Okavango River Basin Transboundary Diagnostic Analysis Technical Report

OKACOM

The Permanent Okavango River Basin Water Commission

Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 2 of 4: Indicator Results) Report No: 07/2009

J.M. King, et al.

December 2009

Environmental protection and sustainable management of the Okavango River Basin

EPSMO

ENVIRONMENTAL FLOW ASSESSMENT SERIES

DOCUMENT DETAILS

PROJECT	Environment protection and sustainable management of the Okavango River Basin: Preliminary Environmental Flows Assessment
TITLE:	Scenario Report: Ecological and social predictions. Indicator results
VOLUME:	Volume 2 of 4
DATE:	December 2009
LEAD AUTHORS:	The Angola, Namibian and Botswana Discipline Specialists (see The Team).
REPORT NO.:	07/2009
PROJECT NO:	UNTS/RAF/010/GEF
FORMAT:	MSWord and PDF.
CONTRIBUTING AUTHORS:	J.M. King, C.A.Brown, A.R. Joubert, J. Barnes.

THE TEAM

Project Managers
Chaminda Rajapakse
Nkobi Moleele
Geofrey Khwarae

Angola
Manual Quintino (Team Leader and OBSC member)
Carlos Andrade
Helder André de Andrade e Sousa
Amândio Gomes
Filomena Livramento
Paulo Emilio Mendes
Gabriel Luis Miguel
Miguel Morais
Mario João Pereira
Rute Saraiva
Carmen Santos

Namibia
Shirley Bethune (Team Leader)
Colin Christian
Barbara Curtis
Celeste Espach
Aune-Lea Hatutale
Mathews Katjimune assisted by Penehafo Shidute
Andre Mostert
Shishani Nakanwe
Cynthia Ortmann
Mark Paxton
Kevin Roberts
Ben van de Waal
Dorothy Wamunyima assisted by Ndinomwaameni Nashipili

Botswana
Casper Bonyongo (Team Leader)
Pete Hancock
Lapologang Magole
Wellington Masamba
Hilary Masundire
Dominic Mazvimavi
Joseph Mbaiwa
Gagoitseope Mmopelwa
Belda Mosepele
Keta Mosepele
Piotr Wolski

EFA Process Management
Jackie King
Cate Brown
Hans Beuster
Jon Barnes
Alison Joubert
Mark Rountree

Okavango Basin Steering Committee
Tracy Molefi-Mbui
Laura Namene

List of reports in report series

Report 01/2009: Project Initiation Report
Report 02/2009: Process Report
Report 03/2009: Guidelines for data collection, analysis and scenario creation
Report 04/2009: Delineation Report
Report 05/2009: Hydrology Report: Data and models
Report 06/2009: Scenario Report: Hydrology (2 volumes)
Report 07/2009: Scenario Report: Ecological and social predictions (4 volumes)
Report 08/2009: Final Report

Other deliverables:
DSS Software
Process Management Team PowerPoint Presentations

Citation

This document should be cited as:

EPSMO-BIOKAVANGO Eflows Team. 2009. Scenario Report. Report 07-2009 vol. 2 of 4. EPSMO/BIOKAVANGO Okavango Basin Environmental Flows Assessment Project, OKACOM, Maun, Botswana. 220 pp.

Acknowledgements

Many thanks for logistical support to:

- Corinne Spadaro of FAO)
- Ros Townsend, Karl Reinecke and Rembu Magoba of Southern Waters

Executive Summary

The Okavango River Basin Commission, OKACOM, initiated a project titled the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO). This was approved by the United Nations Development Program (UNDP), to be executed by the United Nations Food and Agriculture Organization (FAO). The standard UNDP process is a Transboundary Diagnostic Analysis followed by a Strategic Action Programme of joint management to address threats to the basin's linked land and water systems. Because of the pristine nature of the Okavango River, this approach was modified to include an Environmental Flow Assessment (EFA). To complete the EFA, EPSMO collaborated with the BIOKAVANGO Project at the Harry Oppenheimer Okavango Research Centre of the University of Botswana, in 2008 to conduct a basin-wide EFA for the Okavango River system.

This is report number 7 (Volume 2 in the report series for the EFA. It summarises the predicted biophysical and socioeconomic impacts linked to climate change, with the details of the DSS outputs provided in volume 4 of this report.

Table of Contents

1. INTRODUCTION 13
1.1. Project background 13
1.2. Objectives of the EF assessment 13
1.3. The scenarios 14
1.4. Presentation of the results 14
1.4.1 Rivers and delta 14
1.4.2 Societal wellbeing 14
1.5. Economic value 14
1.6. The location of the ecological sites and links with IUAs 14
2. Indicators 16
2.1.1 The nature and purpose of indicators 16
2.1.2 Biophysical indicators 16
2.1.3 Social indicators 17
3. GEOMORPHOLOGY 19
3.1. Photographs 20
3.1.1 Extent - Exposed Rocky Habitat 20
3.1.2 Extent – Coarse Sediments 20
3.1.3 Cross Sectional Area of Channel 21
3.1.4 Extent of Backwaters 21
3.1.5 Extent of Vegetated Islands 21
3.1.6 Sand Bars at low flow 22
3.1.7 Percentage Clays on Floodplain 22
3.1.8 Extent of inundated floodplain 23
3.1.9 Inundated Pools and Pans 23
3.1.10 Extent of Cut Banks 24
3.1.11 Carbon sequestration 24
3.2. Extent - Exposed Rocky Habitat 25
3.3. Extent of Coarse Sediments On The Bed 27
3.4. Cross Sectional Area of Channel 27
3.5. Extent of Backwaters 29
3.6. Sand Bars at low flow 31
3.7. Extent of Vegetated Islands 33
3.8. Percentage Clays on Floodplain 35
3.9. Extent of inundated floodplain 37
3.10. Inundated Pools & Pans 39
3.11. Extent of Cut Banks 41
3.12. Peat - carbon storage 43
4. Water Quality 44
4.1. Photographs 44
4.2. pH 45
4.3. Conductivity 47
4.4. Temperature 49
4.5. Turbidity 51

4.6. Dissolved oxygen....53
4.7. Total nitrogen....55
4.8. Total phosphorus....57
4.9. Chlorophyl a....59
5. Vegetation....61
5.1. Photographs....62
5.1.1 Channel Macrophytes....62
5.1.2 Lower Wet Bank (hippo grass, papyrus)....62
5.1.3 Upper Wet Bank 1 (reeds)....62
5.1.4 Upper Wet Bank 2 (trees, shrubs)....63
5.1.5 River Dry Bank....63
5.1.6 Floodplain Dry Bank....64
5.1.7 Floodplain residual pools....64
5.1.8 Lower Floodplain....65
5.1.9 Middle floodplain (grasses)....65
5.1.10 Upper Floodplain (trees)....66
5.2. Channel macrophytes....67
5.3. Lower Wet Bank (hippo, papyrus)....69
5.4. Upper Wet Bank 1 (reeds)....71
5.5. Upper Wet Bank 2 (treeshrubs)....73
5.6. River Dry Bank....75
5.7. FP resid pools, Open water (6)....77
5.8. Lower floodplain....79
5.9. Middle floodplain (grasses)....81
5.10. Upper floodplain (trees)....83
5.11. Floodplain Dry Bank....85
5.12. Open waters....87
5.13. Permanent swamps....88
5.14. Lower floodplain....89
5.15. Upper floodplain....90
5.16. Occasionally flooded grassland....91
5.17. Sporobolus Islands....92
5.18. Riparian woodland, trees....93
5.19. Savanna and scrub....94
5.20. Wet bank....95
6. Macroinvertebrates....96
6.1. Photographs....96
6.2. Channel-submerg veg....97
6.3. Channel-marg veg....99
6.4. Channel-fine sed....101
6.5. Channel-cobbles, boulders....103
6.6. Channel rapid, fast flowing....105
6.7. Channel-pools....107
6.8. FP-marg veg....109
6.9. FP-pools, backw (seasonal fp 7)....111
7. Fish....113

7.1. Photographs 114
7.1.1 Fish resident in river 114
7.1.2 Migrate floodplain small fish 114
7.1.3 Migrate floodplain large fish 114
7.1.4 Fish–sandbank dweller 114
7.1.5 Fish-rock dweller 115
7.1.6 Fish-marginal vegetation 115
7.1.7 Fish in backwaters 115
7.2. Fish resident in river 117
7.3. Migrate fplain small fish 119
7.4. Migrate fplain large fish 121
7.5. Fish-Sandbank dweller 123
7.6. Fish-Rock dweller 125
7.7. Fish-marginal vegetation 127
7.8. Fish in backwaters 129
8. Wildlife 131
8.1. Photographs 131
8.1.1 Semi Aquatics (hippos, crocodiles) 131
8.1.2 Frogs, river snakes 132
8.1.3 Lower floodplain grazers 132
8.1.4 Middle floodplain grazers 133
8.1.5 Outer floodplain grazers 133
8.2. Semi Aquatics 135
8.3. Frogs, river snakes 137
8.4. Lower floodplain grazers 139
8.5. Middle floodplain grazers 141
8.6. Outer floodplain grazers 143
9. Birds 145
9.1. Photographs 145
9.1.1 Piscivores – open water 145
9.1.2 Piscivores – shallow water 146
9.1.3 Piscivores and invertebrate feeders 146
9.1.4 Specialists – floodplains 147
9.1.5 Specialists – water lilies 147
9.1.6 Specialists – fruit trees 147
9.1.7 Breeders – reedbeds, floodplains 148
9.1.8 Breeders – overhanging trees 148
9.1.9 Breeders – banks 149
9.1.10 Breeders – rocks, sandbars 149
9.2. Piscivores, open water 151
9.3. Piscivores, shallow water 153
9.4. Piscivores 155
9.5. Specialists, floodplains 157
9.6. Specialists, water lilies 159
9.7. Specialists, fruit trees 161
9.8. Breeders, reedbeds and fldplns 163

9.9. Breeders, overhanging trees 165
9.10. Breeders, banks 167
9.11. Breeders, rocks, sandbars 169
10. Socio-economic indicators 171
10.1. Photographs 171
10.1.1 Household income - fish 171
10.1.2 Household income - reeds 171
10.1.3 Household income - floodplain grass 172
10.1.4 Household income - floodplain gardens (molapo farming) 172
10.1.5 Household income and wealth - livestock 173
10.1.6 Household income - tourism 173
10.1.7 Wellbeing/welfare from intangibles 174
10.1.8 Indirect use 175
10.1.9 Non-use 175
10.2. Household income - fish 176
10.3. Household income - reeds 181
10.4. Household income - floodplain grass 186
10.5. Household income - floodplain gardens (e.g. molapo farming) 191
10.6. Household income and wealth - livestock (floodplain grazing) 195
10.7. Household income and macro effects - tourism 200
10.8. Potable water/water quality 205
10.9. Wellbeing/welfare from intangibles 208
10.10. Indirect use 209
10.11. Non use 210

List of Figures

Figure 1.1 Map showing site locations and linked IUAs.....15

Plus: Time-series graphs for each indicator.

List of Tables

Table 1.1 The Environmental Flow (EF) sites and their corresponding socio-economic Integrated Unit of Analysis (IUA) 15
Table 2.1 Biophysical indicators used in the EPSMO/BIOKAVANGO EF process.....16

Acronyms and abbreviations

DWAF	Department of Water Affairs and Forestry
EFA	Environmental Flow Assessment
EPSMO	Environmental Protection and Sustainable Management of the Okavango River Basin
Ha	hectare
HOORC	Harry Oppenheimer Okavango Research Centre
IUA	Integrated Units of Analysis
PD	Present Day
SAP	Strategic Action Programme
TDA	Transboundary Diagnostic Analysis

1. INTRODUCTION

1.1. Project background

The origin of the project is described in Report 01/2009: Project Initiation Report. Essentially, an OKACOM initiative titled the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) project was approved by the United Nations Development Program (UNDP), to be executed by the United Nations Food and Agriculture Organization (FAO). In 2008 it collaborated with the Biokavango Project at the Harry Oppenheimer Okavango Research Centre (HOORC) of the University of Botswana, to conduct a basin-wide Environmental Flows Assessment (EFA) for the Okavango River system. This would be a major part of a standard UNDP process: a Transboundary Diagnostic Analysis (TDA) followed by a Strategic Action Programme (SAP) of joint management to address threats to the basin's linked land and water systems. In the case of the Okavango Basin, the standard approach, designed for rehabilitating degraded rivers, would be modified because of the near-pristine nature of the river ecosystem.

