CHAPTER 15 ECONOMIC VALUE OF GROUNDWATER

15.1 Analysis of Value Added of Irrigation and Livestock Farming by Using Generalised Data

15.1.1 Spectral Water Use

As Table 15.1-1 indicates, water consumptions per year on stock watering and irrigation are almost same. Total water consumption for them is 84% of the total consumption in the study area.

Table 15.1-1 Sectoral Water Use

Sectors	Water Use (million m^3/year)	Proportion (%)
1. Domestic water		
1.1 Village	0.577	4.82
1.2 Commercial farms	1.224	10.23
1.3 Communal lands	0.132	1.10
Sub-total	1.933	16.15
2. Industries	0	0
3. Tourism	0.004	0.03
4. Stock watering	5.003	41.80
5. Irrigation	5.025	41.99
Total	11.968	100.00

15.1.2 Economy of Irrigation and Livestock Farming

Annual rainfall in the Study Area averages only 185 mm implying that no crops could grow without irrigation. According to the hydro-census data, commercial irrigation farming is practiced on 546 ha (permitted irrigation area 399.5 ha). Most of farming areas are compelled to be utilized groundwater for livestock grazing because of poor soil and arid climate of the area.

To analyse economic efficiency of main irrigation and livestock farming activities using groundwater, costs and benefits on the activities are estimated based upon generalised data from the related authorities such as Hardap cooperative and MAWRD (refer to Table 15.1-2).

Table 15.1-2 Cost and Benefit from Irrigation and Livestock

Crops	Unit	Gross Income	Production Cost	Net Income
Maize	N$/ha	8,000	4,700	3,300
Wheat	N$/ha	6,000	4,320	1,680
Lucerne	N$/ha	12,000	5,880	6,120
Grapes	N$/ha	40,000	17,668	22,332
Cotton	N$/ha	11,000	5,360	5,640
Sweet Melon	N$/ha	40,000	12,708	27,292
Sheep	N$/head	230	90	140
Beef Cattle	N$/head	1,750	1,005	745

Source: MAWRD and Hardap Cooperative

Grapes and Sweet melon produce high profits which are over 20,000 N$. Their net incomes per hectare are much greater than those of other crops. Whilst, prevailing carrying capacity in the Study Area is 3 ha/SSU or 18 ha/LSU, which implies that net income from sheep grazing is only N$47/ha (140/3) and N$41/ha from cattle respectively (refer to 13.2.7). The result indicates that irrigation farming generates higher net income than livestock in spite of its higher investment. However the extent of this depends on land use and crop selection.

15.1.3 Estimation of Water Fee for Groundwater

As mention in Chapter 9, there are water tariffs established by Namwater scheme but there is no tariff charged for groundwater. In order to use groundwater efficiently and sustainably, pricing is considered as one of groundwater management tool. But a main problem in pricing policy is how much should be charged to give farmers incentive to use ground water more efficiently.

This case uses the present worth value of one borehole for water fee estimation, assuming that the Namibian government invests in installing a borehole to abstract groundwater for commercial farmers. Calculating discounted initial, running and maintenance costs during fifty years which is the lifetime of a borehole, water fees which the government should charge for the investment are estimated based upon three different discount rates: 10%, 15% and 20%.

Basically, the government decides priority of investment projects analysing time preference, profitability and so forth. Therefore, considering the interest rates ranged from 10 to 18 per cent for last 10 years in this country, three cases of water fees are simulated to cover the whole cost (refer to Table 15.1-6). As the result, it is recognised that a possible water fee could be between N$ 0.32 and 0.4 per m^3

To be noticed is that this case assumes the investment only for one borehole. However water supply system may require not only a borehole but also reservoirs, bulk cars and so forth. In case of including these costs, total cost would be much higher and water fee would be more expensive.

15.1.4 Estimation of Value Added of Farming Activities

"Value added" method is used in this study to look at economic efficiency of groundwater use. This approach could also be one of the methods to access the water fee for ground water, analysing value added per unit of water in agricultural products which are the main activities in the study area (refer to Table 15.1-3 – 5).

As Table 15.1-4 and 5 shows this case use generalised economy data of crops and livestock farming based upon their net income and water consumption volumes on a unit basis, and estimates the value added.

According to these tables in general the value added per unit of water for livestock is higher than that of crops. Even within crops, a wide range of value added was recognized. Grapes and sweet melons have a higher value added than other crops.

Table 15.1-3 Estimation of Value Added of Livestock Productions in the Study Area

	No. in the Study Area (2000)	Culling for Sale (head)	Net Income (N$/head)	Total Value Added (N$)	Unit Water Consumption (m^3/head)	Total Water Consumption (m^3/year)	Value Added per m^3 (N$/$m^3$)
Cattle	134,771	16,846	1,100	18,531,008	0.045	276,702	66.97
Sheep	582,363	87,354	130	11,356,085	0.012	382,613	29.68
Goats	135,031	20,255	140	2,835,658	0.012	88,716	31.96
Total	-	-	-	32,722,751	-	748,030	43.75

Note: Culling rates for sale are 12.5% for cattle and 15% for sheep/goats, respectively, Agricultural Bank's Guideline

Table 15.1-4 Value Added per Cubic Meter of Water by Crop

	Net Income (N$/ha)	Water Consumption (m^3/ha)	Value Added per m^3
Wheat	1,680	10,156	0.165
Lucerne	5,500	21,360	0.257
Prickly Pears	2,000	5,000	0.400
Cotton	5,640	13,756	0.410
Maize	3,300	7,070	0.467
Tomato	13,748	9,020	1.524
Grapes	22,332	12,301	1.815
Sweet Melon	10,182	11,468	2.083

Source: Hardap Cooperative and MAWRD

Annual water consumption by crop is 6,502,356m^3 (= 567ha x 11,468 m^3)

Table 15.1-5 Estimated Total Value Added in the Study Area

		N$/year	Value Added (N$/$m^3$)
Crops	10,182N$/ha x 567 ha	5,772,911	0.89
Livestock		32,722,751	43.75
Total		38,495,661	-

Note: 5,772,911N$/(567ha x 11,468cu.m)=0.89

Table 15.1-6 Estimation of Water Price for Groundwater

(Unit:N$/Borehole)

