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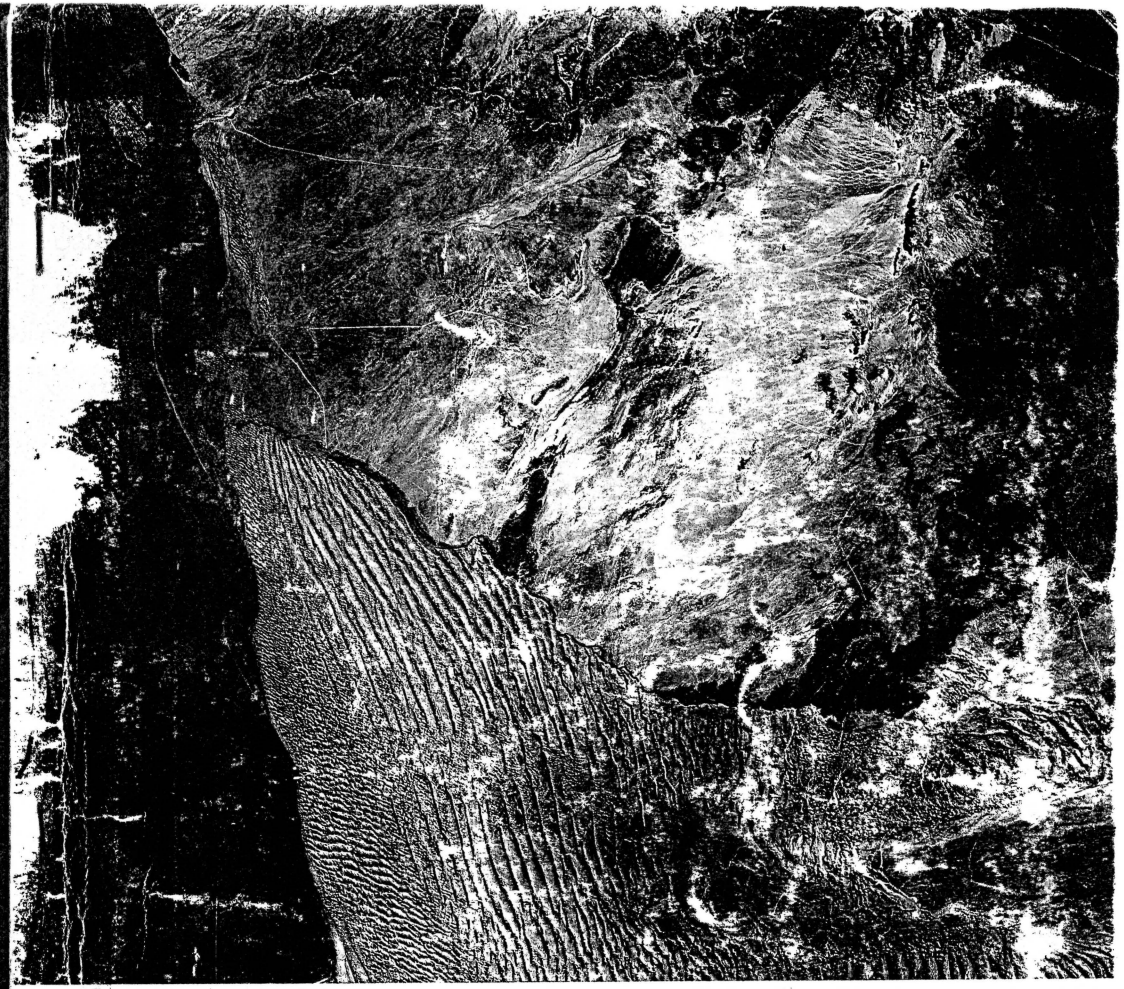

The Kuiseb environment: the development of a monitoring baseline

B J Huntley (Editor) 1985

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO. 106

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A Report of the Committee for Terrestrial Ecosystems
National Programme for Environmental Sciences

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO

106

Issued by
Foundation for Research Development
Council for Scientific and Industrial Research
P O Box 395
PRETORIA
0001
South Africa
from whom copies of reports in this series are available on request.