The EFA began with a Planning Meeting in July 2008 and was finalised in June 2009. It used mainly existing knowledge and understanding of the river ecosystem and its users. It was generally acknowledged that this was a first, low-confidence, trial run of an EFA for this system, which should be followed by a more comprehensive and long-term exercise where important missing data and knowledge could be addressed to provide higher-confidence predictions.

1.2. Objectives of the EF assessment

There were two main objectives.

- Complete a basin-wide EFA of the Okavango River system as a major part of the wider Technical Diagnostic Analysis. This would be done through several subsidiary objectives:
    - Collate all existing hydrological data on the river system and set up a basin hydrological model that could simulate flows under various possible future Scenarios
    - Reach agreement with the three riparian governments on the scenarios to be explored
    - Bring together specialists in a range of relevant disciplines from across the basin to share knowledge and data, and reach consensus on the:
        - relationships between flow and a series of biophysical indicators of the river system
        - relationships of the condition of the ecosystem and social indicators
    - Develop a DSS that would capture these relationships and produce predictions of ecological and social change for each scenario that would complement the macroeconomic predictions emanating from a separate exercise
    - Incorporate the EFA findings in the TDA document.
- Promote basin-wide communication and collaboration, and build capacity in collaborative basin-wide Integrated Water Resource Management in all disciplines in all three countries. This was done by appointing a full biophysical and socio-economic team from each of the three countries, with planning, coordination and training done by a Process Management Team.

1.3. The scenarios

Through a process of government consultation, three scenarios of increasing water-use were chosen for the EFA, viz. low, medium and high water use. The details are provided in Report 06/2009: Scenario Report: Hydrology, and in Volume 1 of this report.

1.4. Presentation of the results

1.4.1 Rivers and delta

For each scenario, the predicted changes in the river and delta are evaluated in three ways:

1. time-series of abundance, area or concentration of key indicators (see list in Chapter) under the flow regime resulting from each scenario (This report);
2. estimated mean percentage changes from present day in the abundance, area or concentration of key indicators (This report);
3. estimated change in discipline-specific integrity, relative to present day (Volume 1)
4. estimated change in overall ecological integrity, relative to present day (Volume 1).

1.4.2 Societal wellbeing

For each scenario the predicted changes to socio-economic wellbeing are measured in the following ways:

1. time-series of production measure (catch, harvest or output) of key socio-economic indicators (see list in Chapter 2) under the flow regime resulting from each scenario (This report);
2. estimated mean percentage changes from present day in production measure (catch, harvest or output) of key indicators (This report);
3. estimated change in terms of livelihoods (net income or wellbeing) measured in national currency, for key indicators (this report);
4. estimated change in terms of contribution to national income of basin countries (change in gross national income), measured in national currency, for key indicators (this report).

1.5. Economic value

In a separate exercise, the same three Scenarios were assessed in macroeconomic terms, so that a balanced assessment of the costs and benefits of development could be produced. This involved valuation of the water use developments in the scenarios and comparison of these with the national income measures for flow change indicators measured in the socio-economic component. These are reported in the TDA macro-economic key background report.

1.6. The location of the ecological sites and links with IUAs

The number, and to some extent the position, of the eight biophysical sites was dictated by financial, time and safety constraints, and they did not represent the entire basin. The locations of the eight sites, chosen in an exercise described in Report 04/2009: Delineation Report, are given in Table 1.1 and Figure 1.1.

Each biophysical site corresponded to a wider, socio-economic Integrated Unit of Analysis (IUA; Figure 1.1), where it was used to represent the predicted river changes that would affect people.

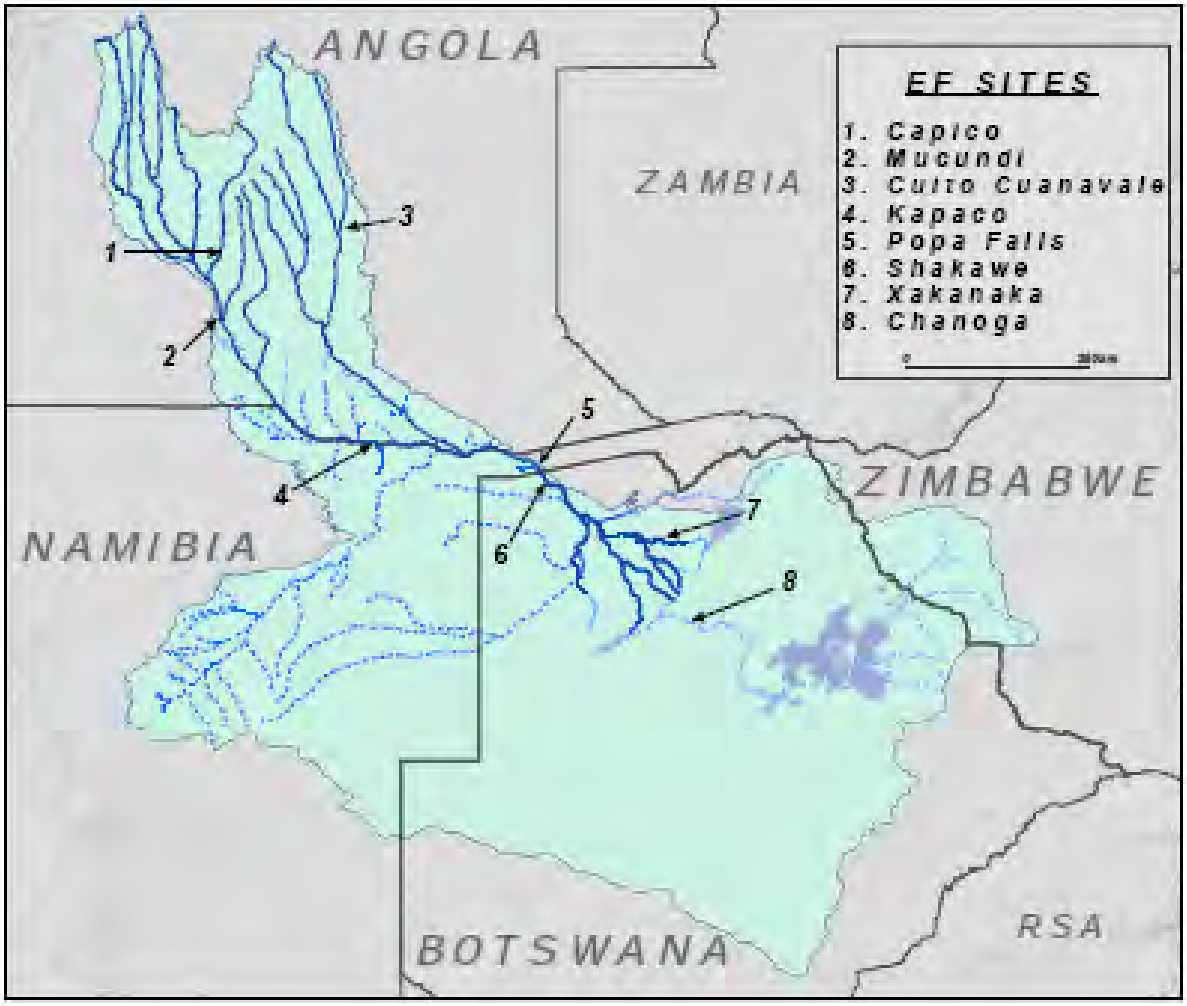


Figure 1.1 **Map showing site locations**

Table 1.1 **The Environmental Flow (EF) sites and their corresponding socio-economic Integrated Unit of Analysis (IUA)**

EF Site	EF Site name	Coordinates	Socio-economic IUA
1	Cuebe @ Capico	15° 33' 05" S 17° 34' 00" E	3
2	Cubango @ Mucundi	16° 13' 05" S 17° 41' 00" E	2
3	Cuito @ Cuito Cuanavale	15° 10' 11" S 19° 10' 06" E	6
4	Okavango @ Kapako	17° 49' 07" S 19° 11' 44" E	8
5	Okavango @ Popa Falls	18° 07' 02" S 21° 35' 03" E	9
6	Okavango @ Panhandle	18° 21' 16" S 21° 50' 13" E	10
7	Okavango Delta @ Xaxanaka	19° 11' 09" S 23° 24' 48" E	11
8	Boteti	20° 12' 51" S 24° 07' 37" E	12

2. Indicators

2.1.1 The nature and purpose of indicators

In this EFA two kinds of indicators are used: biophysical and socioeconomic. They represent attributes of the ecological and social system that are thought to be either directly or indirectly linked to the river and its flow regime. Their predicted changes as flows change provide a composite picture of the ecological and social impacts of the chosen water-resource developments.

2.1.2 Biophysical indicators

Biophysical indicators are attributes of the river ecosystem that can be described in terms of abundance (e.g. number of elephants), area (e.g. area of exposed sand banks), concentration (e.g. nitrates, conductivity) or cover (e.g. vegetation communities.

Those chosen by the biophysical team for use in this project are listed in Table 2.1.

Table 2.1 Biophysical indicators used in the EPSMO/BIOKAVANGO EF process

Discipline	Sites	Indicators used
Geomorphology	1-6	Extent - exposed Rocky Habitat
		Extent - Coarse Sediments
		Cross Sectional Area of Channel
		Extent of Backwaters
		Extent of Vegetated Islands
		Sand Bars at low flow
		Percentage Clays on Floodplain
		Extent of inundated floodplain
		Inundated Pools and Pans
		Extent of Cut Banks
	7	Carbon sequestration
Water Quality	1-8	pH
		Conductivity
		Temperature
		Turbidity
		Dissolved oxygen
		Total nitrogen
		Total phosphorus
		Chlorophyll a
Vegetation	1-6	Channel macrophytes
		Lower Wet Bank (hippo grass, papyrus)
		Upper Wet Bank 1 (reeds)
		Upper Wet Bank 2 (trees, shrubs)
		River Dry Bank
		Floodplain Dry Bank
		Floodplain residual pools
		Lower floodplain
		Middle floodplain (grasses)
		Upper floodplain (trees,)
	7	Open waters
		Permanent swamps
		Lower floodplain
		Upper floodplain
		Occasionally flooded grassland
		Sporobolus islands
		Riparian woodland, trees

Discipline	Sites	Indicators used
		Savanna and scrub
	8	Open water
		Riparian woodland, trees
Macroinvertebrates	1-8	Channel-submerged vegetation
		Channel-marginal vegetation
		Channel-fine sediments
		Channel-cobbles, boulders
		Channel rapid, fast flowing
		Channel-pools
		Floodplain-marginal vegetation
		Floodplain-pools, backwaters
	Plus for 7	Mopane woodland-pools
Fish	1-8	Fish resident in river
		Migrate floodplain small fish
		Migrate floodplain large fish
		Fish-sandbank dweller
		Fish-rock dweller
		Fish-marginal vegetation
		Fish in backwaters
Wildlife	1-8	Semi Aquatics (hippos, crocodiles)
		Frogs, river snakes
		Lower floodplain grazers
		Middle floodplain grazers
		Outer floodplain grazers
Birds	1-8	Piscivores - open water
		Piscivores - shallow water
		Piscivores and invertebrate feeders
		Specialists - floodplains
		Specialists - water lilies
		Specialists - fruit trees
		Breeders - reedbeds, floodplains
		Breeders - overhanging trees
		Breeders - banks
		Breeders - rocks, sandbars

2.1.3 Social indicators

Social indicators are measures of human wellbeing in the river ecosystem that can be affected by changes in flow. They are categorised as those that affect household livelihoods or wellbeing in the basin, and those that affect the broader economies of the basin countries and outside that.

Those chosen by the socio-economic team for use in this project are listed in Figure 2.1

Figure 2.1 **List of socio-economic indicators used in the EFA and their links to the broader economy**

3. GEOMORPHOLOGY

This section provides the time-series of area of geomorphology indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Extent - Exposed Rocky Habitat
- Extent - Coarse Sediments
- Cross Sectional Area of Channel
- Extent of Backwaters
- Extent of Vegetated Islands
- Sand Bars at low flow
- Percentage Clays on Floodplain
- Extent of inundated floodplain
- Inundated Pools and Pans
- Extent of Cut BanksCarbon sequestration.

