience because they had to plan the trip, obtain additional funding, devise lesson plans and a reward system as well as organizing and giving a report-back session to staff of that and other institutions. Clearly, this capacity building exercise did not just serve to increase their knowledge of the subjects studied, but also improved their social and organizational skills.

In addition, the children from the Tshanowa JP school obtained knowledge of various meteorological factors, with special emphasis on the formation and harvesting of fog. This was achieved in a novel and enjoyable manner - and will hopefully inspire some to study further in this field.

The research team was multidisciplinary, comprising geographers, meteorologists, environmental managers, civil engineers and climatologists. Contact was also made with agriculturalists and economists. Three universities were involved in the project, namely, UNISA, University of the North (a historically disadvantaged university) and the University of Pretoria. In addition, a private consulting service, Metarg, was also involved. The project was thus instrumental in bringing together people from diverse academic, ethnic and social backgrounds - thereby fostering respect and cooperation.

The outputs of the project included a prototype fog water collection system; potable water; capacity training and training; new knowledge concerning the use of unconventional water sources in high elevation regions; publications, reports, a web page and a data base for the Tshanowa school site. The latter contains data logger records of hourly water collection rates, rainfall, wind speed and wind direction and spans the March 1999 - April 2001 period. The data have been archived on a CD-ROM and will be available from the WRC.

## 6.2 RECOMMENDATIONS: FUTURE SCENARIO

Before the implementation of this project, the school and surrounding communities were reliant on extremely limited amounts of water. Obviously, no development could take place under these conditions. However, this project has demonstrated that fog water collection is a viable domestic water source at Vondo in the Soutpansberg. If more funds can be obtained, a series of water tanks could be installed and excess water, not required for domestic purposes, could be used to establish community gardens. This would enhance the quality of life of the community to a considerable extent. With the provision of a dependable supply of water, commercial agricultural ventures might be attempted provided suitable crops can be identified. This would generate employment and income. In addition, once the demand for such a system increases, the community will be in a position to provide advice and expertise to potential users.

This technology has great potential for implementation elsewhere. The Tshanowa school site is not the most ideal with respect to elevation. Suitable sites for fog water collection occur in all the high elevation sites which are exposed to fog and rain bearing winds. Such sites can be found in other parts of the Soutpansberg, the entire length of the Drakensberg and Escarpment, the Cape mountains and along the west coast. According to experiments conducted previously, such sites could obtain yields of more than four times the volumes recorded at the school (Schutte, 1971; Olivier *et al*, 1999). The major constraint is accessibility since many high elevation sites cannot be reached by road.

In addition to being used by rural communities for domestic and agricultural purposes, the water can be used to:

- Supplement ponds and dams that are visited by wild or domesticated animals. In the Canary Islands, for instance, a series of small fog water collectors provides water for migrating birds.
- To promote tourism in an area. Dassen Island, for example, is a nature reserve with a unique population of tortoises and bird life. Unfortunately, there are no natural water sources. This limits tourism. Paradoxically, the Island is prone to frequent fog episodes - a ready source of potable water.
- Supply water at remote sites without conventional water supplies - such as overnight huts along hiking trails or at fire watch towers. This would reduce the cost of supplying water to these areas, would make them more comfortable, and raise their level of hygiene.
- Another possibility is to market this unique product.

If a donor is found for the agricultural aspects, private industry, local farmers and the Department of Agriculture could also become involved in such a project.

To bring about the widespread use of fog and rainfall harvesting, two actions are necessary, namely:

- A campaign to promote the concept and technology and
- To create a mechanism whereby more people can be trained in the erection and implementation of the water collecting system.

Although these results indicate that - in terms of both quality and magnitude of yield - fog water harvesting can be used successfully to supplement water supplies in the fog prone mountainous regions of the country, great care should be taken in the selection of sites for future projects. The orientation of the collector with regards to the direction of fog bearing winds must also be determined with great precision. Ideally, the site should be exposed to frequent fog bearing winds and, in the mountainous areas, have an elevation in excess of 1 000m.

In view of the advantages of this type of system and its application potential in many areas, it is clear that efforts should be made to make the technology available to as many people as possible. The Water Research Commission is in an ideal position to do this. It is therefore recommended that:

- The WRC actively promotes the use of fog and rainwater harvesting to relevant organizations, such as the Department of Water Affairs and Forestry, Umgeni Water, and other water authorities
- The WRC make recommendations to the proper authorities and funding agencies for bridging finance to maintain the system and
- The WRC supports the acquisition of funding for a larger project or the expansion of the project at the Soutpansberg site.

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# ADDENDUM 1

# BUILDING A FOG WATER COLLECTOR

by

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# BUILDING A FOG WATER COLLECTOR

## 1 INTRODUCTION

Fog is made up of very small water droplets kept in suspension by the smallest wind eddies. Fog water can be collected if the fog droplets collide with the individual shade net strands. This design follows the El Tofo (Chile) system but adapted to South African conditions.