Printed in 1985 in the Republic of South Africa

ISBN 0 7988 3397 1

Cover: Landsat image of the central Namib Desert, illustrating the strong contrast between the dune sea to the south and the gravel plains to the north of the Kuiseb River. The valley of the Kuiseb River passes westwards through the Namib-Naukluft Park to the Atlantic Ocean at Walvis Bay. The valley is occupied by tall Acacia albida and A erioloba woodlands, providing a linear oasis and migration route for both animals and plants through the desolate sand dune sea and gravel plains. The deep sands of the river bed provide a reservoir of water, the rapid exploitation of which could lead to major changes in the ecological, hydrological and geomorphological dynamics of this desert environment. This report describes the environmental factors which could be most seriously influenced by water extraction, and provides a data base for monitoring such changes, should extraction occur at an excessive rate. Cover acknowledgement: Hartebeesthoek Satellite Remote Sensing Centre, National Institute for Telecommunications Research, CSIR.

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AIMS OF THE KUISEB ENVIRONMENT PROJECT

The Kuiseb Environmental Project is one of several large multi-disciplinary studies coordinated on behalf of participating organizations by the CSIR's Foundation for Research Development (previously Cooperative Scientific Programmes). Its specific aims are:

- To identify, assess and review potential environmental problems in the Kuiseb basin arising from water use, agricultural, mining, tourist and nature conservation developments.
- To identify and quantify key environmental features which, through regular monitoring, will provide baseline information on the types and rates of change within the system.
- To determine research needs on the processes influencing or influenced by such changes and to coordinate such research within a cooperative programme.
- To develop models of selected portions of the hydrological cycle and other environmental processes to assist in the assessment and prediction of the consequences of development.
- To provide responsible agencies with information and advice on means of reducing the undesirable effects of such changes.

PARTICIPATING ORGANIZATIONS

Council for Scientific and Industrial Research
Department of Agriculture and Nature Conservation, SWA/Namibia
Department of Environment Affairs
Department of Mineral and Energy Affairs
Department of Water Affairs, SWA/Namibia
Desert Ecological Research Unit (until 1974)
Municipality of Walvis Bay
State Museum, Windhoek
University of Durban-Westville
University of Natal
University of Pretoria
University of Stellenbosch
University of the Orange Free State
University of the Witwatersrand

ABSTRACT

The development of the world's largest open-cast uranium mine in the Namib Desert introduced rapidly increasing demands for water to the area in the early 1970's. In the absence of scientifically based information on the likely impact of water extraction from the fragile desert ecosystem, various government departments and universities established a cooperative research project to investigate the problem. This report outlines the nature of the regional environment, the types of changes expected to occur in the area as a consequence of water extraction from the Kuiseb River, and provides details of features of the geomorphology, hydrology and ecology that might be used as baselines against which to measure changes within the system.

SAMEVATTING

Die ontwikkeling van die grootste oopgroef-uraanmyn in die Namibwoestyn het 'n vinnig-stygende behoefte aan water in die gebied in die vroeë sewentigerjare tot gevolg gehad. In die afwesigheid van wetenskaplik-gefundeerde inligting oor die waarskynlike impak van wateronttrekking vanuit die sensitiewe woestynekosisteem het verskeie regeringsdepartemente en universiteite 'n koöperatiewe navorsingsprojek daargestel om die probleem te ondersoek. Hierdie verslag beskryf die aard van die omgewing in die gebied, die tipe veranderinge wat verwag word as gevolg van die onttrekking van water vanuit die Kuisebrivier, en dit verskaf besonderhede van aspekte van die geomorfologie, hidrologie en ekologie wat as 'n basis gebruik kan word om veranderinge in die sisteem te bepaal.

ACKNOWLEDGEMENTS

The execution of the multidisciplinary study described in this report would not have been possible without the enthusiastic leadership of the late Mr Bernabé de la Bat and Dr Wessel van Wyk (Chairman, Steering Committee) who played critical roles in guiding the project from initiation to completion.

Special thanks are also due to Mrs E Auret of the Foundation for Research Development, who acted as secretary to the Steering Committee throughout its term of office, and who organized and followed through the numerous discussion group meetings, workshops and general project administration. Her assistance in the preparation of the final report is also greatly appreciated.

EXECUTIVE SUMMARY

1. The development of the world's largest open-cast uranium mine at Rössing in the Central Namib Desert introduced rapidly increasing demands for water to the area in the early 1970's.

2. At the time it appeared that these demands would have to be met by water drawn from the Kuiseb River, either by abstraction from underground reservoirs in its lower reaches in the Namib-Naukluft Park, or through the construction of dams in its upper catchment in the Khomas Hochland and Escarpment.

3. The consequences of the increased use of the water resources of the Kuiseb basin were believed to cause a lowering of the water table which would result in: the death of the dense acacia woodland which forms a linear oasis across the desert; the unhindered northward advance of dunes from the main Namib Sand Sea; the termination of subsurface flow of freshwater from the Kuiseb to Sandvis Lagoon; the depletion of drought reserves for plains game and Topnaar Hottentot domestic stock through the loss of the acacia woodland and associated vegetation; and ultimately the siltation of Walvis Bay Lagoon.