3.1. Photographs

3.1.1 Extent - Exposed Rocky Habitat

Photo: C Christian

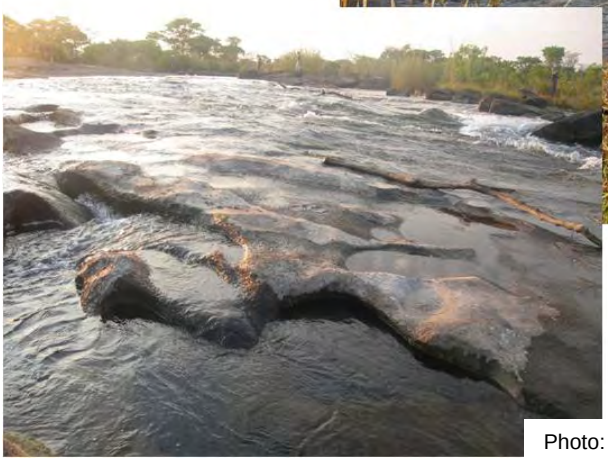


Photo: J King

3.1.2 Extent – Coarse Sediments

Photo: C Christian

3.1.3 Cross Sectional Area of Channel

Photo: C Christian

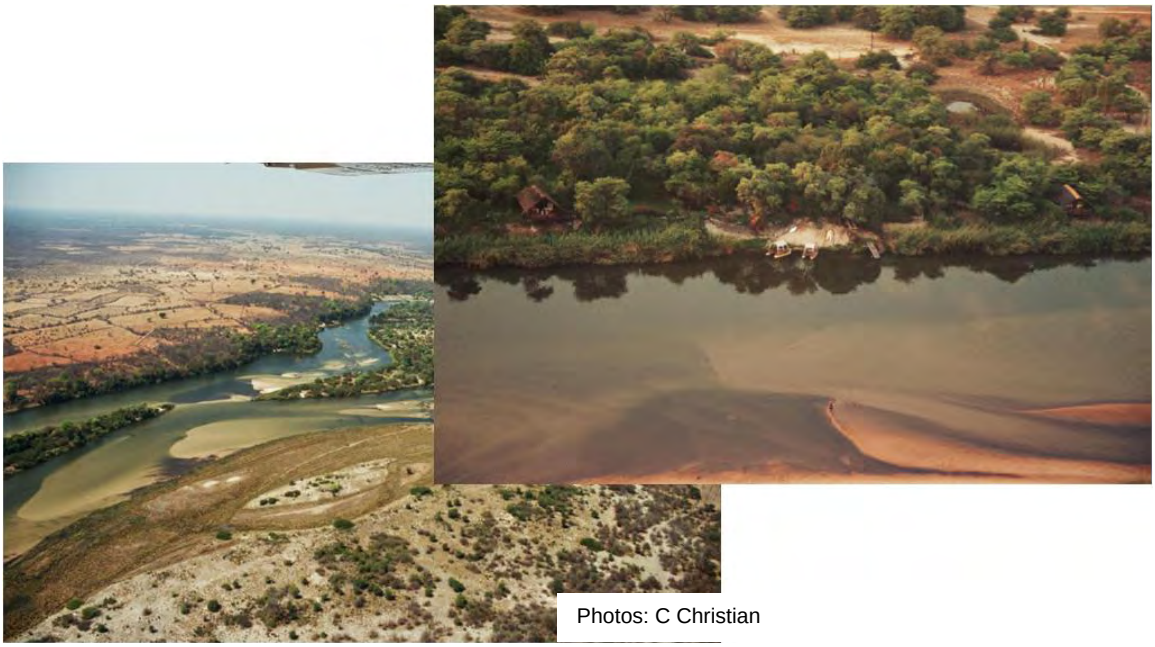
3.1.4 Extent of Backwaters

Photo: C Christian

3.1.5 Extent of Vegetated Islands

Photo: C Christian

3.1.6 Sand Bars at low flow



Photos: C Christian

3.1.7 Percentage Clays on Floodplain

Photo: C Christian

3.1.8 Extent of inundated floodplain

Photo: C Christian

3.1.9 Inundated Pools and Pans

Photo: C Christian

Photos: J King

3.1.10 Extent of Cut Banks

Photos: J King

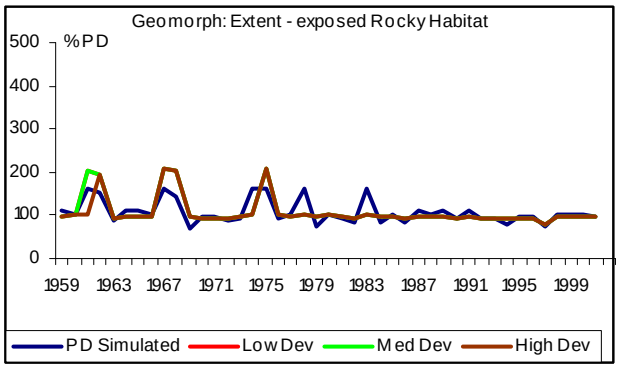
3.1.11 Carbon sequestration

Photo: B Curtis

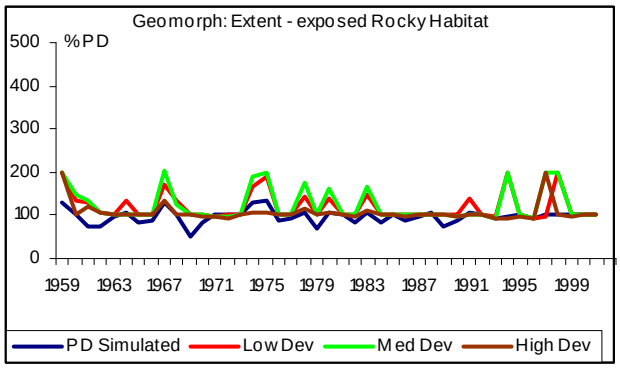
3.2. Extent - Exposed Rocky Habitat

(Extent of Exposed Rocky Habitat during the low flow season.)- Not considering the impacts of sediment deposition covering bedrock exposures; only considering the exposed bedrock above the water surface.

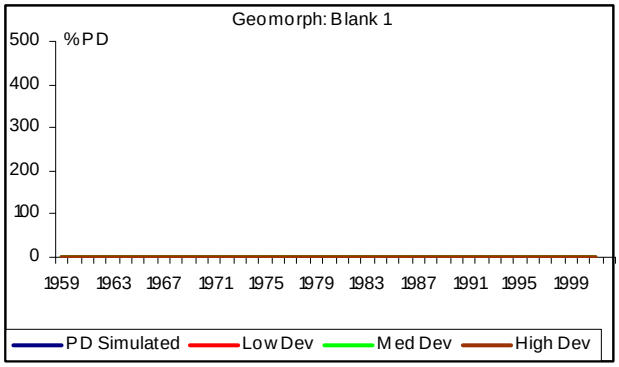
Site 1: Cubango River @ Capico



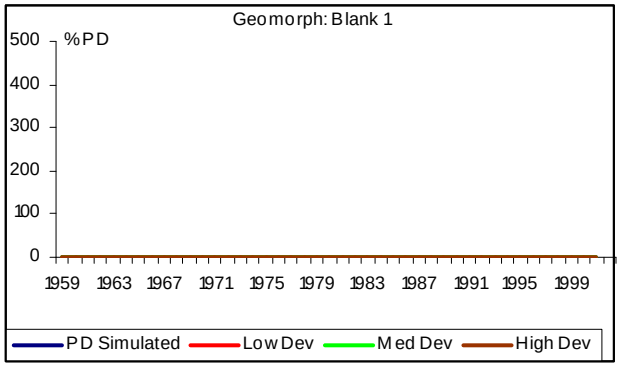
Site 2: Cubango River @ Mucundi



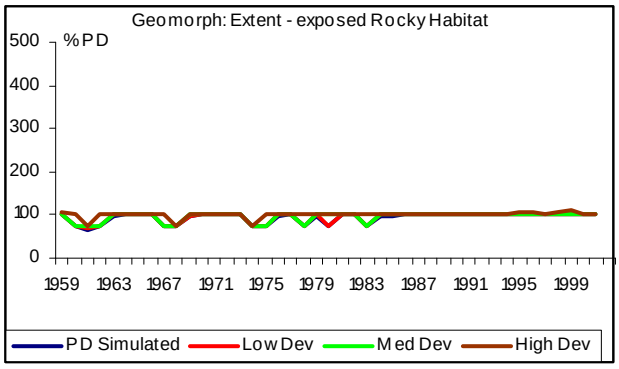
Site 3: Cuito River @ Cuito Cuanavale



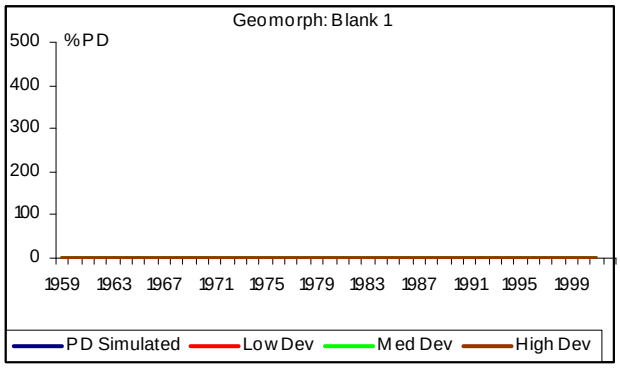
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

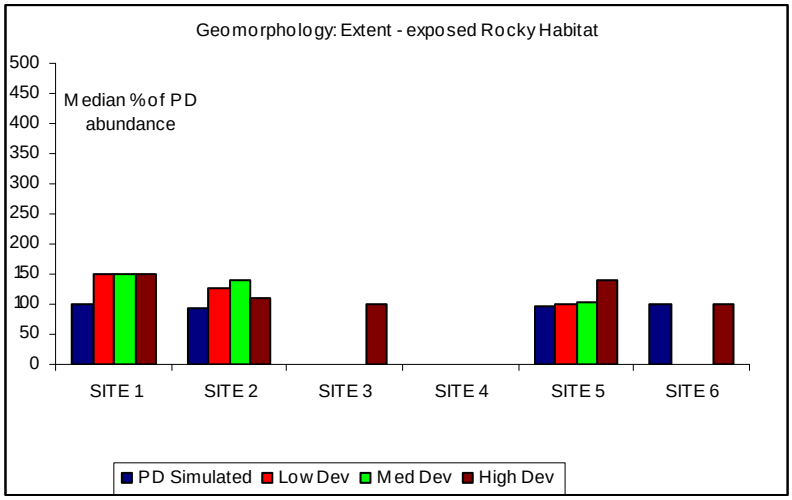


Site 6: Okavango River @ Pan Handle



Summary change per scenario

There is a direct relationship between flow level and rocks exposed above water level. As water level rises, less rocky area is exposed.



Low Scenario

A lot of abstraction is planned in an early phase upstream from Capico. Therefore a greater area of rocks is exposed during the low flow season.

Moderate Scenario

Noticeable increase in exposure of rock at Popa.

High Scenario

Permanent above-median exposure of rocks at Popa, still fluctuating seasonally.

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

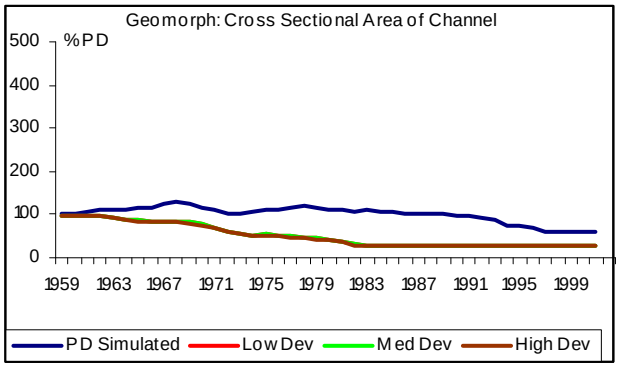
3.3. Extent of Coarse Sediments On The Bed

Not used in predictions.

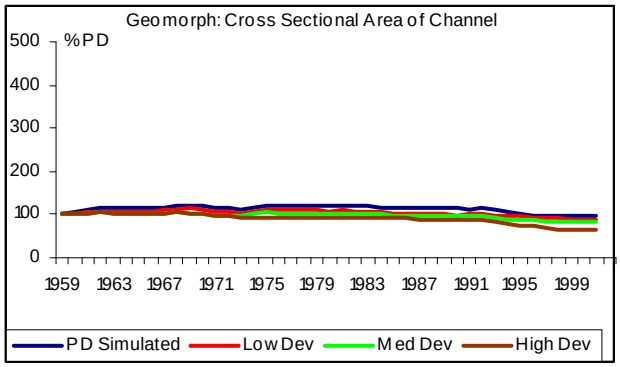
3.4. Cross Sectional Area of Channel

(Cross Sectional Area of Bank Full Channel.)- This refers to the well-defined channel on aerial photographs, which carries the bulk of the flood. It is the perennial channel in present day conditions.