## 2 BASIC ENVIRONMENTAL REQUIREMENTS

The fog collector works efficiently when fog moves through the collector at 5 to 30 km/hr. They must face the major fog bearing wind. Near the escarpment the collector should be placed at the head of the valley (or in the saddle between the peaks). Each collector requires a open area of at least 30m by 12m.

## 3 BASIC STRUCTURAL COMPONENTS

The South African design requires one roll of shade net (30%) (50m, width 3m), 3 treated gum poles (200mm x 150mm x 6m), 5mm galvanized cable, 110mm PVC pipe and fittings for gutters, 40mm black plastic pipe, treaded bolts (12mm and 16mm), 16mm nuts and washers, 12mm turnbuckles, high tension isolators, 12mm eye nuts and cable clamps.

### The Shade Net

The shade net must be cut into 6 lengths each 8,3m long and hand stitched, using plastic twine, to form two units of 8,3 x 9m each. The two net sections, double folded over its supporting cables, forms the two collector units each 9m wide x 4m high. A gutter and down pipes are attached below the net to collect the fog water.

### The Structure

#### *Poles*

The vertical poles are treated saligna poles 6m in length with the top end diameter at least 150mm. They are buried (in concrete) 500mm deep, at least 9,1m apart and are attached to two 5mm galvanized anchor cables. The poles experience vertical forces alone because the horizontal wind stress, imparted by wind, is transferred via the net support cables to the anchors. Figure 1 provides the basic design dimensions.

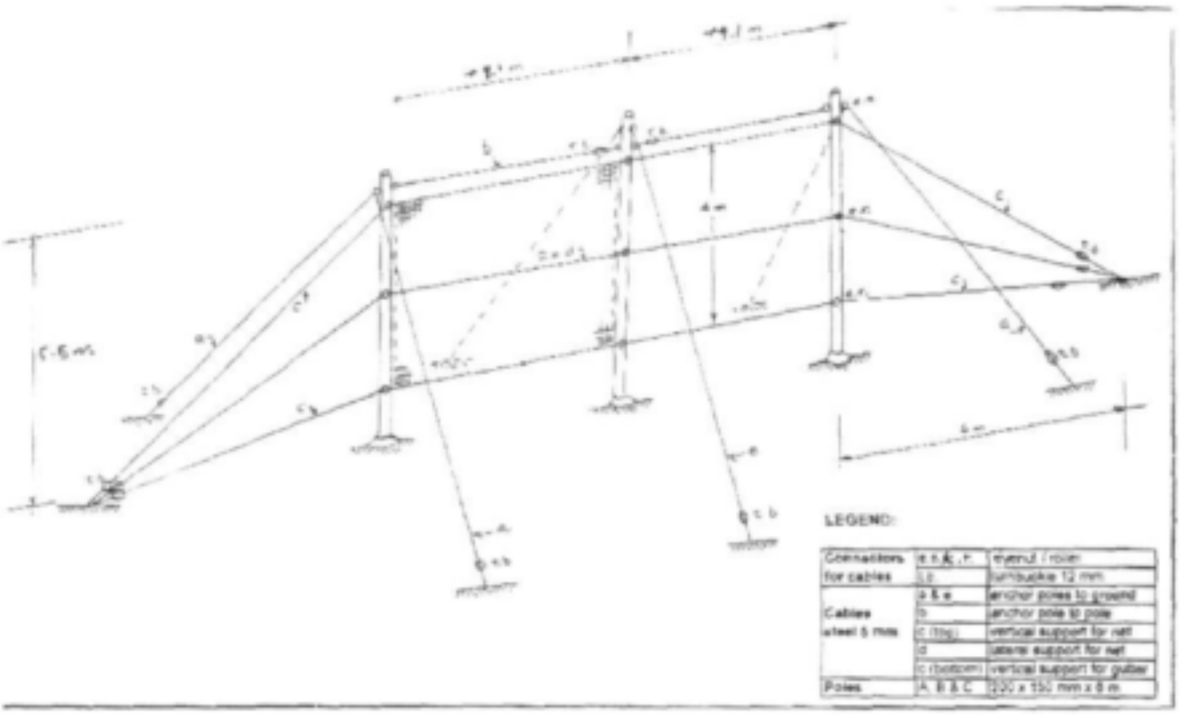



**Fig 1 (a) Basic structure and design of fog water collector (b) Photo of fully operational collector showing sand filter, measuring device and rain gauge**

***Anchors Cables***

Anchor cables fitted to the end poles are spaced 120° to the line of the poles, but the two anchor cables attached to the center poles are at right angles to this line. All the anchor cables are all attached to the poles by means of 12mm eye nuts, threaded bolts, nuts and washers. Apply locking nuts. All the cables are stressed by means 12mm (or larger) turnbuckles. The two center turnbuckles (top cable) are of the eye and hook type but the rest are eye and eye type. Use 5mm or 6mm cable clamps, two per fitting.

This design provide for three net supporting cables. The bottom support cable should slope at least 500mm over the 18m length of the net. The net support cables run around baked enamel rollers normally used as isolators on electricity power lines. These rollers have 16mm holes and are attached to the poles by 16mm threaded bolts nuts and washers. For the center cable use a double 5mm cable so that both sides of the net can run between them. If gale force winds occur frequently use two center cables spaced equidistant between the top and bottom support cables.