					Present Value by Discount Rate											
					Int.= 0.1				Int.= 0.15				Int.= 0.20			
Year	Initial Cost	O & M Cost	Replacement Cost	Total	Intial Cost	O&M Cost	Replacement	Total	Intial Cost	O&M Cost	Replacement	Total	Intial Cost	O&M Cost	Replacement	Total
1	193,600	5,800	0	199,400	193,600	5,800	0	199,400	193,600	5,800	0	199,400	193,600	5,800	0	199,400
2	0	5,800	0	5,800	0	5,273	0	5,273	0	5,043	0	5,043	0	4,833	0	4,833
3	0	5,800	0	5,800	0	4,793	0	4,793	0	4,386	0	4,386	0	4,028	0	4,028
4	0	5,800	0	5,800	0	4,358	0	4,358	0	3,814	0	3,814	0	3,356	0	3,356
5	0	5,800	0	5,800	0	3,961	0	3,961	0	3,316	0	3,316	0	2,797	0	2,797
6	0	5,800	0	5,800	0	3,601	0	3,601	0	2,884	0	2,884	0	2,331	0	2,331
7	0	5,800	0	5,800	0	3,274	0	3,274	0	2,508	0	2,508	0	1,942	0	1,942
8	0	5,800	0	5,800	0	2,976	0	2,976	0	2,180	0	2,180	0	1,619	0	1,619
9	0	5,800	0	5,800	0	2,706	0	2,706	0	1,896	0	1,896	0	1,349	0	1,349
10	0	5,800	0	5,800	0	2,460	0	2,460	0	1,649	0	1,649	0	1,124	0	1,124
11	0	5,800	0	5,800	0	2,236	0	2,236	0	1,434	0	1,434	0	937	0	937
12	0	5,800	0	5,800	0	2,033	0	2,033	0	1,247	0	1,247	0	781	0	781
13	0	5,800	0	5,800	0	1,848	0	1,848	0	1,084	0	1,084	0	651	0	651
14	0	5,800	0	5,800	0	1,680	0	1,680	0	943	0	943	0	542	0	542
15	0	5,800	130,000	5,800	0	1,527	34,233	35,760	0	820	18,373	19,192	0	452	10,125	10,577
16	0	5,800	0	5,800	0	1,388	0	1,388	0	713	0	713	0	376	0	376
17	0	5,800	0	5,800	0	1,262	0	1,262	0	620	0	620	0	314	0	314
18	0	5,800	0	5,800	0	1,147	0	1,147	0	539	0	539	0	261	0	261
19	0	5,800	0	5,800	0	1,043	0	1,043	0	469	0	469	0	218	0	218
20	0	5,800	15,000	5,800	0	948	2,453	3,401	0	408	1,054	1,462	0	182	470	651
21	0	5,800	0	5,800	0	862	0	862	0	354	0	354	0	151	0	151
22	0	5,800	0	5,800	0	784	0	784	0	308	0	308	0	126	0	126
23	0	5,800	0	5,800	0	713	0	713	0	268	0	268	0	105	0	105
24	0	5,800	0	5,800	0	648	0	648	0	233	0	233	0	88	0	88
25	0	5,800	0	5,800	0	589	0	589	0	203	0	203	0	73	0	73
26	0	5,800	0	5,800	0	535	0	535	0	176	0	176	0	61	0	61
27	0	5,800	0	5,800	0	487	0	487	0	153	0	153	0	51	0	51
28	0	5,800	0	5,800	0	442	0	442	0	133	0	133	0	42	0	42
29	0	5,800	0	5,800	0	402	0	402	0	116	0	116	0	35	0	35
30	0	5,800	130,000	5,800	0	366	8,195	8,561	0	101	2,258	2,359	0	29	657	687
31	0	5,800	0	5,800	0	332	0	332	0	88	0	88	0	24	0	24
32	0	5,800	0	5,800	0	302	0	302	0	76	0	76	0	20	0	20
33	0	5,800	0	5,800	0	275	0	275	0	66	0	66	0	17	0	17
34	0	5,800	0	5,800	0	250	0	250	0	58	0	58	0	14	0	14
35	0	5,800	0	5,800	0	227	0	227	0	50	0	50	0	12	0	12
36	0	5,800	0	5,800	0	206	0	206	0	44	0	44	0	10	0	10
37	0	5,800	0	5,800	0	188	0	188	0	38	0	38	0	8	0	8
38	0	5,800	0	5,800	0	171	0	171	0	33	0	33	0	7	0	7
39	0	5,800	0	5,800	0	155	0	155	0	29	0	29	0	6	0	6
40	0	5,800	8,600	5,800	0	141	209	350	0	25	37	62	0	5	7	12
41	0	5,800	0	5,800	0	128	0	128	0	22	0	22	0	4	0	4
42	0	5,800	0	5,800	0	117	0	117	0	19	0	19	0	3	0	3
43	0	5,800	0	5,800	0	106	0	106	0	16	0	16	0	3	0	3
44	0	5,800	0	5,800	0	96	0	96	0	14	0	14	0	2	0	2
45	0	5,800	130,000	5,800	0	88	1,962	2,049	0	12	277	290	0	2	43	45
46	0	5,800	0	5,800	0	80	0	80	0	11	0	11	0	2	0	2
47	0	5,800	0	5,800	0	72	0	72	0	9	0	9	0	1	0	1
48	0	5,800	0	5,800	0	66	0	66	0	8	0	8	0	1	0	1
49	0	5,800	0	5,800	0	60	0	60	0	7	0	7	0	1	0	1
50	0	5,800	0	5,800	0	54	0	54	0	6	0	6	0	1	0	1
Total	193,600	290,000	413,600	483,600	193,600	63,257	47,052	303,908	193,600	44,426	21,999	260,025	193,600	34,796	11,302	239,698
Annu:	3,872	5,800	8,272	9,672	3,872	1,265	941	6,078	3,872	889	440	5,200	3,872	696	226	4,794

	Interest Rate	Interest rate	Interest Rate
	10%	15%	20%
a. Total Intake of water	15,000 m3/year		
b. Costs	Present Value/year	Present Value/year	Present Value/year
b.1 Total cost and annual cost (financial price)	3,872	3,872	3,872
b.2 Annual OM costs (financial)	1,265	889	696
b.3 Replacement costs (financial)	941	440	226
Total	6,078	5,200	4,794
c. Water Price (N$/$m^3$)=	0.405	0.347	0.320

15.2 Analysis of Mitigation Measures

15.2.1 Main Problems in the Study Area

Groundwater in the Study area is source not only for domestic use but also for livestock and agricultural activities which are the major economic activities producing crops and livestock and employing many people. It is also of great importance that the groundwater in the regional economy will not be changed for this is an indispensable resource and is vital for the future of regional economy.