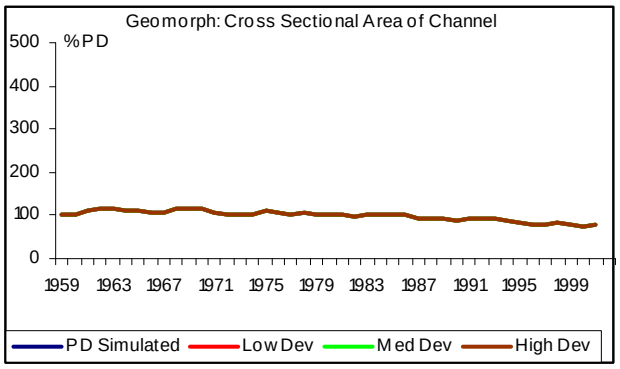
Site 1: Cubango River @ Capico



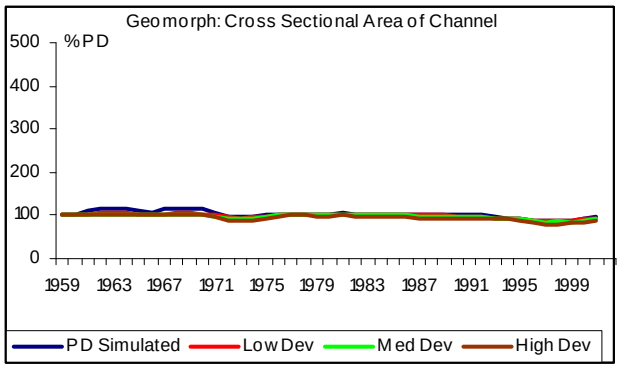
Site 2: Cubango River @ Mucundi



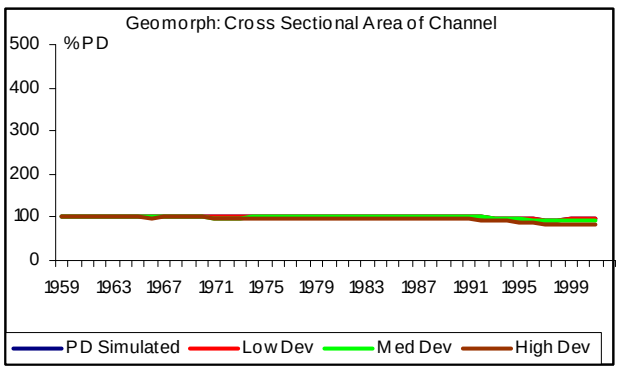
Site 3: Cuito River @ Cuito Cuanavale



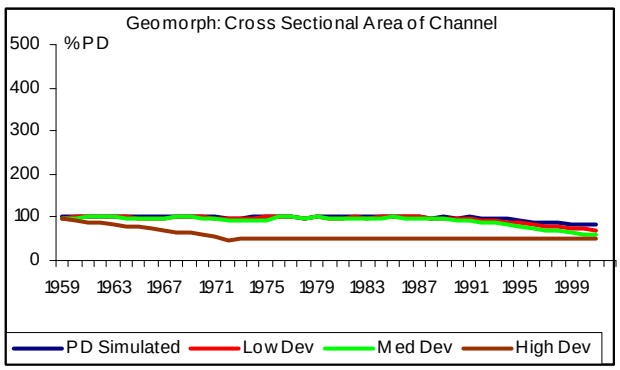
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

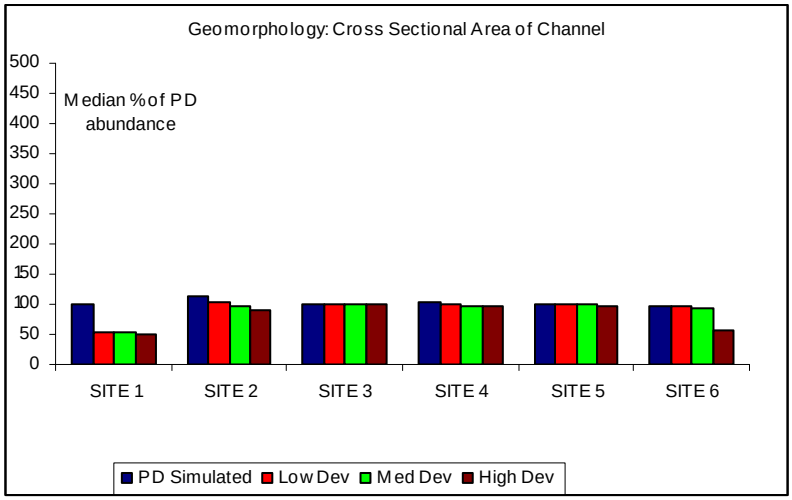


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Channel cross section responds mainly to flood conditions. Floods larger than the historical maximum should rapidly enlarge the cross sectional area. However, the channel also responds to low flow conditions or extended low flow conditions - which enables vegetation to encroach into the channel, trapping sediment, and ultimately reducing the channel cross section. This process is much slower than channel enlargement. However, intervening floods are expected to undo this trend.



Low Scenario

Channels would tend to get smaller, slowly, but flood peaks still come through and reset the channel size.

Moderate Scenario

A state between low and high flow scenarios.

High Scenario

Channels get smaller due to reduced flows, but now large floods are less frequent and smaller. Therefore resetting does not occur and there will be a cumulative trend towards smaller channel section.

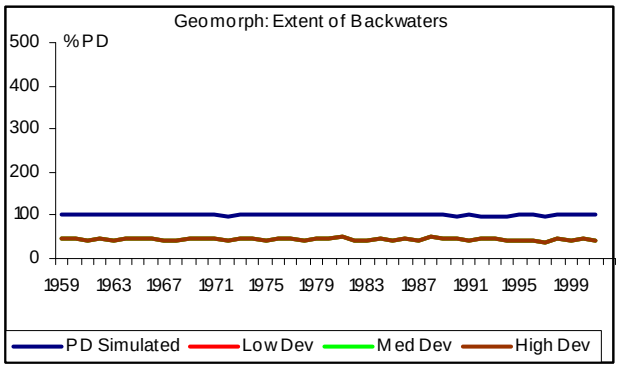
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

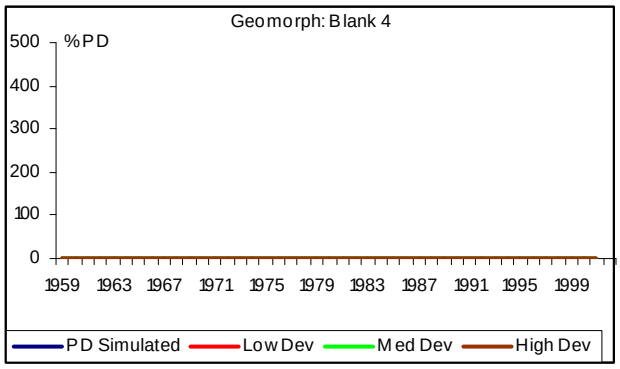
3.5. Extent of Backwaters

(Extent of (Slow/No Flow) Backwater Areas)- Backwaters are remnants of obsolete channels, which are still connected to the main channel. During the low flow they will fill by water backing up from the river, but during flooding they may also receive water that flows over the floodplain.

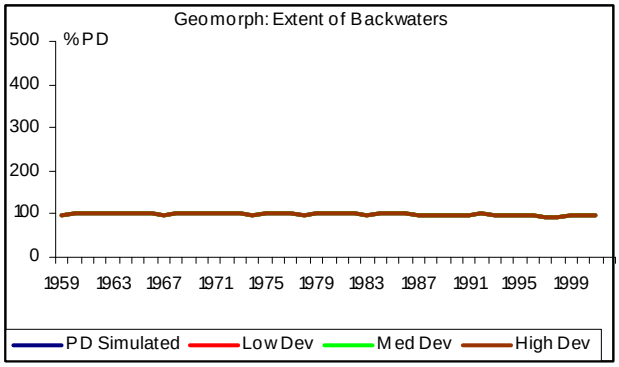
Site 1: Cubango River @ Capico



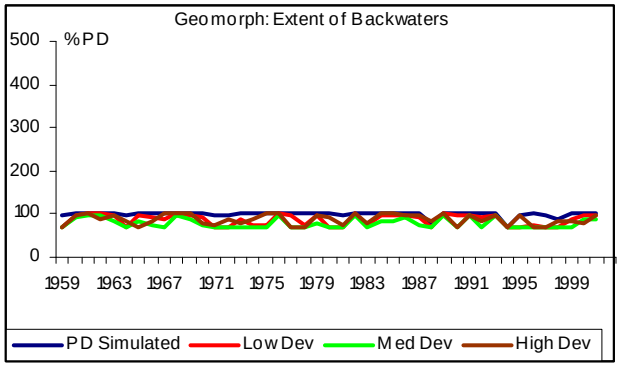
Site 2: Cubango River @ Mucundi



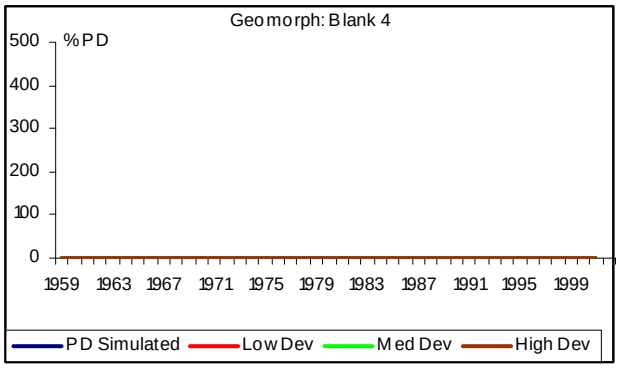
Site 3: Cuito River @ Cuito Cuanavale



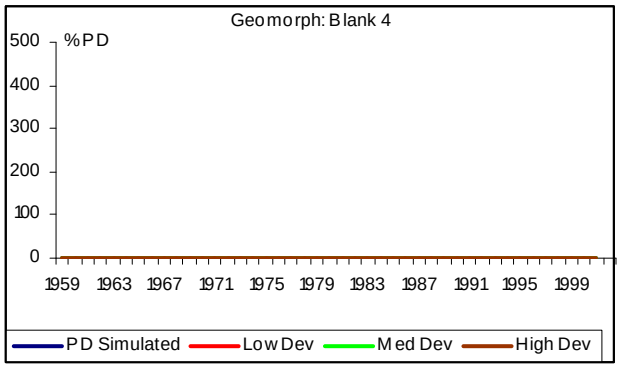
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

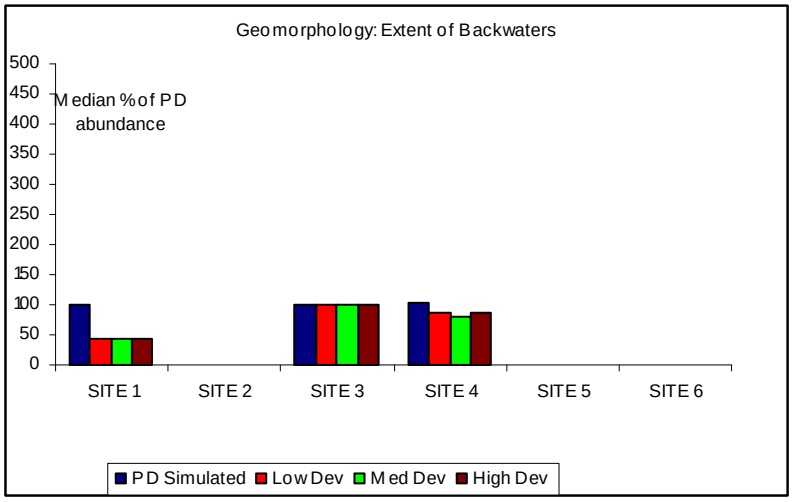


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Filling or emptying of backwaters is directly related to the water level in the river. Backwaters gradually fill with sediment and therefore may be shallower than the main channel - in that case they may empty before the river dries up. The backwaters tend to be steep sided, so the surface area changes little as water depth changes.



Low Scenario

The area of backwaters is not greatly affected by the low scenario.

Moderate Scenario

An intermediate between low and high scenarios.

High Scenario

A high degree of abstraction results in considerably reduced flows. Abstraction for irrigation is also greatest during the low flow season (hot season in October-November) when the river is at its lowest. Therefore backwaters are very likely to dry out.