Figures 2a and b provide details of the cable fittings while figure 3 shows the anchor detail.

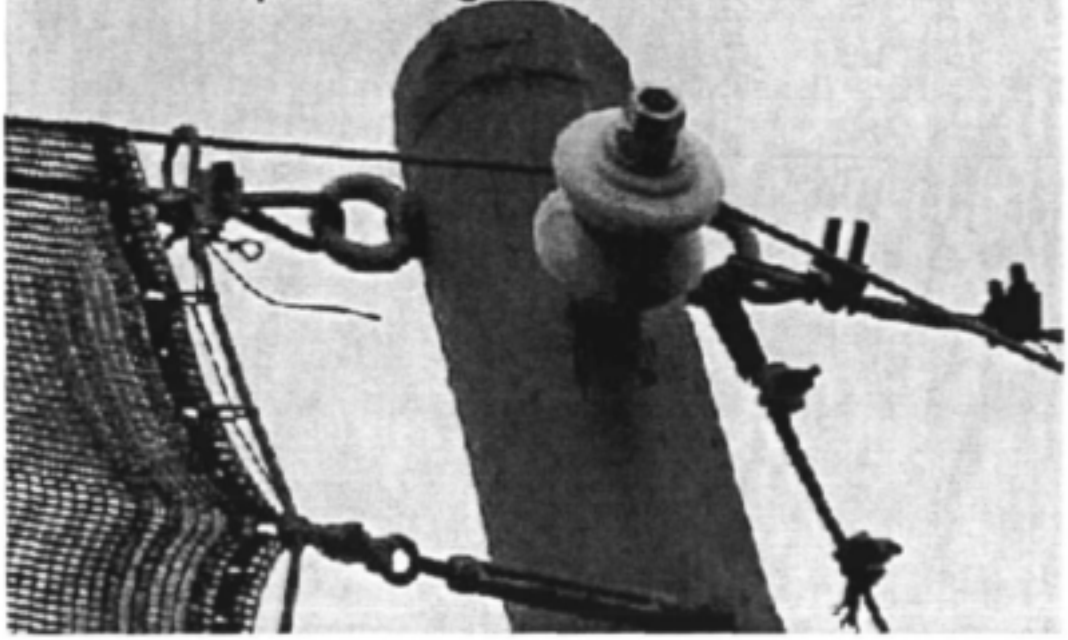
Figure 2: Anchor- and support cable pole fittings.

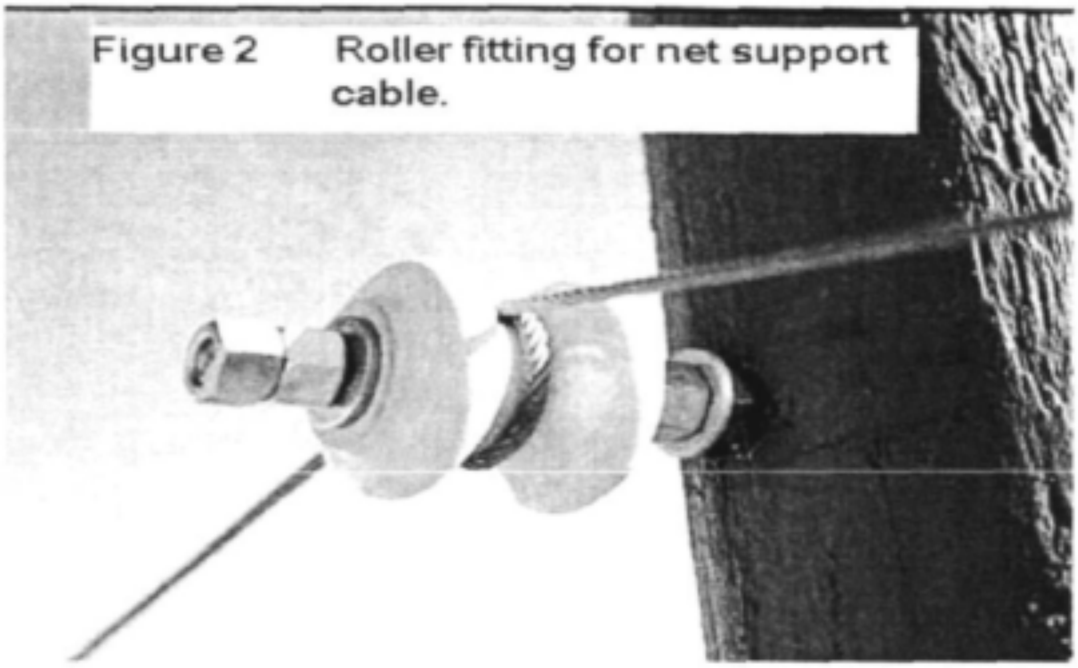


**Fig 2 (a) Anchor- and support cable pole fittings (b) Roller fitting for net support cable**

***Anchors***

For anchors use large rocks (minimum 500 x 750 mm) or other suitable material. Use one cable fitting for each anchor or support cable. Anchor rocks are concreted 1m deep using a dry cement mixture. Cut a small channel in the hole for the cables as depicted by figure 3.