According to the result of ground water simulation (refer to Chapter 12), the existing situation of ground water use in Study area can be divided into two categories. The first being the Stampriet (Area II, refer to Fig. 10.1-1) and the second being simply other area. Area II where irrigation farming is concentrated has more serious situation than the other areas, because drawdown of groundwater level is very fast.

Area II extracts ground water at the rate of 5.3 million m^3/year which amount to 40% of the whole groundwater usage of which 94 % of this extracted water is used for irrigation farming. Because of high pumpage, groundwater from Karahari aquifer in Area II will dry up sooner than the other areas. Therefore, an urgent reduction of irrigation water use is indispensable in Area II.

15.2.2 The ‘Optimal Depletion’ for Sustainable Ground Water Use

Ideally the norm of sustainable groundwater use is defined as the water use that enables to maintain a constant groundwater level. Using this definition, simulation results lead to an optimal depletion rate which is far below the actual rate of 5.3 million m^3/year. The volume of optimal depletion is determined by the geo-hydrological analysis which estimated the annual recharge and extraction in the Stampriet basin. As a result, an optimal depletion level that could not cause drastic decline of groundwater level was determined as 14,000 m^3/year (refer to Chapter 12).

To achieve this goal, varied efforts shall be made depending upon the geo-hydrological condition. In Area II where the extraction and drawdown of the ground water level are critical, the extraction rate which currently amounts to 14,615m^3/day should be halved for sustainable use.

15.2.3 Possible Applicable Methods for Saving of Irrigation Water Use

A wide range of mitigation measures should be introduced to control the water use such as raising awareness by education and information, legal measures and economic measures. However, considering the existing condition in the Study Area, this study focuses on points mentioned below from economic perspectives.

1) More effective water use by tradable permit
2) Changing of crop types
3) Application of more efficient irrigation methods
4) Reduction of irrigation area
5) Pricing for groundwater use

1) Introduction of permit trade system

Trading water using market mechanism is commonly used in many countries, as one of economic tools for water use management. In this case study, to examine applicability of this method, the existing permission system which is controlled by the Department of Water Affairs (DWA) is analysed based upon the data of irrigation permit holders. Basically, 'water market' has two norms of both 'right to abstract' and 'water itself', however this study focuses on the latter only, because it is not allowed to trade 'right to abstract' by the Water Act which was established by DWA.

As the result of analysis upon the data and information from DWA, various permit level and water use can be identified in the Study Area (refer to Chapter 10 (10.1.7) and Fig. 10.2-1). Considering the existing water allocation and water extraction, it could be identified that water trading within Area II where groundwater level is seriously declining cannot help solve the situation in the area. The main reasons are as follows:

- Most of the permitted irrigation farm (35) belong to Area II and water trading among them would cause more serious drawdown within the area.
- Water allocation given as a permit is not decided considering the geo-hydrological situation properly and are varied within the area.

For instance, assuming that Farmer No. 33 who has allowable extraction volume of 400,000 m^3/year trades water to Farmer No 14 who over extracts groundwater more than the permitted water allocation by the same amount of water volume, the total extraction volume in this area would be increased by this trading, and it would cause more serious drawdown of groundwater level (refer to Fig. 15.2-1).

To avoid such situation, before application of water trading policy, the existing permit scheme has to be improved including punishment system as well as permit level.

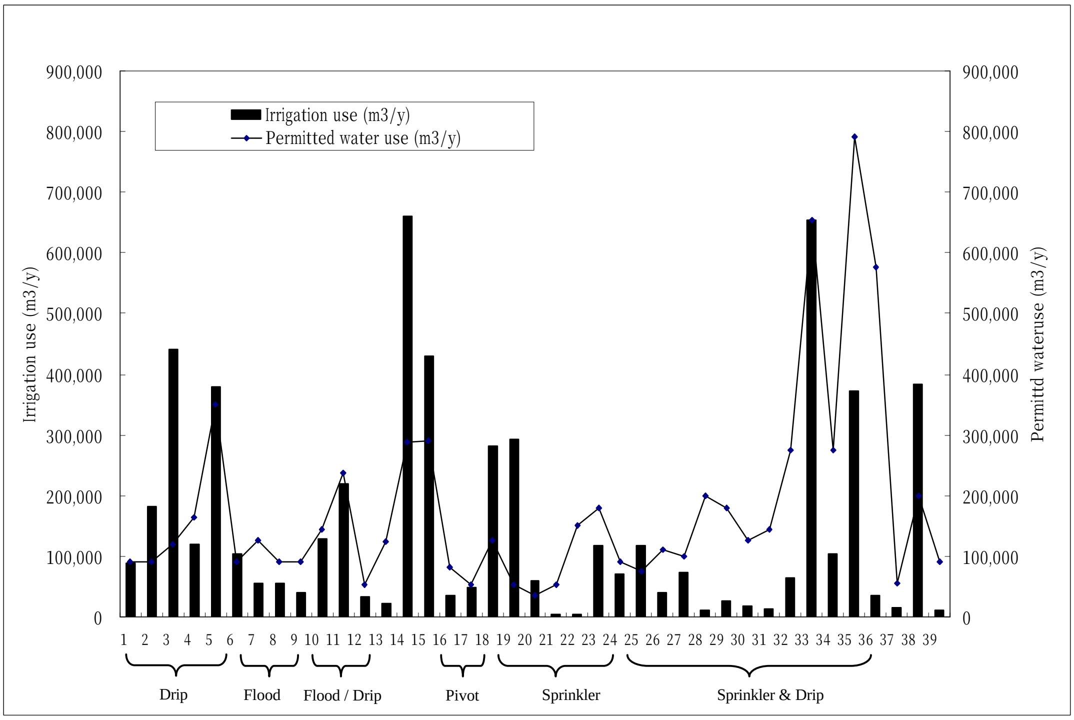


Fig. 15.2-1 Actual Irrigation Use and Permitted Water Use

2) Changing of crops

To improve water use efficiency from an economic aspect, it would require the controlling of Lucerne and Cotton production which consume a lot of water compared with other crops and also have a lower value added compared to other crops. What would be required would be to expand the production of high value added crops such as sweet melon, tomatoes, watermelon and other vegetables whilst curtailing the production of low value added crops (refer to Table 15.1-4).