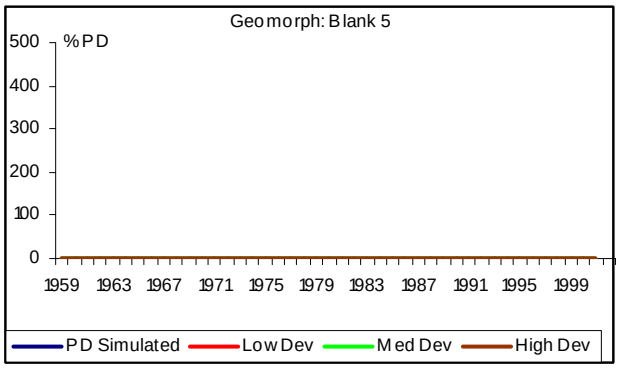
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

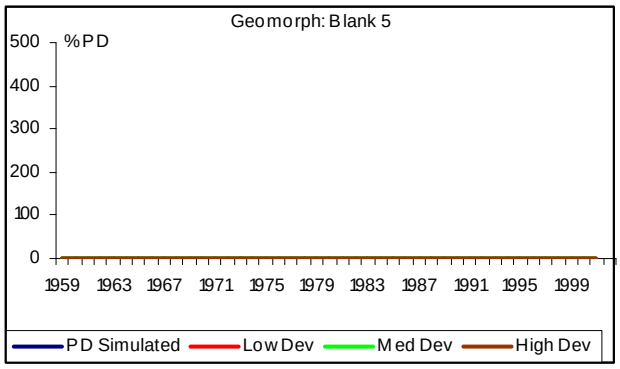
3.6. Sand Bars at low flow

(Extent of Exposed Sand Bars at Low Flow) - Extensive exposed sand bars exist mainly below the falls. Upriver the sand bars are mostly submerged just below the surface during the low flow season.

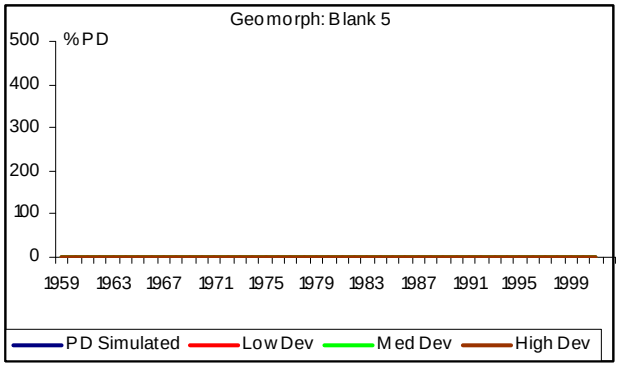
Site 1: Cubango River @ Capico



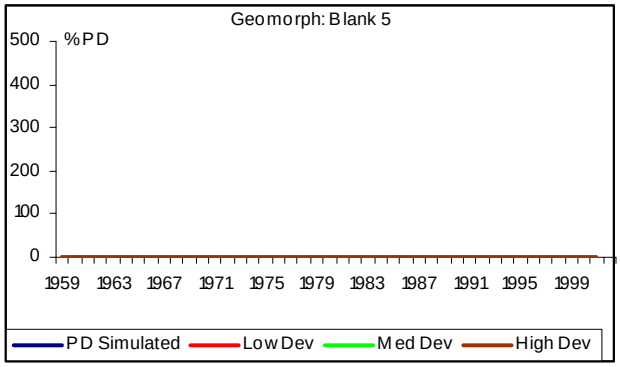
Site 2: Cubango River @ Mucundi



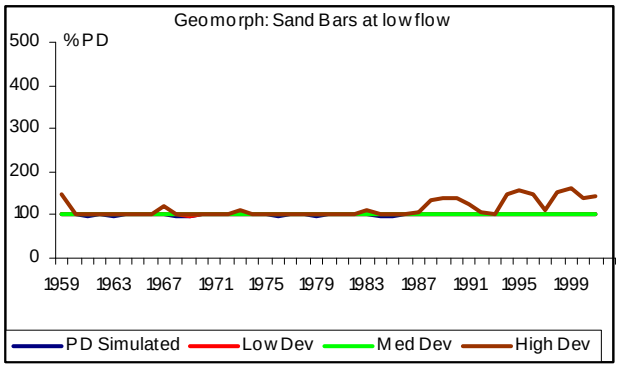
Site 3: Cuito River @ Cuito Cuanavale



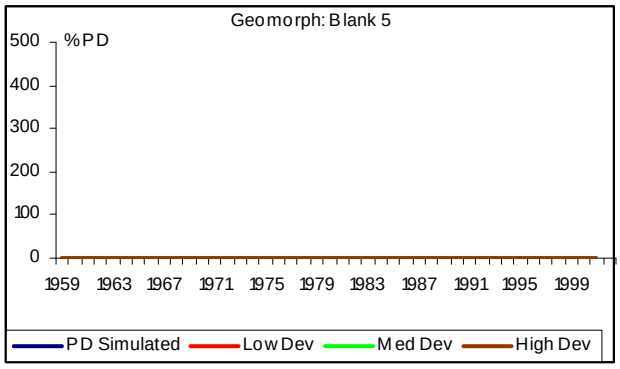
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

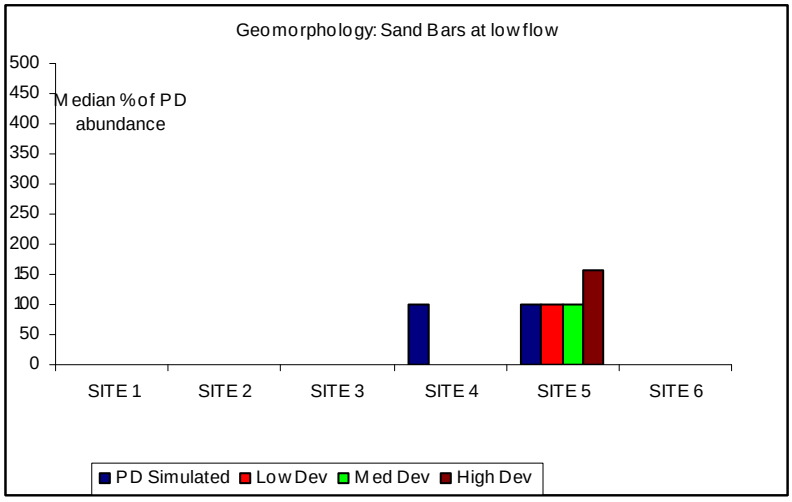


Site 6: Okavango River @ Pan Handle



Summary change per scenario

If one considers only the effect of water flow on sandbanks, then lower flow will expose a greater extent of sandbanks. However, the real issue here is not water but the fact that dams and weirs trap sediment. Downstream of a weir or dam the river is deprived of sediment, so it erodes its bed, banks and floodplains until it is once again carrying its maximum load. Thus, for some distance downstream of a weir or dam the sandbanks will be removed.



Low Scenario

The DSS model is not able to take into account the effects of sediment being trapped in impoundments. Therefore, the response curves do not relate to this issue.

Moderate Scenario

The DSS model is not able to take into account the effects of sediment being trapped in impoundments. Therefore, the response curves do not relate to this issue.

High Scenario

The DSS model is not able to take into account the effects of sediment being trapped in impoundments. Therefore, the response curves do not relate to this issue.

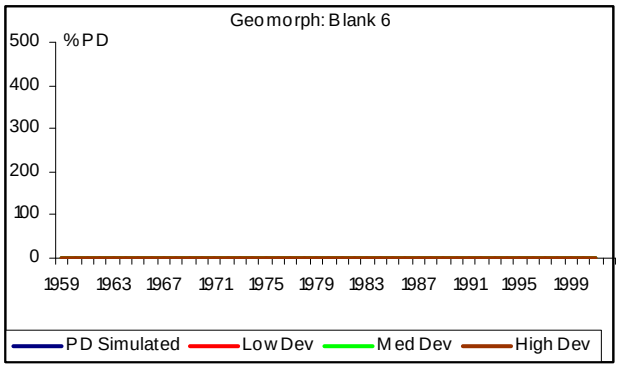
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

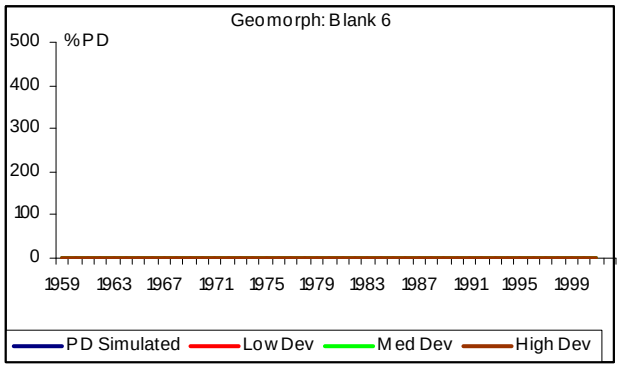
3.7. Extent of Vegetated Islands

(Extent of Vegetated Islands)- Vegetated islands in the Mukwe-Andara-Popa Falls section of the river (and upstream) are normally comprised of sand on bedrock. Grass, reeds, bush and trees stabilise the sand by reducing wash away during above-average high flows and also promoting deposition of more sand during overtopping of the island.

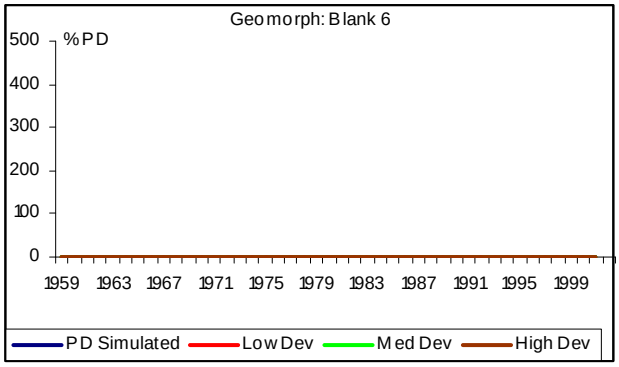
Site 1: Cubango River @ Capico



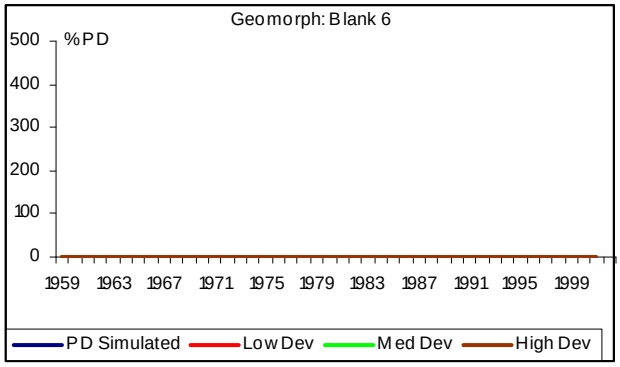
Site 2: Cubango River @ Mucundi



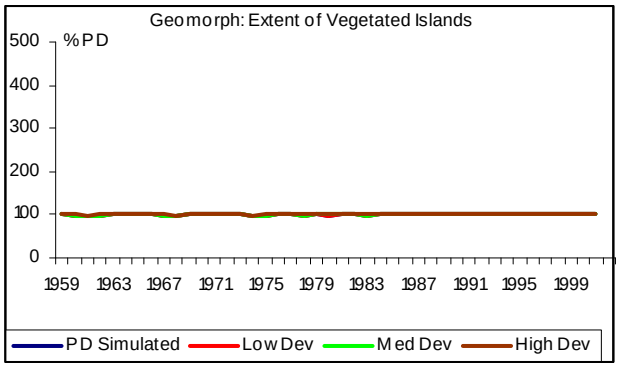
Site 3: Cuito River @ Cuito Cuanavale



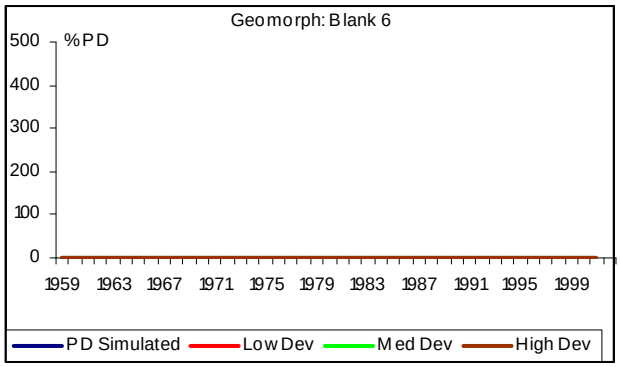
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

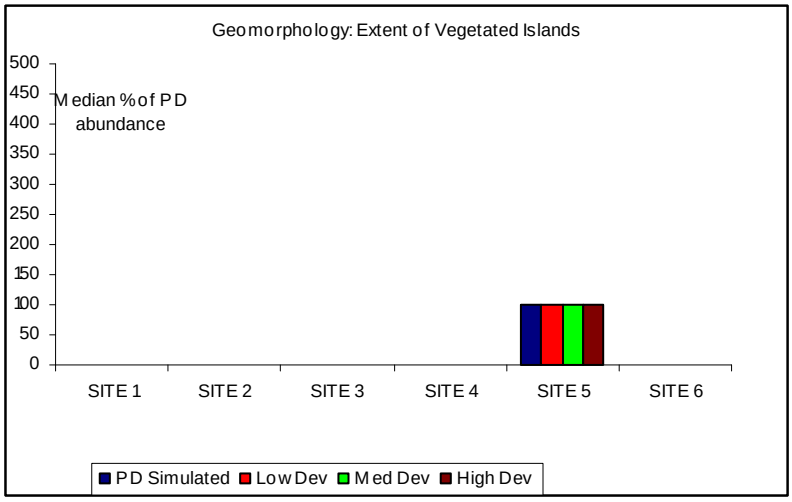


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Reduced flows have little impact on vegetated islands as long as the plants there still get enough water to survive and regenerate themselves. Excessively high floods, however, are likely to cause erosion of the margins of islands. In many cases this erosion is limited to the margins because of the bedrock base to the island.