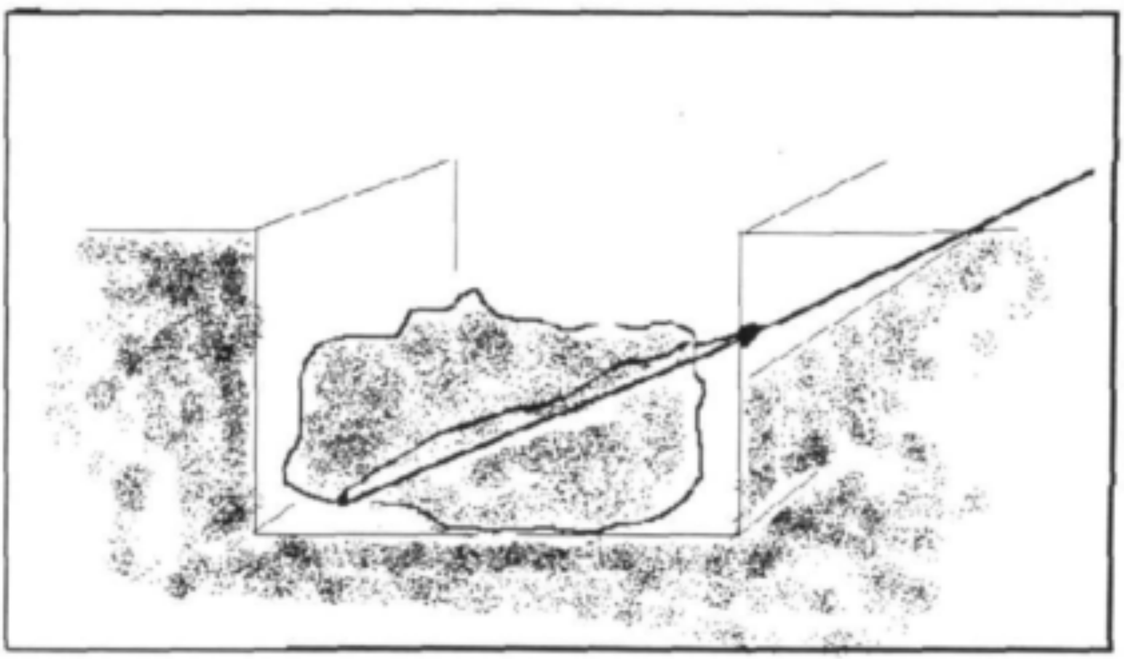

**Fig 3 Pole support anchor**

***Fastening the Net***

Each 8m long and 9m wide net is folded over the top supporting cable, threaded between the center cables and hangs on the outside of the bottom cable. The net is tied to the center cables using plastic twine. The bottom of the net is fastened to the cable using 20mm x 3mm flat aluminum bar cut to 1m lengths. The flat bars are paired and drilled with one line of 5mm holes, 100mm apart. The net ends are clamped between the aluminum flats using 5mm aluminum or stainless steel nuts and bolts (or 5mm aluminium pop rivets). Avoid vertical tensioning of the net. The four sides of the nets are tied to 5mm vertical cables each attached to the support cables and the poles. Figure 4 shows the net fastening and figure 5 details the gutter construction.