Considering the farm size and the value added of crops, below different scenarios of water reduction, all of which are realistic and efficient in the water use are simulated as an example. Accordingly, it is examined how much water could be saved from conversion from Lucerne production into higher value added crops, while maintaining the same income of farmers.

In case that farmers change their farming operation from Lucerne to Grape in Scenario 1-2 (changing ratio: 50 %) or from Lucerne to Maize in Scenario 2-1 (changing ratio:100 %), the groundwater extraction will meet the short-term goal of a 30 % reduction in water use, which is the aim of this master plan. In Scenario 1-1 (changing ratio: 100 %) the groundwater extraction will attain the sustainable use level (68% reduction in water use).

Case 1 Lucerne → Grape

	Ratio of Changing Area	Reduced Water Volume (m^3)	Reduction Ratio
Scenario 1-1	100%	6,140,737	89 %
Scenario 1-2	50%	3,070,368	45 %
Scenario 1-3	20%	1,228,147	18 %

Case 2 Lucerne → Maize

	Ratio of Changing Area	Reduced Water Volume (m^3)	Reduction Ratio
Scenario 2-1	100%	1,917,569	28 %
Scenario 2-2	50%	958,784	14 %
Scenario 2-3	20%	383,514	6 %

3) Application of efficient irrigation methods

As Table 15.2-1 shows, Micro irrigation methods such as Drip and Micro sprayer enable more efficient water use than with Sprinkler and Flood irrigation. Ideally irrigation water use can be saved by the application of more efficient methods.

Table 15.2-1 Minimum Requirements for Different Crops and Irrigation Methods

Methods / Crop type	Minimum requirement (m^3/ha/year)	Irrigation method		
		Micro (m^3/ha/year)	Sprinkler (m^3/ha/year)	Flood (m^3/ha/year)
Maize	5,656	6,284	7,070	9,427
Melon/Vegetable.	6,280	6,978	7,850	10,467
Tomato	7,216	8,018	9,020	12,027
Wheat	7,312	8,124	9,140	12,187
Citrus	7,888	8,764	9,860	13,147
Grapes	8,857	9,841	11,071	14,761
Cotton	9,904	11,004	12,380	16,507
Lucerne	17,088	18,987	21,360	28,480

Source: MAWRD

Note: Sprinkler = Minimum requirement / 0.8
Drip = Minimum requirement /0.9
Flood = Minimum requirement/0.6

As shown in Table 15.2-3, most of the farms have applied efficient methods such as drip, micro spray and so forth. In order to estimate exact water saving volume by alteration of irrigation methods, appropriate irrigation methods for crop types should be considered based upon the data of irrigation areas and applied irrigation methods by each crop type. However, the hydro census data does not cover the detailed data of irrigation area by crop types. Because of such data constraint, this study estimates a possible saving water volume considering the below cases which exclude the farms applying spray and flood irrigation methods mixed with other micro irrigation methods and examines how much alteration of irrigation methods could contribute to water saving (refer to Table 15.2-2).

As Table 15.2-2 indicates, the switching of irrigation methods leads to a reduction of 215,500 m^3 per year which amounts to about 3 % of the total irrigation water use in the study area. The figure does not meet the short-term goal as well as the sustainable water use level. However using a variety of efficient irrigation methods more reduction could be expected.

Table 15.2-2 Water Saving Volume with Application of Micro Irrigation Methods

	Cases applied with micro irrigation method	Saving volume (m^3/ year)	N.B.
Case 1	Flood → Micro (30% saving)	91,500	30.5ha x 10,000 m^3 x 30%
Case 2	Sprinkler→Micro (10% saving)	83,000	83ha x 10,000 m^3 x 10%
Case 3	Pivot → Micro (10% saving)	15,000	15ha x 10,000 m^3 x 10%
Case 4	Flood, Sprinkler →Micro (20% saving)	26,000	13ha x 10,000 m^3 x 20%
Total		215,500	

Note: 10,000 m^3 = averaged water consumption per ha
20% is the average of Case 1 and 2

An important aspect to be noticed as Table 15.2-1 and Fig. 15.2-2 indicates is that the application of micro irrigation methods does not always contribute to water saving. For instance, water consumptions of some farmers are far more than 28,480 m^3 per year which is almost maximum water requirement of crops, although they have applied efficient irrigation methods which require much less water than that.

The main reason for this is that water saving highly depends upon the way which the farmers use the technologies and groundwater. That is because some farmers may not have adequate knowledge about how to use the efficient irrigation methods properly and, furthermore, may not be aware of the scarcity and the importance of ground water.

To improve their knowledge and awareness, education for the farmers should be initiated in parallel with the application of more efficient irrigation methods.

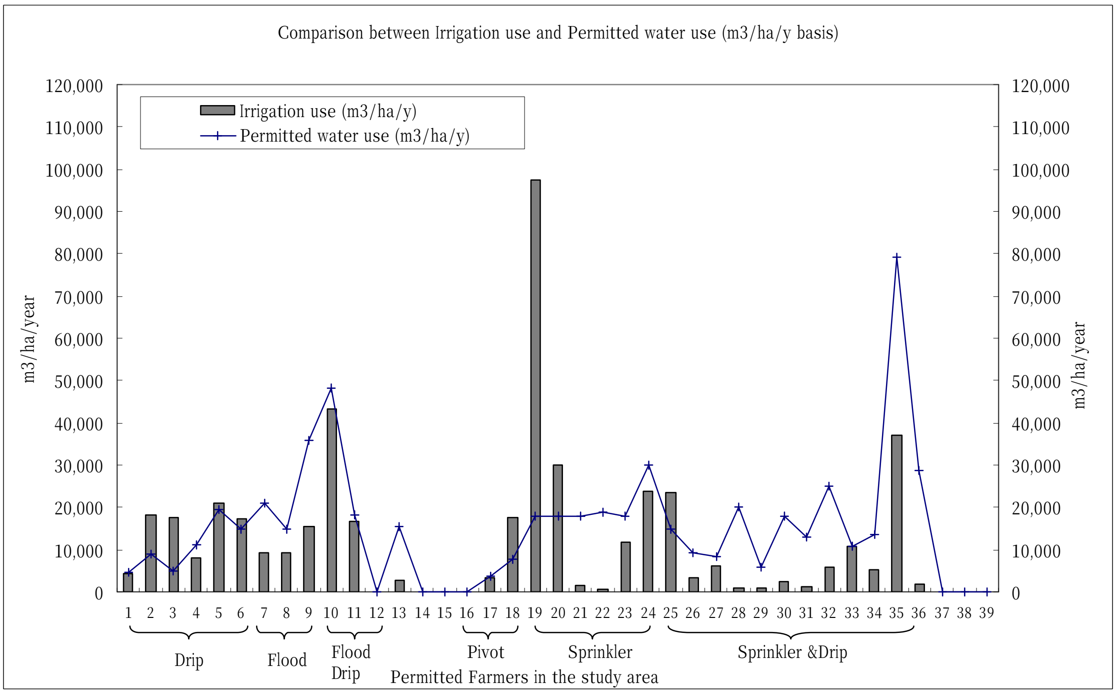
Table 15.2-3 Irrigation Areas by Methods