Low Scenario

If high flows are consistently lower, then the islands may actually expand as vegetation begins to encroach into the channels. However, that process would be reversed during very large floods - which still come through in the low scenario at many of the sites.

Moderate Scenario

An intermediate response between low and high scenarios.

High Scenario

In the high scenario even the big floods may be reduced, so that islands may grow. (Another factor not modelled in the DSS is the fact that low dry season flows would allow people access to the islands, which was not previously possible. They will remove trees and other vegetation, making the islands more susceptible to erosion of the sandy covering.)

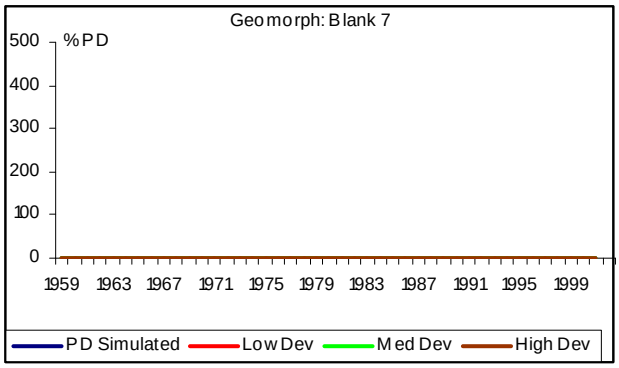
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

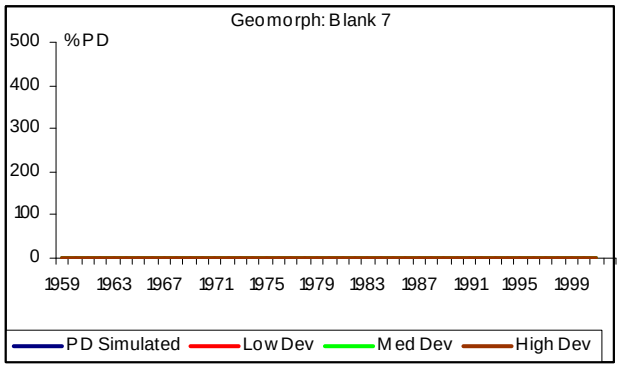
3.8. Percentage Clays on Floodplain

(Percentage Silt & Clays in the top 300mm of the Floodplain) - Floodplains are made predominantly of fine sand, but there is a small amount of silt and clay-sized particles, which are also deposited by the river. The silt and clay is significant for agriculture because it helps to retain moisture and nutrients.

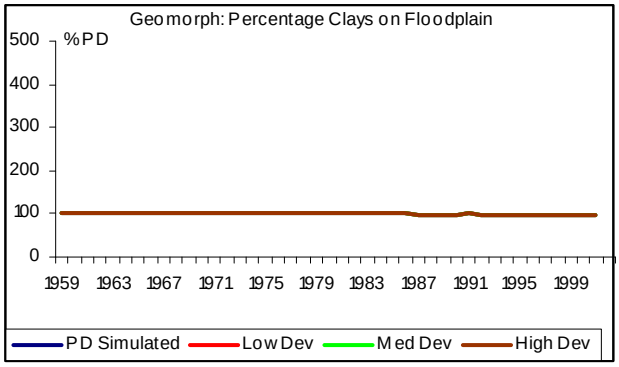
Site 1: Cubango River @ Capico



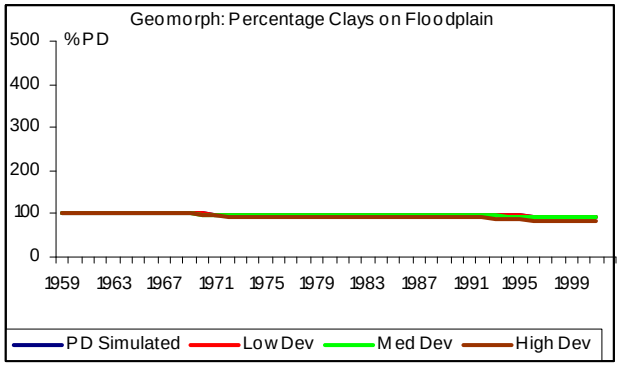
Site 2: Cubango River @ Mucundi



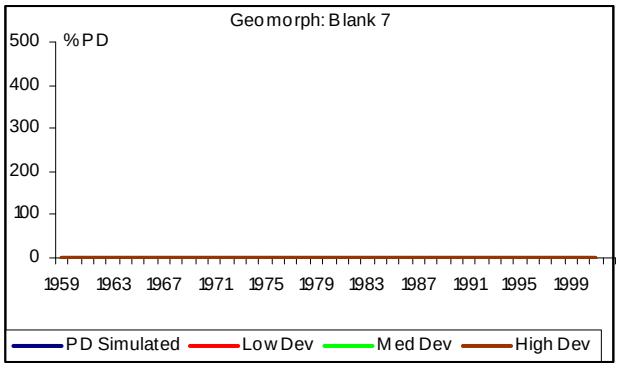
Site 3: Cuito River @ Cuito Cuanavale



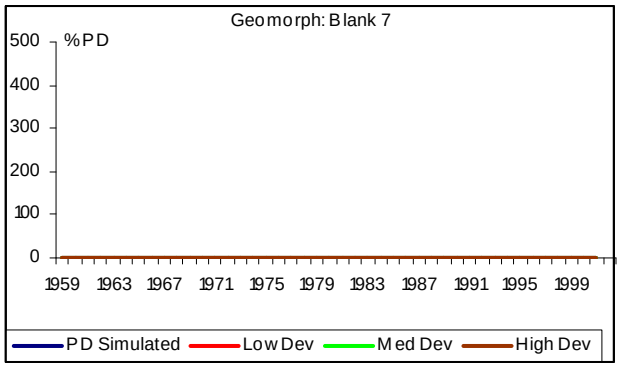
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

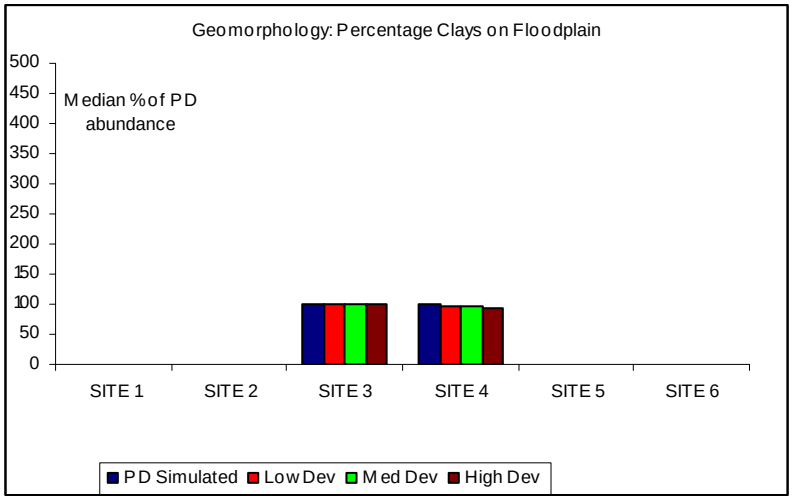


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Silt and clay tend to get lost due to downward mixing by soil organisms, trampling by livestock, and removal by wind. However, these fine particles are replenished by flooding.



Low Scenario

Since the big floods still come through (although their duration is reduced) there will still be some deposition of silts and clays on floodplains.

Moderate Scenario

With reduced flooding, reduced duration of flooding, and longer dry season flows, floodplains will lose more silt and clay and be replenished less than before. Soil moisture and nutrient retention will diminish over time.

High Scenario

The medium scenario is further accentuated.

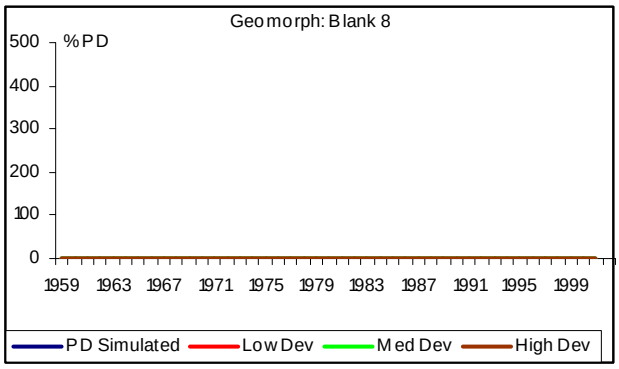
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

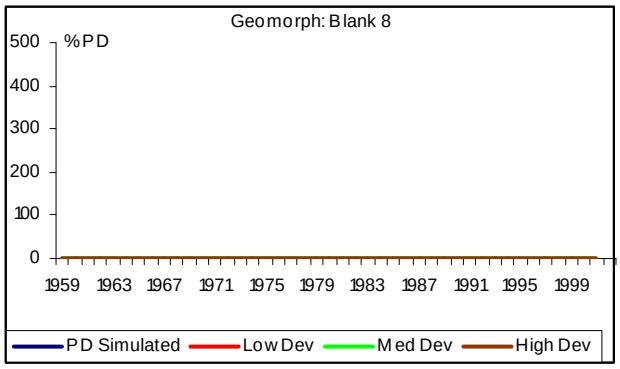
3.9. Extent of inundated floodplain

(Extent of the floodplain flooded each wet season) - Reduced volume of flow in the flood season will result in less overbank flooding. This results in smaller areas of the floodplain being inundated.

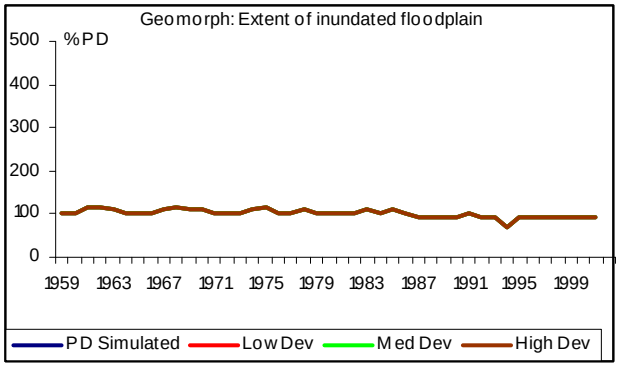
Site 1: Cubango River @ Capico



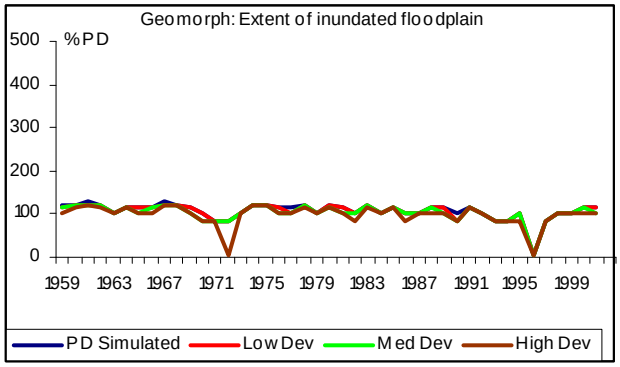
Site 2: Cubango River @ Mucundi



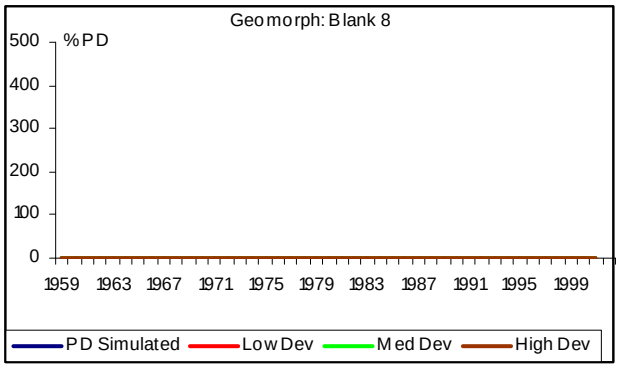
Site 3: Cuito River @ Cuito Cuanavale



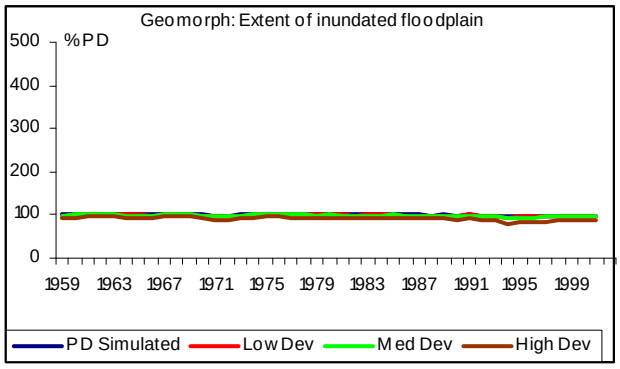
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