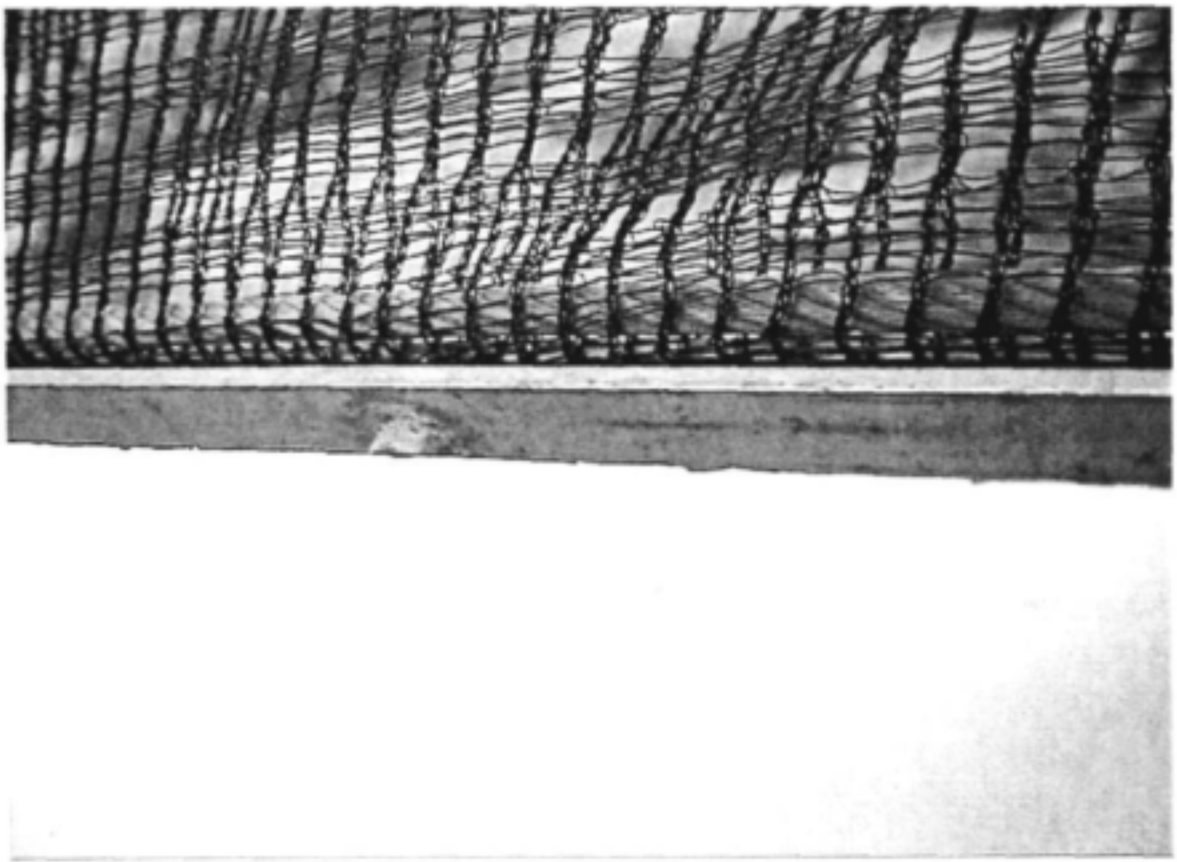

**Fig 4 Aluminium strips attaching lower end of net below the cable**

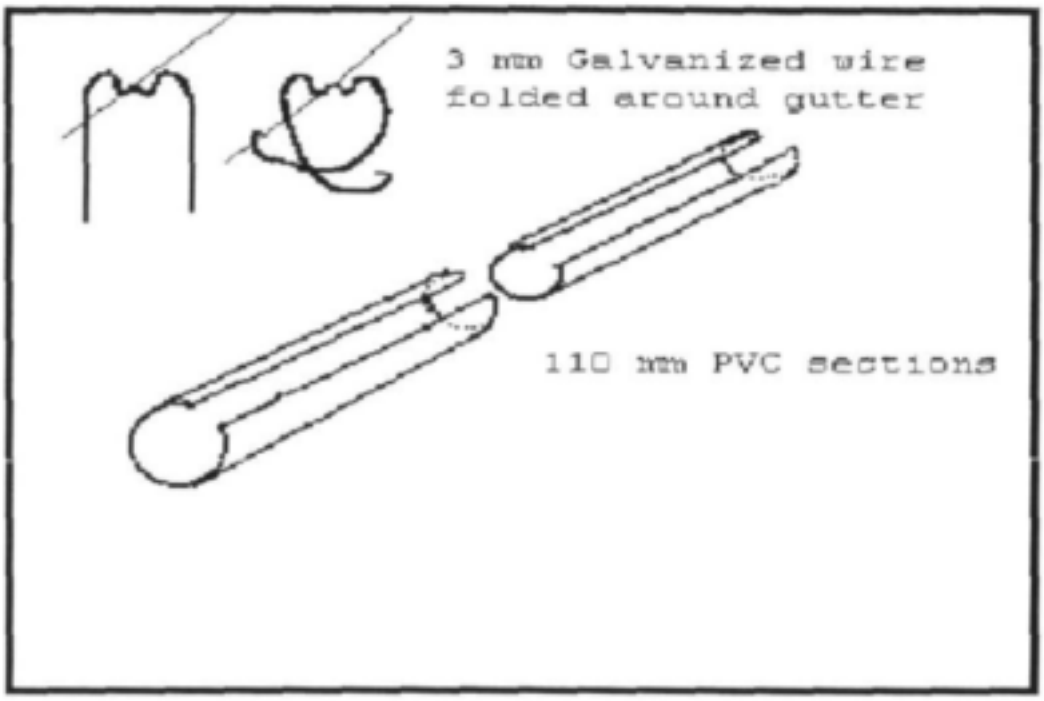


**Fig 5 Sketch of gutter and gutter hangers**

***Gutter and Down Pipe***

The gutter follows the Chilian design. Cut 110mm PVC pipe into 1,5 m lengths. A 70mm lengthwise section is cut from each 1,5 m section. The gutter can then be constructed by inserting the lower end of the pipe section to the top end of the next. This forms a gutter which bends horizontally with the bottom end of the net. Maintain a slope of at least 1:36 to ensure that the weight of the water does not cause the gutter to bend downwards and leak.