Unit: ha

Irrigation method \ Area	I	II	III	IV	VII	Total	%
Drip		98.5		2.0	4.1	104.6	23.8
Sprinkler		56.0	1.0	20.0	6.0	83.0	18.9
Sprinkler, Flood, Drip		77.0				77.0	17.5
Sprinkler, Drip	2.0	62.5				64.5	14.7
Flood	3.0	17.5	4.0		6.0	30.5	6.9
Flood, Drip					21.0	21.0	4.8
Pivot		15.0				15.0	3.4
Micro sprayer	1.0	12.0			1.0	14.0	3.2
Sprinkler, Flood	1.0	10.0			2.0	13.0	3.0
Sprinkler, Drip, Micro sprayer	12.5					12.5	2.8
Flood, Micro sprayer	2.0					2.0	0.5
Micro sprayer, Drip					2.0	2.0	0.5
Hose				0.5		0.5	0.1

Source: JICA analysis based upon Hydro-census data

Fig. 15.2-2 Comparison Between Irrigation Use and Permitted Water Use



Source: JICA analysis based upon DWA data

4) Reduction of Irrigation Area to Permitted Level

As mentioned in Chapter 10 (10.1.7 1)), farmers especially in Area II have exceeded their irrigation quotas and therefore a reduction in the irrigation area is one of the efficient ways to reduce groundwater extraction.

If the current irrigation areas (432 ha) of permitted farmers in Area II are scaled down to the permitted level by 30% reduction, then simply the same ratio of water consumption can be reduced. In this case groundwater extraction in the Study area would almost meet the sustainable level.

5) Pricing of Ground water

Enhancement and promotion of more efficient water use by education and campaign are basically conducted at the initial stage of the water reduction implementation program. However, such a policy may face some difficulty in persuading the farmers to change their behaviours. That is because currently ground water is not charged in the Study area. Also it could be expected that farmers will not agree to pay for ground water. However, charging for groundwater is a useful tool for providing incentives to the farmers. As an ultimate economic measure pricing or taxing can be applied considering affordability and acceptability to farmers.

This study considers the crop conversions with pricing policies as one of recommendations to solve the problem (refer to 15. 2. 3 1)). Based upon the generalised data of costs, benefits and required water volumes for crop productions, value added per cubic meter for main crops in the study area are calculated. The figures basically indicate how efficient crop productions use groundwater.

According to Scenario1-2, changing of crop production from Lucerne to Grape enables a reduction of 34% of current water usage. However, this is quite difficult without sufficient motivation to farmers, because such a shift requires some additional costs and physical efforts on the part of the farmers.

Due to the economic principle, basically farmers change their farming activities based upon costs and benefits with the aim to get more profit with less investment. They tend to change their activities from irrigation farming with low value added to livestock farming with high value added.

As Table 7.3-6 indicates in the case where the government charges a price between N$ 0.4 to 1.5/m^3 for ground water, farmers who cultivate Wheat, Maize and Cotton etc which produces lower value added than N$ 0.4/m^3 will encounter a deficit with this charging. According to economic theory we would then expect to observe farmers to change their cultivating crop type from the lower value added ones to the higher value added ones like Grapes and Sweet melon. As a result of this pricing policy and consequently change of crop type water consumption is expected to be reduced and should approach the sustainable level of water use.

Table 15.2-4 Value Added of Crops

Crops	Gross Income (N$/ha)	Total Cost (N$/ha)	Net Income (N$/ha)	Unit Water Consumption (m^3/ha)	Value Added (N$ /m^3)
Wheat	6,000	4,320	1,680	12,187	0.138
Lucerne	12,000	5,880	6,120	28,480	0.215
Cotton	11,000	5,360	5,640	16,507	0.342
Maize	8,000	4,700	3,300	9,427	0.350
Grapes	40,000	17,668	22,332	14,761	1.513
Sweet Melon	40,000	12,708	27,292	10,467	2.607