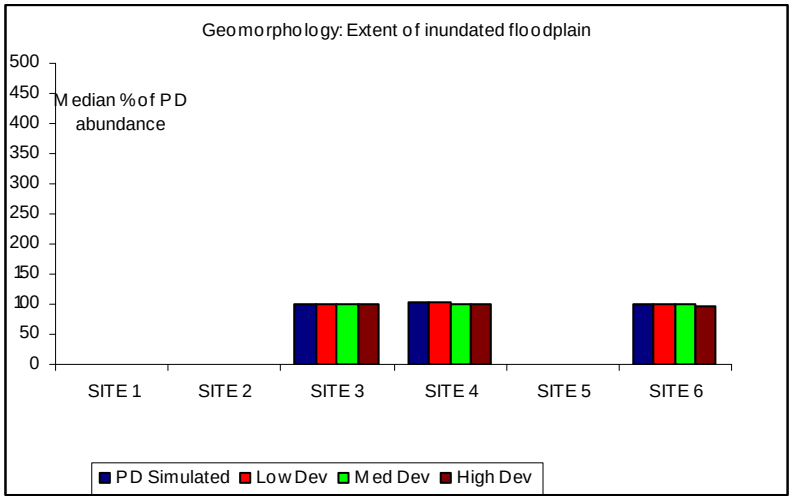


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Reduced volume of flow in the flood season will result in less overbank flooding. This results in smaller areas of the floodplain being inundated.



Low Scenario

Large floods still come through but the extent of floodplain inundation is reduced. The duration of inundation is also reduced.

Moderate Scenario

An intermediate response between low and high scenarios.

High Scenario

In some cases floodplain inundation may be drastically reduced or may not occur.

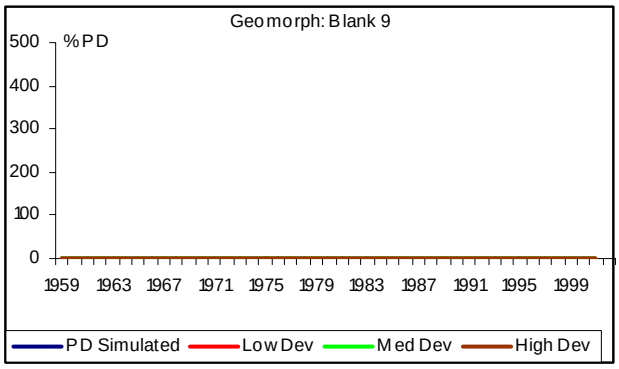
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

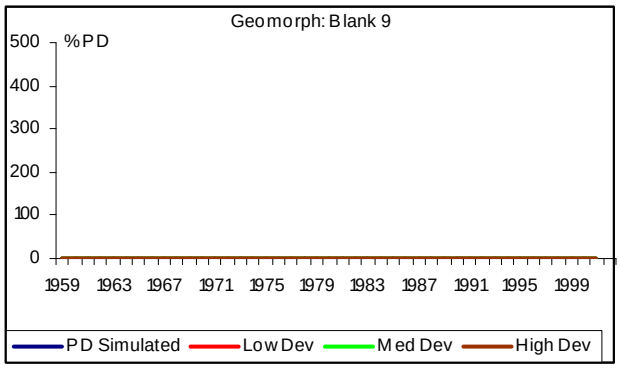
3.10. Inundated Pools & Pans

(Extent of Inundated Pools/Pans on Floodplain at the end of the Dry Season) - Pools that remain on the floodplain at the end of the dry season are assumed to be supported by groundwater movement from the river channel.

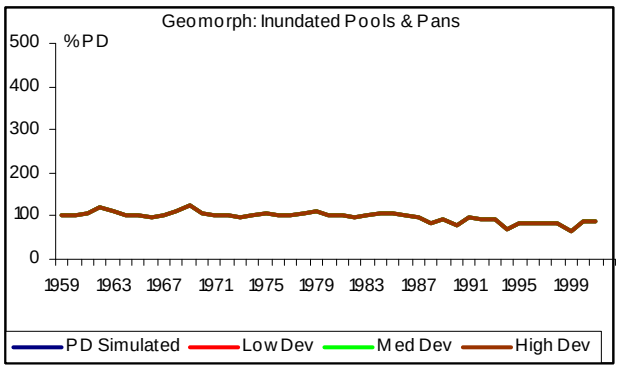
Site 1: Cubango River @ Capico



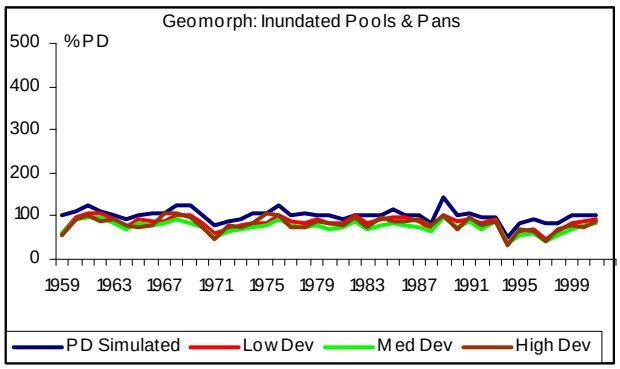
Site 2: Cubango River @ Mucundi



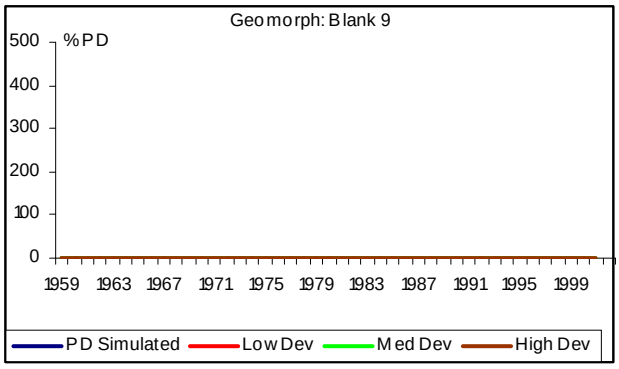
Site 3: Cuito River @ Cuito Cuanavale



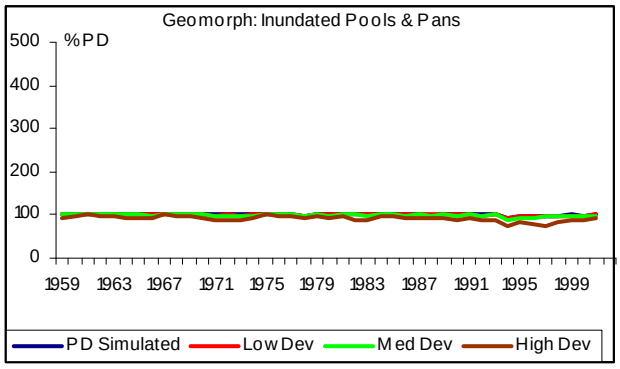
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

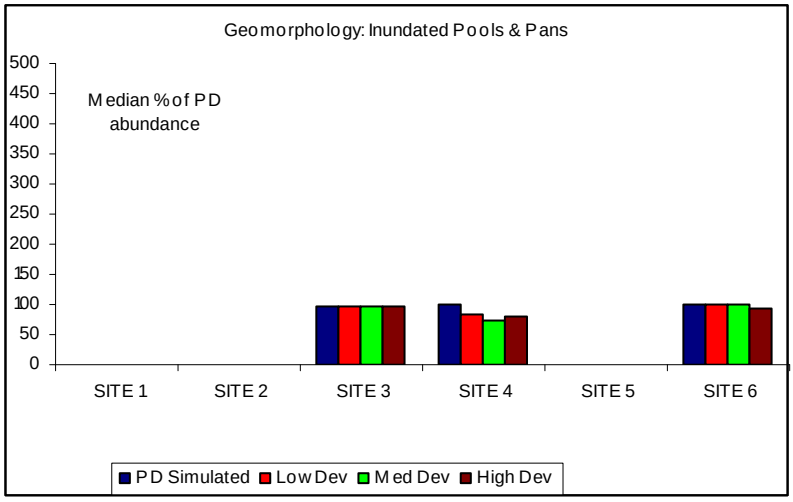


Site 6: Okavango River @ Pan Handle



Summary change per scenario

As the river level drops, so the water table in the floodplain will also drop. If the bed of a pool no longer intersects the water table, the pool will dry out. (Seepage into the pool from the non-saturated zone may also contribute to pool water.) Although high flows play a role by replenishing groundwater in floodplains, we assume that perennial pools at the end of the dry season are maintained by groundwater.



Low Scenario

Reduced low flow levels begin to affect pools - some of which may dry out.

Moderate Scenario

An intermediate response between low and high scenarios.

High Scenario

Probably most of the floodplain pools will dry out.

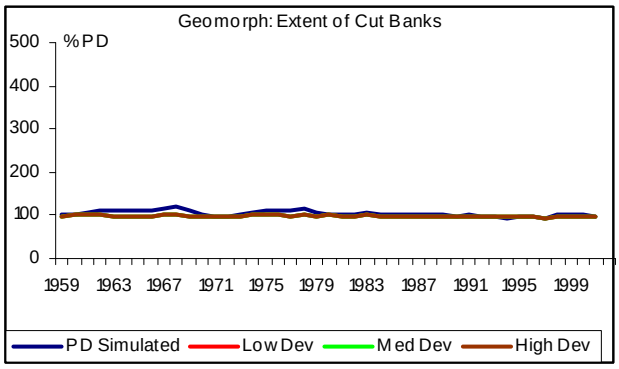
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

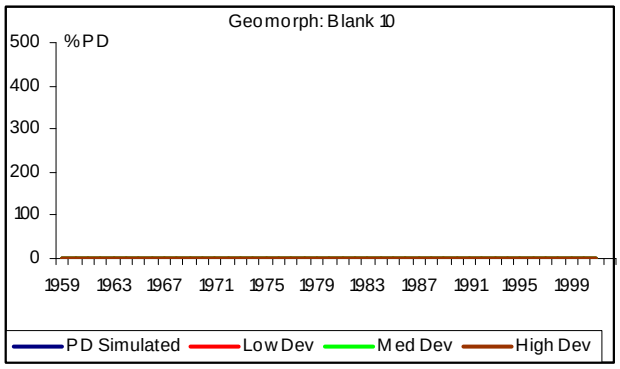
3.11. Extent of Cut Banks

(Extent of Cut Banks Along the Active Channel) - Cut banks are a function mainly of high flow periods, but they are also affected when river flow drops rapidly - in that case bank collapse tends to occur.