The gutter is fixed to the bottom supporting cable using 3mm galvanized wire fittings, two per gutter unit. These are bent as shown in the figure 5. They hang on to the bottom cable and are fitted to the gutter with the inner loops of the fixture below the height of the gutter. The upper end of the gutter is closed with a stop end and the lower end of each net fitted with a 110 to 40mm reducer. Each reducer is connected via a 90° bend to the 40mm down pipe.

Figure 6 shows how the gutters from the two sections of nets are joined together.

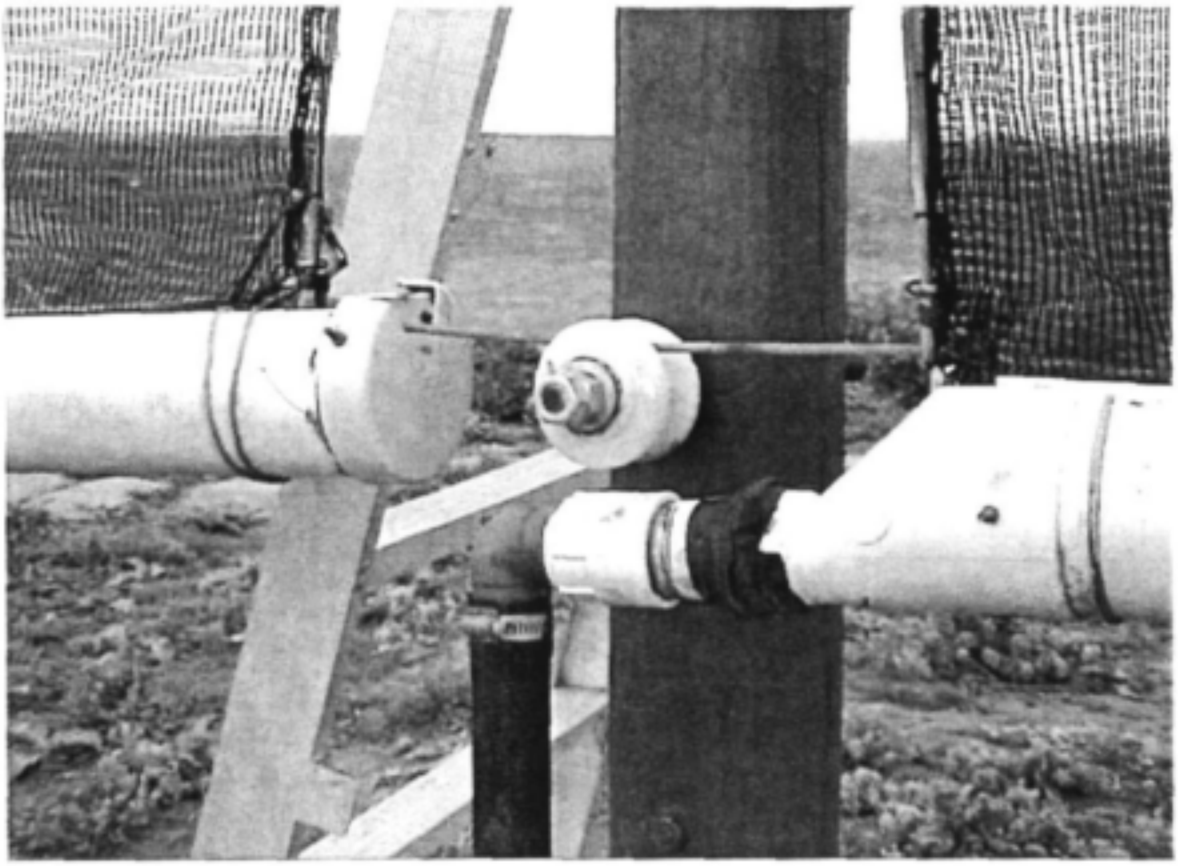

**Fig 6 Join between two sections of gutter**

*Sand Filter and Measuring Devices*

Use a conventional sand filter to trap dust and dirt collected on the net and gutters during dry periods. A simple sand filter is shown in figure 1(a). A few pieces of marble or dolomite in the sand filter will correct the fog water pH value. If a measuring device is required it should be fitted to the outlet of the sand filter.

*Water Storage*

The capacity of the storage facility will depend on the number of collectors employed, which depends on the community requirements. For a single collector one 10 kl plastic water tank per collector is adequate. Install the tank with its top below the output of the sand filter.

## CONSTRUCTION

### First Phase

Clear the terrain (35m x 15m) of all brush and trees. Mark the position of the poles, 9 + m apart. Ensure that the net will face the fog bearing wind. Dig the 500mm holes for the poles first maintaining separation of at least 9m. Mark and dig the anchors holes some 6 m from the pole positions. Fit and concrete the anchors as detailed above. Allow at least 3 days for the concrete to set before any force is applied to the anchors. Measure the check the 5mm cable lengths.

**Second Phase**

Measure, mark and drill the 12- and 16 mm holes for the anchor and net support cables in the top end poles, measuring from the top of the poles. (Structure the cable at 150mm and the supporting cable at 250mm from top). Fit the eye nuts and rollers following the diagram details. Use ordinary grease to prevent moisture penetration in the drilled holes. Attach the three top anchor cables to the two poles as well as two ropes so that each pole can be secured independently. Attach the hook and eye turnbuckle to the top anchor (pole to pole) cable.