Source: MAWRD and Hardap Cooperative

References

No	Author	Published Year	Title	Publication
1	Central Bureau of Statistics, National Planning Commission	-	1991 Population and Housing Census Basic Analysis with Highlights	Central Bureau of Statistics, National Planning Commission
2	Central Bureau of Statistics, National Planning Commission	-	1991 Population and Housing Census Report B, Statistical Tables, Volume I	Central Bureau of Statistics, National Planning Commission
3	Central Bureau of Statistics, National Planning Commission	-	1991 Population and Housing Census Report B, Statistical Tables, Volume II	Central Bureau of Statistics, National Planning Commission
4	Central Bureau of Statistics, National Planning Commission	-	1991 Population and Housing Census Report B, Statistical Tables, Volume III	Central Bureau of Statistics, National Planning Commission
5	Central Bureau of Statistics, National Planning Commission	-	1992 Population and Housing Census Report C, Statistics on Enumeration Areas	Central Bureau of Statistics, National Planning Commission
6	Central Bureau of Statistics, National Planning Commission	April, 1977	1994/1995 Namibia Agricultural Census: Basic Analysis of Communal Agriculture	Central Bureau of Statistics, National Planning Commission
7	Central Bureau of Statistics, National Planning Commission	April, 1977	1994/1995 Namibia Agricultural Census: Basic Tables of Commercial Agriculture	Central Bureau of Statistics, National Planning Commission
8	Central Bureau of Statistics, National Planning Commission	April, 1977	1994/1995 Namibia Agricultural Census: Basic Tables of Communal Agriculture	Central Bureau of Statistics, National Planning Commission
9	Central Bureau of Statistics, National Planning Commission	April, 1977	1994/1995 Namibia Agricultural Census: Technical Report	Central Bureau of Statistics, National Planning Commission
10	Government of Nmaibia	-	A Digest of the Water Supply and Sanitation Sector Policy of the Government of Namibia	Gamsberg Macmillan
11	Tredoux G	1981	A geohydrochemical investigation of the Stampriet Artesian Basin (Namibia/South West Africa) (in Afrikaans)	Ph.D-dissertation, University of the Orange Free State, South Africa
12	McDonald, M.G. and A.W.Harbaugh	1988	A modular three-dimensional finite-difference ground-water flow model, U.S.G.S. Open-File Report 93-875, Book6, Chap.A1, 576p.	*U.S.G.S.*
13	-	1956	An Approach to Sustainable Water Management Using Natural Resource Accounts	RSA / 1956
14	P.S. Meyer	1999	An Explamation of the 1:500000 General Hydrogeological Map Oudtshoorn 3320	Department of Water Affairs and Forestry, Republic of South
15	P.S. Meyer	1998	An Explamation of the 1:500000 General Hydrogeological Map Port Elizabeth 3324	Geohydrology Department of Water Affiars and Forestry, Republic of South Africa
16	Meat Board of Namibia	1990-1998	Annual Report 1990-1998	Meat Board of Namibia
17	Bank of Namibia	Mar.	Annual Report 2000	Bank of Namibia
18	The Survey-General	1977	Aranos State Water Scheme Memorandum of Drilling and Test Pumping	The Survey-General
19	K.E.L. Schalk and W.Hegenberger	1991	Bibliography of Namibian Earth Science Volume 2	Geological Survey, Ministry of Mines and Energy
20	P.J.Hugo,K.E.L.Schalk and Salaha-Jane Barnes	1983	Bibliography of South West Africa/Namibian Earth Science Volume 1	Geological Survey, Ministry of Mines and Energy
21	D J Huyser	1982	C WAT 50 Chemiese Kwaliteit van die Grondwater in Suidwes-Afrika/Namibie Volume 1	-
22	D J Huyser	1982	C WAT 50 Chemiese Kwaliteit van die Grondwater in Suidwes-Afrika/Namibie Volume 2	-
23	H D Goetze	1982	C WAT 50 Chemiese Kwaliteit van die Ondergrondse in Suidwes-Afrika/Namibie Volume 4 - Benaderde Geografiese Posisies van die	-
24	D J Huyser	1982	C WAT 50 Finale verslag oor die Chemiese Kwaliteit van die Ondergrondse in Suidwes-Afrika/Namibie Volume 3 - Deel I - Onverwerkte Data	-
25	D J Huyser	1982	C WAT 50 Finale verslag oor die Chemiese Kwaliteit van die Ondergrondse in Suidwes-Afrika/Namibie Volume 3 - Deel II - Onverwerkte Data	-

No	Author	Published Year	Title	Publication
26	C.S. Kingsley	1985	CDM Minerak Surveys, Sedimentological Anaysis of The ECCA Sequence in the Kalahari Basin, South West Africa/Namibia,	Gamsberg Macmillan Publishers Ltd
27	C.S. Kingsley	1985	CDM Mineral Surveys Sedimentological Analysis of the Ecca sequence in the Kalahari Basin, South West Africa / Namibia	CDM
28	Geological Survey, Ministry of Mines and Energy	-	CDM Mineral Surveys: Open File Report EG 087 (Aranos Basin) SWA coal project	Geological Survey, Ministry of Mines and Energy
29	C.S. Kingsley	1985	CDM Mineral Surveys: Sedimentological Analysis of the ECCA Sequence in the Kalahari Basin, South West Africa/Namibia	CDM
30	Klaus Dierks	1999	Choronology of Namibian History From Pre-Historycal Time Idependent Namibia	Namibia Scientific Soiety, Windhoek Namibia
31	-	-	Constituency and Regional Boundary Changes	Geological Survey, Ministry of Mines and Energy
32	Central Bureau of Statistics, National Planning Commission	2001	Consumer Prices and Inflation Interim Consumer Price Index: Windhoek	Central Bureau of Statistics, National Planning Commission
33			Deep Borehole Sections, Namibia-Botsuwana	-
34	Jan Davis and Gerry Garvey, with Michael	1993	Developing and Managing Community Water Supplies	Oxfam
35	G.Tredoux, J.C.Vogel J.Kirchner	1978	Die Geohidrologie van DIE ARTESIESE KOM STAMPRIET Deel III : Data	Department of Water Affairs, Ministry of Agriculture, Water and Rural Development
36	G.Tredoux, J.C.Vogel J.Kirchner	1979	Die Geohidrologie van DIE ARTESIESE KOM STAMPRIET Deel II : Kaarte	-
37	Domenico, P A & Schwartz, F W	1990	Domenico, P A & Schwartz, F W, 1990. Physical and chemical hydrogeology	John Wiley & Sons, New York.
38	-	-	Drilling of a Deep Fresh Water Borehole In the Eehnana Area Applying the EDL-Technique, 1998	Namwater
39	Water Reseach Commision	-	Enhanced of the National Groundwater Data Base Facilities -Extended Executive Summary-	Department of Water Affairs, Ministry of Agriculture, Water and Rural Development
40	Ian Clark, Peter Fritz	1997	Environmenal Isotopes in Hydeogeology	CRC Press LLC
41	-	-	Environmental Management Act Act x of 1998 (Final draft)	-
42	Shibasaki, T. et al.	1995	Environmental Management of Groundwater Basins,202p.	Tokai Univ. Press,
43	D.J.L Visser	-	EXPLANATION" GEOLOGICAL MAP, The Geology of the Republics of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of lesotho and Swaziland	GeologicalSurvey Repubic of South Africa
44	-	-	Feasibility Study on measures to secure water supply to the Central Areas of Namibia Vol.I	-
45	-	1997	Feasibiliy Study on the Okavango River to Grootfontein Link of the Easterin Nationl WaterCarrier Volume 1-6	Ministry of Agriculture, Water, Republic of Namibia
46	Eugene J. Wilson	1965	Final Geological Report and Summary of Operations	-
47	-	-	First National Development Plan (NDP1) Volume 1	-
48	-	-	First National Development Plan (NDP1) Volume 2	-
49	Central Bureau of Statistics, National Planning Commision	Sept. 2000	ForeignTrade Statistics: Quaterly Trade Statistics Bulletin April to June 2000	Central Bureau of Statistics, National Planning Commision
50	Central Bureau of Statistics, National Planning Commision	Jun. 2000	ForeignTrade Statistics: Quaterly Trade Statistics Bulletin January to March 1999	Central Bureau of Statistics, National Planning Commision
51	Central Bureau of Statistics, National Planning Commision	Dec. 2000	ForeignTrade Statistics: Quaterly Trade Statistics Bulletin January to March 1999	Central Bureau of Statistics, National Planning Commision
52	Central Bureau of Statistics, National Planning Commision	Jun. 2000	ForeignTrade Statistics: Quaterly Trade Statistics Bulletin January to March 1999	Central Bureau of Statistics, National Planning Commision
53	Central Bureau of Statistics, National Planning Commision	Nov. 2000	ForeignTrade Statistics: Quaterly Trade Statistics Bulletin July to September 2001	Central Bureau of Statistics, National Planning Commision