4. In the absence of adequate factual information, an inconclusive debate between parties in favour or against the concept of increased water use from the Kuiseb River ensued. In 1973 however, the responsible authorities established a multidisciplinary cooperative research programme, the Kuiseb Environmental Project to, inter alia, identify and quantify key environmental features which, through regular monitoring, would provide baseline information of the types and rates of change within the system under an anticipated declining water table in order to provide decision makers with scientifically sound information on which to base management and conservation plans.

5. The limited availability of funds and manpower led to the use of a systems analytical approach in which the Kuiseb basin was divided into hydrological/ecological compartments within and between each of which the rates and directions of water transfers, and the factors influencing or influenced by these flows, could be studied.

6. The geological/geomorphological history of the Namib was studied and the results indicate that a desert environment has predominated uninterrupted for at least the last 65 million years. The present Kuiseb River valley developed approximately 16 million years ago, although the present incised course is probably 2-3 million years old. The Kuiseb River has been an effective barrier to the northerly advance of the main Namib Sand Sea for at least the last 1,8 million years.

7. Hydrological and geohydrological studies indicate that the Kuiseb catchment receives on average only 159 mm rainfall per annum and provides an extremely widely fluctuating water yield, ranging from ca 220 M m^3 to zero, with a mean of ca 40 M m^3 per annum at the base of the escarpment, with an as yet undetermined flow to the main abstraction area at Rooibank. During the last 146 years the river surface flow has reached the Atlantic on only 15 occasions.

8. Detailed monitoring of the sand dynamics on the Lower Kuiseb indicated that, in the absence of the flushing action of floods, the estimated time for dunes to cross the southern delta channel ranges from 25 to 100 years, approximately 1500 to 2000 years to cross the Rooibank to Swartbank area and from 100 to 800 years in the Swartbank to Natab sector.

9. The vegetation of the Lower Kuiseb was surveyed, classified and mapped and a detailed analysis of the structure and vitality of the woody species was measured in 17 belt transects and 39 permanent quadrats during July 1978 and July 1981. The study sites fell within three hydrological compartments, one of these being the main water abstraction area. Although fairly marked negative changes in the vitality of the woody species were recorded, the changes occurred in all sectors and appeared to be related to the below average rainfall experienced during the study period and not due to changes induced by water abstraction.

10. The use of aerial photographic techniques, especially that involving colour infra-red photographic emulsions, proved to be extremely efficient and accurate in monitoring changes in woody plant structure and vitality.

11. The availability and utilization of forage and water sources within the riverine woodland linear oasis was measured and indicated that they played a significant role in the ecology of oryx and Hartmann's zebra, particularly for the populations occupying the inland dune areas to the south of the Kuiseb. The domestic stock of the Topnaar Hottentot communities of the Lower Kuiseb were almost wholly dependent on these food and water resources.

12. Forage production on the gravel plains to the north of the Kuiseb varied considerably according to rainfall patterns and accounted for the massive fluctuations in the large herbivore population from an estimated maximum of 7212 animals in October 1979 to a minimum of 1039 in June 1981. The surviving animals became increasingly dependent on the food and water resources of the Kuiseb riverine woodland as the drought advanced.

13. The overriding conclusion which could be drawn from the studies conducted within the Kuiseb Environmental Project is that the entire ecosystem is extremely dynamic, undergoing unusually large fluctuations in all climatic, geomorphological, hydrological and ecological processes. Water is unquestionably the principal driving force in the Kuiseb environment and changes to the volume, rate and directions of flows within the system would have major consequences. As yet, man-induced changes to the hydrology of the Kuiseb basin have not been demonstrated to have influenced geomorphological or ecological processes within the area.

14. Water supplied from the nearby Omaruru River caused a considerable reduction in the rate of water abstraction from the Lower Kuiseb, following an initial three-fold increase from 1974 to 1977. This undoubtedly averted major changes being recorded during this study. The detailed baselines established during the project will provide an invaluable benchmark against which changes can be measured in the long term, whether or not increased water use from the Kuiseb becomes necessary in the future.