Pull the pole vertical, fasten the two anchor cables lightly to the turnbuckles and tie the ropes to temporary anchors. Make sure that the eye nuts and rollers are perpendicular to the line of the net. Leave the end pole to center pole cable free. Fill and stamp the holes with a concrete mixture as for the anchors. Use a builders line to determine the position of the lower eye nut on the center pole. Fit the eye nuts and rollers to this pole. Erect the center pole using the anchor cables and ropes. Align this pole by aiming through the eye nuts. Fasten the pole to pole anchor cables. Fill and stamp the hole with the concrete mixture. With all the cables tight and the poles vertical the structure will be stable and the temporary ropes anchors can be removed. Cut off all excess cable.

Stamp the concrete around the poles down again to remove any gaps which may have developed during the final vertical positioning. Build small cement cones around the poles to divert water running down the poles from the pole foundations. The support cables are rolled around the rollers once and secured to the two end anchors. Use a turnbuckle each side. Paint the poles with a sealer. Take special care with the pole tops to prevent water penetration. Use the same material on the cement cones on the pole foundations.

**Third Phase**

Hanging the net it is best done under calm conditions, normally early morning. Using rope pull one of the 8,3m x 9,0m nets over the top cable, between the two center and let them hang to the outside of the bottom cable. Remove all folds in the net and tie lightly to the poles to prevent folding. Fit the aluminum flat bars below the bottom cable. The side of each the net is tied to a vertically hanging 5 mm cable which, in turn is tied lightly to the poles. Tie the net to the double center support cable. Cut the excess netting off using a sharp knife.

Fit the gutters to the bottom cable, one section at a time. Fit the end stops as well as the reducers and down pipes. Install the sand filter after linking the two 40 mm down pipes. The outlet of the sand filter can now be connected to the storage tank. If required a measuring device can be fitted between the sand filter and the storage tank.

## MAINTENANCE

The major hazard to the structure is fire. It is essential to maintain an adequate firebreak around the structure and to keep all vegetation cut short for at least 5 m outside the area bounded by the anchors. Gale force wind causes tears the net along the top cable and the side fittings. This can be avoided by keeping all the cables tight. When severe wind conditions occur it is better that the net gives way but the structure survives. Dust tends to collect in the gutter and should be washed out regularly. Monthly inspection and maintenance is recommended.

## LIST OF COMPONENTS

| Quantity | Part |
|---|---|
| 3 | 200 x 150 x 6m treated gum poles |
| 1 | 50m 30% shade cloth + lacing twine |
| 1 | 350m 5mm galvanised steel cable |
| 8 | Eye nuts |
| 9(12) | Rollers |
| 36/20 | 16/12mm washers |
| 72/20 | 16/12mm nuts |
| 100 | 6mm cable clamps |
| 18 | 6mm thimbles |
| 16 | 12mm turnbuckles |
| 200 | 25 x 5mm aluminum nuts and bolts (pop rivets) |
| 1 | 12mm x 1.5m galvanised threaded bolt |
| 1 | 16mm x 3m galvanized threaded bolt |
| 40 | 20 x 3mm x 1m aluminium flat bar |
| 5 | 6m 110mm PVC pipe |
| 2 | 110mm to 50mm reducer, stop ends etc |
| 2 | 40mm Poly pipe Class 3 |
| * | Fittings, clamps, bends reducers |
| 1 | 10 000l Storage tank |
| * | Various fittings to tank + 25mm tap |
| 15 | 50 kg Cement |
| 1 | 4.8m aluminium ladder |
| 1 | 10kg 3mm galvanised wire |
| * | Sundries |
| * | Unforeseen |
| 1 | 5 l Roof sealant and brushes |
| 5 | 15m x 7mm Ski rope |

## TOOLS REQUIRED

The entire construction can be done with hand tools. Top of the mountain sites are invariable without water. Supply at least 5 x 20 l water containers to transport water to the site.

## ACKNOWLEDGEMENTS

Prof B J van Rensburg, Dept. Civil Engineering, University of Pretoria (UP) for the basic structure design and specifications. The contribution and assistance of Pilar Cereceda and her colleagues are gratefully acknowledged, Mr Danie Jordaan, Civil Engineering Lab, UP for his contribution and Mr Jan Brink, Mechanical Engineering, UP for the construction of the sand filter and measuring device.

# ADDENDUM 2

# THE FOG CATCHERS PROJECT

by

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Pretoria

**Community Project**

## *Cloud Catchers*

From the 5th to the 7th of October 2001 seven meteorology students from the University of Pretoria accompanied by lecturer Liesl Dyson visited the Tshanowa junior primary school at Vondo in Venda. The aim of this visit was to demonstrate to the learners how the fog nets, which are located at the school, work and to give them some idea of the basic scientific principles, which underlie the formation of fog. One of the aims was to broaden the learners' knowledge of the important role that the harvesting of fog water has on the community's water supply, from the point of collection of fog, to the point where it is used. The meteorology students therefore decided to name this project "Cloud Catchers". This community-based project hoped to inform the learners about meteorology in everyday life and how they can benefit from it.