No	Author	Published Year	Title	Publication
54	Central Bureau of Statistics, National Planning Commision	Dec. 2000	ForeignTrade Statistics: Quaterly Trade Statistics Bulletin October to December 2002	Central Bureau of Statistics, National Planning Commision
55	A.M. Altebaeumer F.J. Altebae	Sep, 1990	Geochemical Evaluation of the PCIAC-GSD Masetlheng Pan-1 Well, Botsuwana and an Oil-Sheep Sample From Namibia	-
56	Weaver, J M C, Talma, A S & Cave, L C	1999	Geochemistry and isotopes for resource evaluation in the fractured rock aquifers of the Table Mountain Group	*Report to the Water Research Commission, WRC Report No 481/1/99.*
57	November A. Mthoko, Norbert H. Noisser, Matthias W. Rebentisch	1992	Geography of Namibia, 1990	Gamsberg Macmillan
58	Tredoux	1981	Geohidorochemiese Ondersoek van die Artiese kom Stampriet, Suidwes-Afrika	-
59	Geological Survey, Ministry of Mines and Energy	1979	Geological Map 1 : 1,000,000	Geological Survey, Ministry of Mines and Energy
60	Geological Survey, Ministry of Mines and Energy	-	Geological Map 1:250,000 KOES	Geological Survey, Ministry of Mines and Energy
61	Geological Survey, Ministry of Mines and Energy	-	Geological Map 1:250,000 LEONARDVILLE	Geological Survey, Ministry of Mines and Energy
62	Geological Survey, Ministry of Mines and Energy	-	Geological Map 1:250,000 ARANOS	Geological Survey, Ministry of Mines and Energy
63	Geological Survey, Ministry of Mines and Energy	1981	Geological Map, 1/250,000 GOBABIS	Geological Survey, Ministry of Mines and Energy
64	J.N.Carney D.T.Aldiss N.P.Lock	1994	Geological Survey Department Bulletin Series The Geology of BOTSUWANA	Department of Water Affairs, Ministry of Agriculture, Water and Rural Development
65	-	-	Glacial Temperature and Moisture Transport Regimes Reconstructed from Noble Gases δ18, Stampriet	-
66	-	-	Government Gazette, General Notice, Office of the Prime Minister	-
67	-	1997	Government Gazette, General Notice, Water Supply Regulations (Windhoek Municipality)	Friedrich Ebert Stiftung / 1997
68	Ake Nilson	1988	Groundwater Dams for Small-scale Water Supply	IT publications
69	-		Groundwater Information System - User Manual, 1992	CSIR / RSA
70	Research Group for Water Balance ed	1973	Groundwater Resources Research, Kyoritsu Shuppan Co., Ltd., 397p. (in Japanese)	-
71	Bear, J	1979	Hydraulics of Groundwater,210p	McGraw-Hill
72	Vogel, J C	1967	Investigation of groundwater flow with	*Isotopes in Hydrology, IAEA,*
73	Germanov, A I, Volkov, G A, Lisitsin, A K & Serebrennikov, V S	1959	Investigation of the oxidation-reduction potential of ground waters	*Geokhimiya,* 3, 322 - 329.
74	-		Isotopic Composition of Groundwater In Semi-Arid Regions of Southern Africa, 1974	-
75	Central Statistics Office, National Planning Commission	1996	Living Condition in Namibia Basic description with highlights the 1993/1994 Namibia Household income and expenditure survey Main Report	Central Statistics Office, National Planning Commission
76	-	1999	Meat Board of Namibia Annual Report 1998	Meatboard of namibia Establishment in terms of the
77	Gerald & Marc Hoberman	1999	NAMIBIA	Gerald & Marc Hoberman Collection Ltd.
78	Dr. Mary Seely	1991	Namibia Drought and Desertification	Gamsberg Macmillan Publishers
79	Nicole Grunert	2000	Namibia Facination of Geology, A travel Handbook	Klaus Hess Publishers
80	-		Namibia Regeonal Resources Manual	Geological Survey, Ministry of Mines and Energy
81	-	1999	Namibia Trade Directory: A preview of Namibian Trade and Industry	-
82	-		Namibia Water Corporation Bill	The Survey General
83	Ginger Mauney	1997	Namibia, Environment, Volume 1	-
84	Christed Stern, Brigitte Lau	1999	Namibian Water Resources and Their Management, Preliminbary History	Brigitte LAU and Christel Stern