TABLE OF CONTENTS

1. INTRODUCTION

B J Huntley, CSIR

The Namib Desert occupies 270 000 km^2 of the southwest African coast. It is a land of extreme environmental conditions, of thirst, heat, sandstorms and fog. It possesses unusually impressive landscapes and plants and animals which have evolved some of the most amazing adaphations for survival known to science. It is also a land about which people speak with emotion, their feelings of identity strengthened by such moving tales as those related in Henno Martin's "The Sheltering Desert" and Geoffrey Jenkin's "A Twist of Sand". It is thus not surprising that threats to the sanctity of this environment have aroused the passionate concern of biologists, conservationists and the lay public. The apparent conflict between mining and other industrial demands for water and the maintenance of the Namib ecosystem led to an emotive and often acrimonious debate in the early 1970's. It was due largely to the foresight of the late Bernabe de la Bat that the issue was brought before a properly qualified group of scientists and engineers for evaluation and monitoring.

The conflict originated with the proposal, in long-term water production plans, to pump the groundwaters of the Kuiseb basin to the limits of their yield (Anon 1971; Logan 1974). The water was needed for the rapidly increasing demands set by the Rössing open-cast uranium mine and for other industrial developments in the region. The consequences of such water abstraction, which would greatly exceed the then available estimates of inflow to the Lower Kuiseb, would have possibly included:

- the death of the linear oasis of riverine acacia woodland which provides a major food and shelter resource from the escarpment through the desert virtually to the sea at Walvis Bay;

- the decrease in water availability to desert populations of oryx, Hartmann's zebra and baboons which are largely dependent on the perennial water holes excavated in the bed of the Kuiseb Canyon;

- the reduction of the main forage source of the domestic stock of the Topnaar Hottentot communities, and of the water levels in their traditional wells;

- the movement of dunes across the Kuiseb River, ultimately to engulf Walvis Bay;

- the termination of the freshwater seepage from the Kuiseb under the dunes to Sandvis Lagoon, and the consequent extinction of those plants and animals dependent on this freshwater supply; and

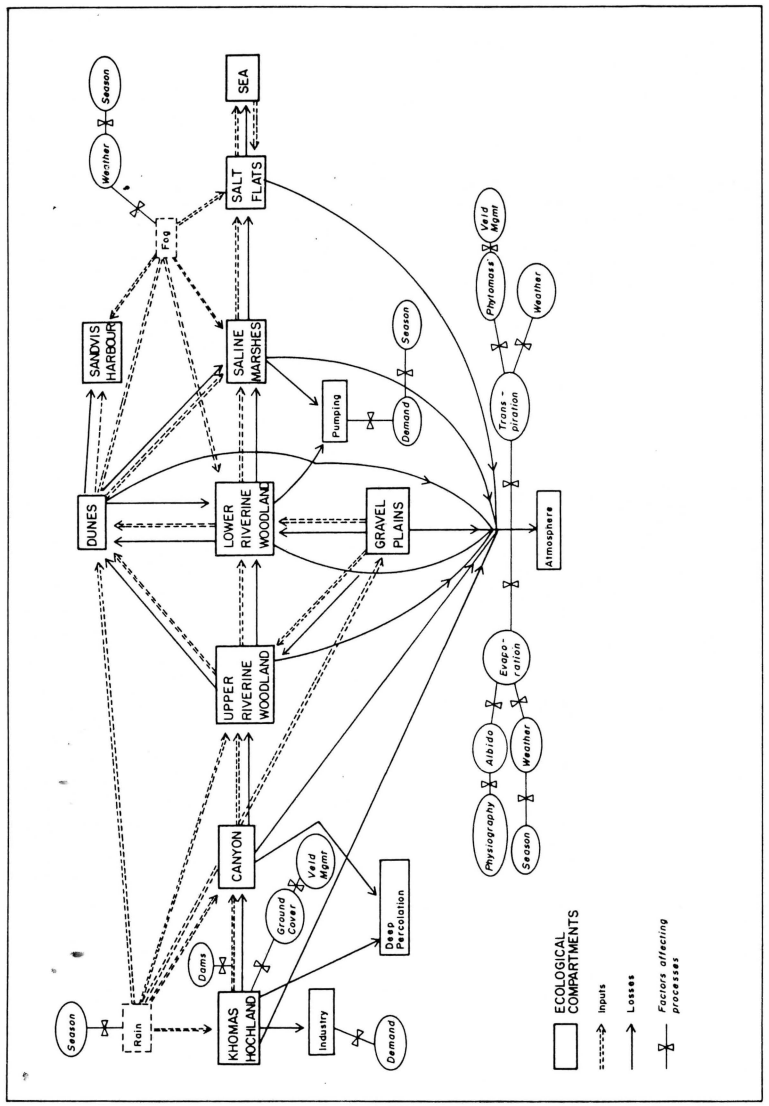

Figure 1. Preliminary descriptive model of Kuiseb basin hydrology.