The project team:

| | |
|---|---|
| Liesl Dyson | Lecturer University of Pretoria |
| Lee-ann Clark | 3rd year Meteorology student |
| Lizelle Maritz | Meteorology honours student |
| Kwashaba Mariboni | 3rd year Meteorology student |
| Mary-Jane Bopape | 3rd year Meteorology student |
| Dirk Benadé | 2nd year Meteorology student |
| Annelise Du Piesanie | 2nd year Meteorology student |
| Makhathe Moletsane | 2nd year Meteorology student |

In order for this project to be a success, all the members of the project team had to contribute and work together as a group

The presentation at the primary school was done with visual aids and an uncomplicated experiment demonstrated the formation and collection of fog. By presenting the project visually, as well as by offering a hands-on demonstration, the project team aimed to capture the attention and imagination of the learners in a fun and educational manner.

*The Cloud Catcher team describes the development of fog on the eastern escarpment.*

Kwashaba Mariboni, one of the Meteorology students, grew up only a few kilometres away from the school. This was a great benefit to the success of the project as she could translate all the information into Venda. Kwashaba Mariboni's participation in the project was very important as her success as a student at the University of Pretoria could hopefully motivate the young learners to work hard and achieve similar success.

*Kwashaba Mariboni tells the learners to study hard while Mary Jane Bopape and Makhathe Moletsane look on*

By using diagrams and pictures it was explained to the learners how the Indian Ocean High feeds in moist air over the eastern sub-continent of Africa. As this moist air rises along the eastern escarpment of South Africa condensation takes place and low cloud or fog forms. This fog then moves through the fog nets where the little water droplets are captured, running down onto the gutter and eventually end up in tanks as water.

*Dirk Benadé uses a small model of a fog net to explain how the water droplets are captured.*

The experiment consisted of a cast-iron iron, a gas cylinder, a spray bottle containing distilled water and a sample of netting ($100cm^2$). With the aid of the experiment the ideal atmospheric conditions to produce fog was simulated. The cast-iron iron, which represented the land, was heated over a gas flame for a few minutes. This represented the heating of the earth by the sun. The distilled water was then sprayed against the hot iron producing water vapour, representing the fog, and it condensed against the netting. Small water droplets then collected at the bottom of the sample. The learners had the opportunity to touch the wet sample fog net, which helped to explain how water vapour can be turned into liquid water.

The project team decided on two competitions for the learners. The aim here was to involve all the learners, have some fun while in the process learning something about the weather. First a synoptic symbol quiz was conducted. They were shown 7 basic weather symbols that they had to identify later in order to win prizes. This resulted in fun and laughter not only for the primary school learners but also for the University project team members.

*Lizelle Maritz tries to mimic the "thunder" synoptic symbol. .*

*The learners receive something sweet by identifying the correct weather symbol.*

The second part of the competition continued as follows:

Two rows of five buckets each were placed approximately ten meters opposite each other. The children were divided into five groups. In each bucket there was a number of tennis balls, each of them marked with the seven synoptic symbols that were shown and discussed earlier, as well as a few balls without any symbols on them. The main objective was for the pupil to take a tennis ball out of the one bucket, run to the opposite bucket, collect the tennis ball with the matching symbol and run back again. If the incorrect tennis ball was brought back, the pupil had to run back again to collect the right one. The group who finished first, won. As prizes they all received a "Cloud Catcher " T-shirt.

*The weather-symbol-tennis-ball-competion course.*

The learners received the project team with great enthusiasm. The pupils listened attentively to the presentations. Considering the response and the amount of questions that were asked it was clear that the presentation was a success.

*Lee-ann Clark demonstrates how water quickly evaporates if sprayed on a warm surface while the learners are listening attentively.*

*The learners listening wide eyed to the Cloud Catcher team*

*"It is amazing where the water comes from" the learners look on in amazement at the fog collection experiment.*

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J Olivier and J van Heerden

The objective of this project was to assess the amount and quality of fog water available in relation to needs of rural communities in various parts of South Africa. Spatial and temporal characteristics of fog occurrence were deduced from measurements made along the West Coast and in the mountainous and escarpment regions of the Northern Province and Mpumalanga. Pilot fog collectors in the form of either 1 $m^2$ or 3.6 $m^2$ screens were installed and tested at several sites in each of these areas. Both area characteristics and site characteristics conducive to high fog-water yields were identified. At the better escarpment sites with altitudes well in excess of 1 000 m, average daily water yield over all seasons was between 10 and 20 □/$m^2$ of collector surface, with even the dry winter months having average daily yields of approximately 2.5 □/$m^2$. Yields along the West Coast were considerably lower but nevertheless comparable to those obtained in a successful fog-water supply project in Chile. Water-poor communities in the Northern Province who might be potential beneficiaries of fog-water collection schemes were identified and a fog-water collection unit for potential large-scale implementation was provisionally designed.

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