No	Author	Published Year	Title	Publication
85	DWA	Jan. 1995	Namibia's Environmental Assessment Policy – For Sustainable Development and Environmental Conservation	–
86	Piet Heyns, Sharon Montgomery,John Pallett, Mary Seely	1998	Namibia's Water A Decision Makers' Guide	DWA and the Desert Research Foundation of Namibia
87	Central Bureau of Statistics, National Planning Commission	Aug. 1999	National Accounts 1983-1998	Central Bureau of Statistics, National Planning Commission
88	Ministry of Agriculture, Water and Rural Development		National Agricultural Policy	Ministry of Agriculture, Water and Rural Development
89	Ministry of Agriculture, Water and Rural Development	Aug. 2000	National Water Policy White Paper: Policy Framework for Equitable, Efficient, and Sustainable Water Resources Management and Water Services	Ministry of Agriculture, Water and Rural Development
90	Harold Fullar (ed) J.L. Earle (ed)	1996	New Visual Atlas	George Philop & Son Limited, London
91	Harold Fullard, M.Sc.	1996	New Visual Atlas, New Syllabus	JUTA & CO, LTD, Kenwyn 7790
92	G. Dolby	1989	Palynological Analysis of Core Samples from the VREDA 281 No. 1 Well, Namibia	–
93	Shibasaki, T.	1972	Permissive Capacity in Groundwater Pollution	Environmental Information Science
94	Domenico, P.A. and F.W. Schwatrs	1998	Physical and Chemical Hydrogeology, 2nd ed., John Wiley and Sons, 506p.	Inc.
95	Hill, M.C.	1990	Preconditioned Conjugate-Gradient 2 (PCG2), A computer program for solving ground-water flow equations, U.S.G.S. Water-Resour. Invest. Report 90-4048, 43p.	U.S.G.S
96	–	1986	Progress Report No.1 on the Stampriet Artesian Basin, Results of the Borehole Survey within the Stampriet – Gochas Area, Report No. 3100/9/G21, 19p	Department of Water Affairs, South West Africa/Namibia
97	–	1987	Progress Report No.2 on the Stampriet Artesian Basin, Results of the Borehole Survey within the Aranos – Leonardville Area, Report No.	Department of Water Affairs, South West Africa/Namibia
98	–	1989	Progress Report No.3 on the Stampriet Artesian Basin, Results of the Borehole Survey in Area 3, the North-Western Intake Area, Report No. 12/9/G3, 17p.	Department of Water Affairs, South West Africa/Namibia
99	–	1999	Publicatation and Open File, Price List	Ministry of Mines and Energy
100	Bank of Namibia	Jun.	Quarterly Bulletin June 2001 Volime 10 No.2	Bank of Namibia
101	–		Regional Geoscience Division	Geological Survey, Ministry of Mines and Energy
102	–	1999	Republic of Namibia 1998/1999 Annual Agricultural Survey, Basic Amaysis of Communal Agriculture	Central Bureau of Statistics National Planning Commission, Windhoek
103	National Planning Commission/UNDP/NEPRU/XFAM		Section throuth the Kalahari between Auob & Nossob rivers	National Planning Commission/UNDP/NEPRU/XFAM
104	The Survey-General	1976	Simplified Geological Map of Namibia 1 : 2 000	The Survey-General
105	Geological Survey, Ministry of Mines and Energy	1998	Some notes on the Geohydrology and Hydrochemistry of the Salt Block whithin the Stampriet	Geological Survey, Ministry of Mines and Energy
106	Piet van Wyk	1993	South Africa, Trees, A photographic Guide	Struik publishers, Ltd, Cape
107	The Water and Environment Team	1998	State of the Enivironment Report Water in Namibia (DRAFT)	Milano, Agip C.
108	Office of the President, National Planning Commision, Central Bureau of Statistics	Oct. 1999	Statistical Abstract 1999 No.6	Office of the President, National Planning Commision, Central Bureau of Statistics
109	Mannheim, F T	1961	Stockholm Contributions in Geology, 8, p 27.	Mannheim, F T, 1961. Stockholm Contributions in Geology, 8, p 27.
110	World Bank United Nations Development	Apr. 1995	Sub Saharan African Hydrological Assessment SADC countries Country Report: Namibia (Draft Report)	World Bank United Nations Development Programme
111	Center for Development Cooreration Services, Vrie Universitiet Amstedam	1996	Successful natural resource management in South Africa	Gamsberg Macmillan publishers Ltd

No	Author	Published Year	Title	Publication
112	-	Jan.1990	Technical Cooperation Hydrocarbon Exploration	Department of Water Affairs, Ministry of Agriculture, Water and Rural Development
113	Stephen Devereux Martin Rimmer Devie LeBeau Wade Pendleton	Dec. 1993	The 1992/1993 Drought in Namibia: An Evaluation of its socio-economic impact on affected household	Social Sciences Division, Multi-Displinary Research Centre, University of Namibia
114	Vogel, J C, Talma, A S & Heaton, T H E	1982	The age and isotopic composition of groundwater in the Stampriet Artesian Basin, SWA	Final report to the Steering committee for Water Research in SWA. NPRL, CSIR, Pretoria, Project 400/90615.
115	-	-	The Age and Isotopic composition of Groundwater in the Stampriet Artesian Basin, SWA (April,1982)	-
116	-	1977	The Age and Isotopic composition of Groundwater in the Stampriet Artesian Rasin, SWA	The Survey-General
117	Geological Survey, Ministry of Mines and Energy	1980	The Artesian Area in South West Africa	Geological Survey, Ministry of Mines and Energy
118	G. Dolby	Aug. 1990	The Biostratigraphy of the G.S.D. P.C.I.A.C. Masetlheng Pan-1 Well, Botsuwana	-
119	Tredoux G & Kirchner J	1981	The evolution of the chemical composition of artesian water in the Auob Sandstone (Namibia/South West Africa)	Trans. Geol. Soc. S.Afr., 84, 169 - 175
120	Drever, J I	1988	The geochemistry of natural waters. Second Edition.	Second Edition. Prentice Hall, New Jersey.
121	Tredoux G & Kirchner J	1979	The geohydrology of the Stampriet Artesian Basin	Report submitted to the Steering Committee for Water Research in South West Africa (Namibia).
122	World Trade	1998	The Namibian Development Services Directory	World Trade Organization / 1998
123	W. Hegenberger	-	The Regional Geology of Northeast South West Africa/Namibia (1982)	Geological Survey, Ministry of Mines and Energy
124	-	-	The Stampriet Artesian Basin, with Special Reference to the Salt Block	Geological Survey, Ministry of Mines and Energy
125	Kirchner J & Tredoux G,	1975	The Stampriet Artesian Basin, with special reference to the Salt-block: The chemical composition of the ground water with respect to Geological Formations	Presented at SARCCUS Meeting, Bulawayo, Zimbabwe, May
126	-	1995	The United Nations Development programme, Sub Saharan Africa Hydrological Assessment, SADC Countries	The World Bank
127	Schalk, K	1961	The water balance of the Uhlenhorst cloudburst in South West Africa	The water balance of the Uhlenhorst cloudburst in South West Africa
128		1994	Understaindg the Oshana Environment	Gamsberg Macmillan Publishes
129	Harbaugh, A.W. and M.G.McDonald	1996	User's documentation for MODFLOW-96, an update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model, U.S.G.S. Open-File Report 96-485, 56p.	U.S.G.S
130	The Department of Water Affairs and	1998	Waste Management and the Minimum Requirements, First Edition	-
131	Geological Survey, Ministry of Mines and Energy	-	Water Act No.54 of 1956	Geological Survey, Ministry of Mines and Energy
132	-	1994	Water In Namibia, 1994	Department of Water Affairs, Ministry of Agriculture, Water and Rural Development