- the siltation of Walvis Bay Lagoon.

Both parties involved in the conflict considered themselves to have valuable interests at stake - the development of the regional economy or the preservation of the natural environment. A further point in common was their singular lack of any incontrovertible evidence on which to base their diverging opinions on the influences of water extraction from the Lower Kuiseb.

On 16 March 1973 the late Mr de la Bat convened a meeting of interested parties to consider the need for a research programme into the ecology of the Kuiseb River system. The meeting led to the establishment of the Kuiseb Project Advisory Committee (Convener: Dr M K Seely) and to the approval on 9 January 1974 by the Executive Committee of the South West Africa Administration, of a memorandum which inter alia recommended the formal establishment of a coordinated cooperative study of the Kuiseb River environment. The original Advisory Committee was later succeeded by a Steering Committee (Chairman: Dr W L van Wyk) which, in addition to the strong support provided by South West African organizations, received substantial funds from the CSIR's National Programme for Environmental Sciences for research undertaken by scientists from universities and museums.

Thus within the course of a few years a major cooperative research venture of scientists and engineers from all persuasions had joined forces to examine the real nature of the structure and functioning of the Kuiseb environment. These studies would ultimately meet the project's principal objective, viz:

> "The determination of the optimal utilization of the natural resources of the entire catchment area and lower reaches of the Kuiseb River which will result in a minimum of damage to the environment".

From the outset it was clear that neither funds nor manpower would suffice to undertake a fully comprehensive study of all aspects of the Kuiseb environment. At an early stage a systems analytical approach was adopted, albeit in a rudimentary form (Anon 1976). A series of workshops were convened to identify current and future environmental problems arising from water use, mining, agriculture, tourism and nature conservation activities.

In particular an attempt was made to identify and quantify those environmental features which, through regular monitoring, would provide information on the types and rates of changes within the system. The monitoring programme would lead to the identification of major research needs, as would the review of available information which was undertaken by the original working groups established at the initiation of the project. One of the first workshops developed a crude descriptive model of the Kuiseb basin's hydrology (Figure 1) which helped to define the major ecological compartments, the inputs and losses of water to and from these and the factors affecting the directions and rates of these transfers. This model helped in defining the key questions which related to a core set of studies which were further developed by specialist working groups.

In the ten years that have passed since the cooperative project was conceived, a considerable volume of information has been assembled by participating researchers, in particular on the geomorphology, hydrology and ecology of the Kuiseb basin. Knowledge on the area's environment has furthermore been vastly extended by the detailed research activities undertaken by the Desert Ecological Research Unit at Gobabeb and by their workers in the Namib-Naukluft National Park.

The purpose of this report is not to review all the available literature on the Kuiseb basin. It is rather aimed at providing a brief synopsis of the first phase of the study, which aimed at establishing baselines for long-term monitoring of key environmental processes. Most of the information which has resulted from the project may be found in the published papers, and unpublished reports and theses which are referred to in the various chapters. Much of the information on water resources is contained in departmental records and is not readily available for quotation in the open literature. Sufficient information is however provided to allow a coherent discussion to be developed.

Several factors have contributed to making the Kuiseb Environmental Project a particularly interesting and challenging undertaking:

- The study area's distance from major research institutions and its inhospitable, mostly inaccessible terrain which made detailed studies using sophisticated techniques impractical.

- The prevailing rainfall pattern passed from exceedingly wet years (1974, 1976) to a very dry period (1980 to 1982). No flooding occurred during the latter period.

- The rate of water extraction, after rapidly increasing from 1975 to 1977, was reduced in 1980 to the estimated normal rate of replenishment.

- The fact that all extraction took place in one hydrologic compartment, without apparently influencing the hydrological state of those upstream, allowed for comparisons to be made of the response of vegetation to a wide range of water table changes.

- As a consequence of the marked fluctuation in rainfall patterns, forage and water availability, the large herbivore population fluctuated from over 7000 to nearly total depletion of forage reserves and a crash in the large herbivore population to less than 1100 animals.

The first phase of the Kuiseb Environmental Project was aimed, as noted above, at establishing a monitoring baseline. In many respects it did more than this, in providing a detailed description of important facets of the environment and in some cases providing important insights relating to ecosystem processes. The information gained has provided decision makers with a clearer understanding of many contentious issues, several of these being the "raison d'etre" for the Kuiseb Environmental Project.

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