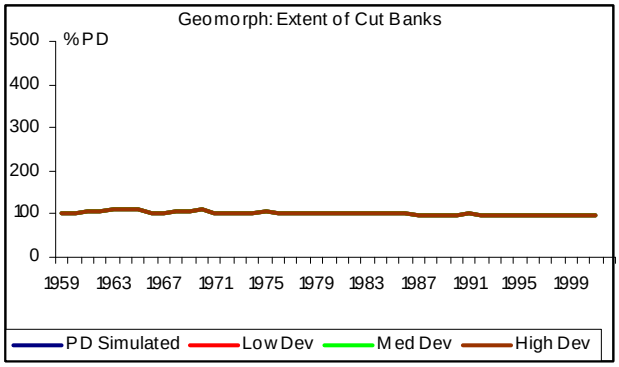
Site 1: Cubango River @ Capico



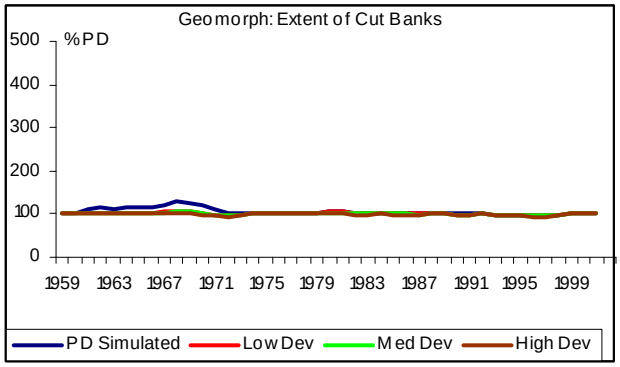
Site 2: Cubango River @ Mucundi



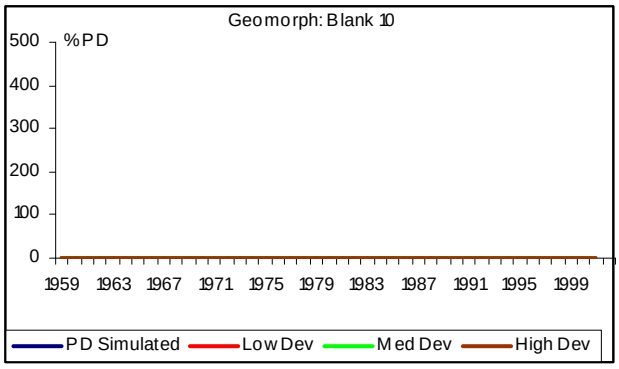
Site 3: Cuito River @ Cuito Cuanavale



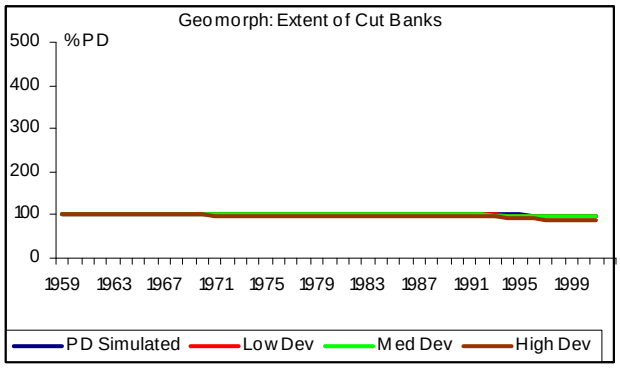
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

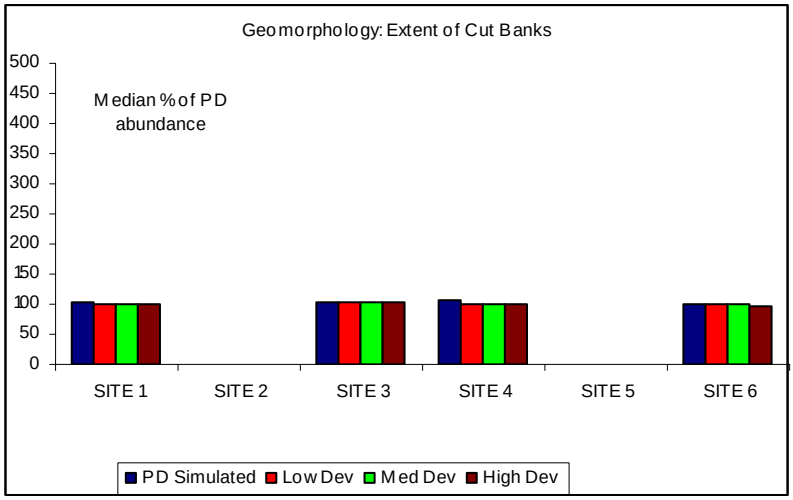


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Higher flow velocities during flooding will erode the banks. When the water level drops rapidly, then hydrostatic pressure of water in the sandy bank material tends to result in bank collapse.



Low Scenario

Flood peaks still come though so bank cutting will still occur.

Moderate Scenario

An intermediate between low and high scenarios.

High Scenario

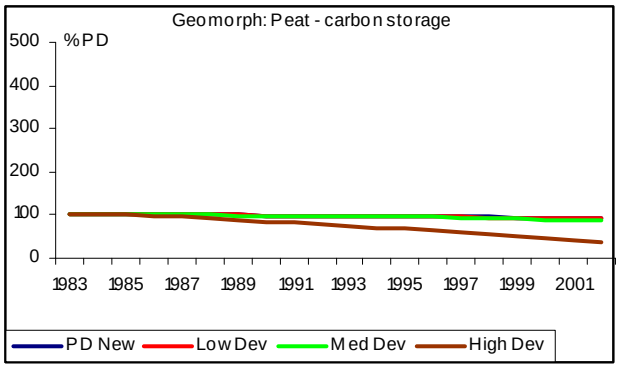
Only the extreme flood events come through.

References

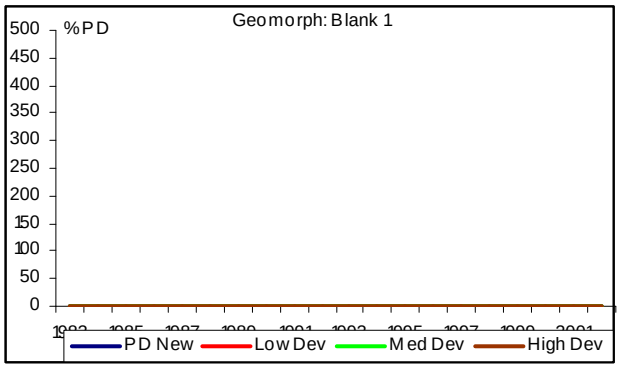
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

3.12. Peat - carbon storage

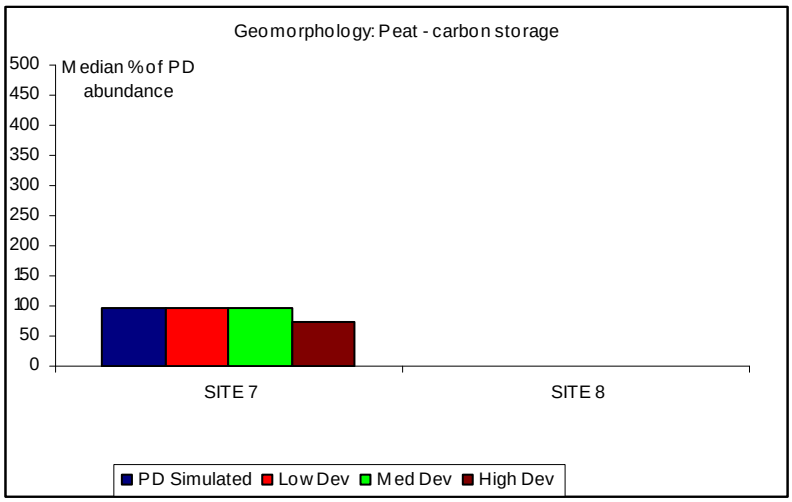
Site 7: Okavango River @ Xakanaxa



Site 8: Boteti River



Summary change per scenario



References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

4. Water Quality

This section provides the time-series for water quality indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- pH
- Conductivity
- Temperature
- Turbidity
- Dissolved oxygen
- Total nitrogen
- Total phosphorus
- Chlorophyll a.

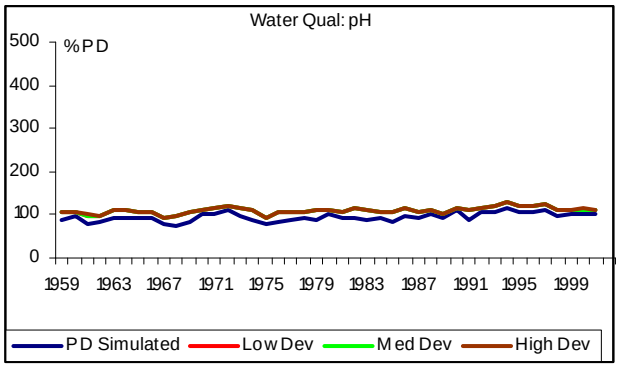
4.1. Photographs

Photos: J King

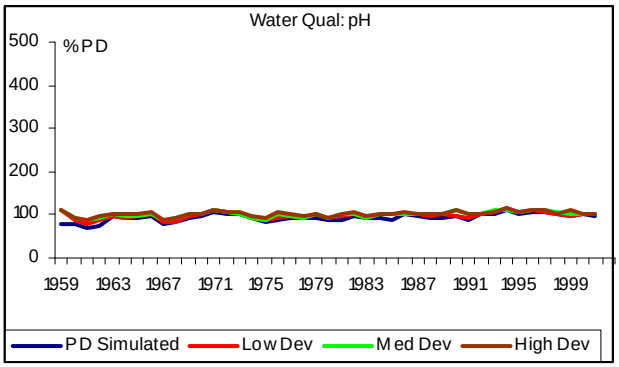
4.2. pH

(In channel) - Unitless.

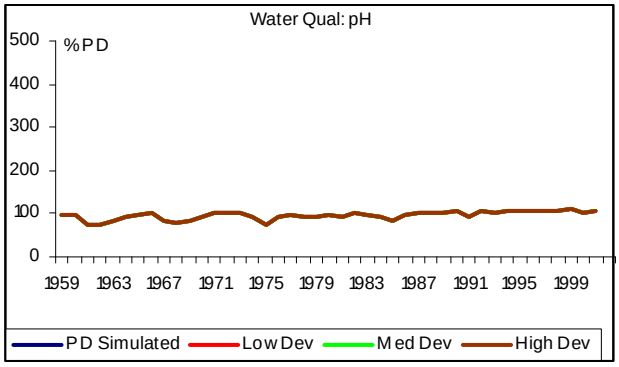
Site 1: Cubango River @ Capico



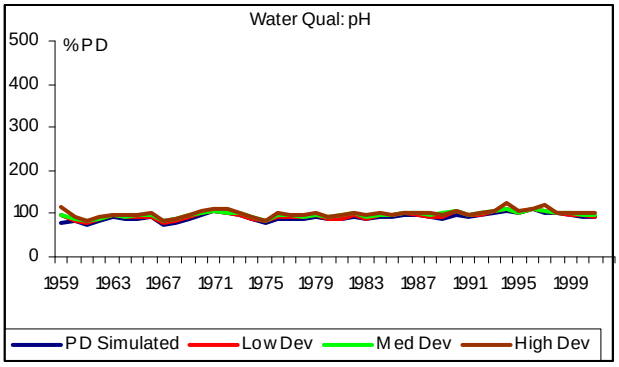
Site 2: Cubango River @ Mucundi



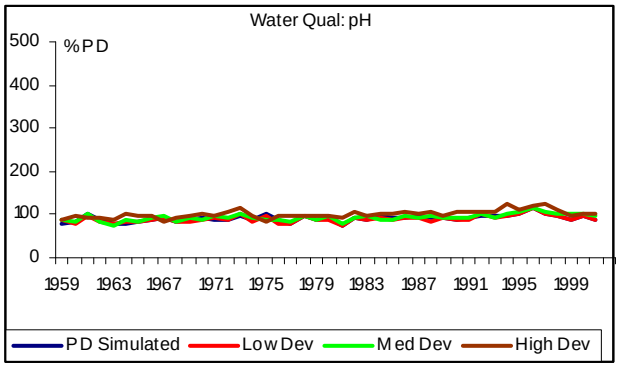
Site 3: Cuito River @ Cuito Cuanavale



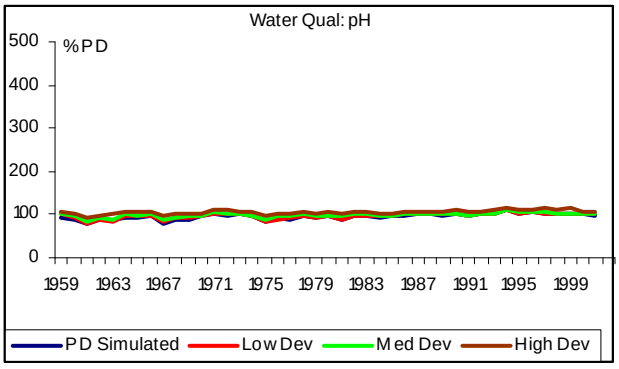
Site 4: Okavango River @ Rundu



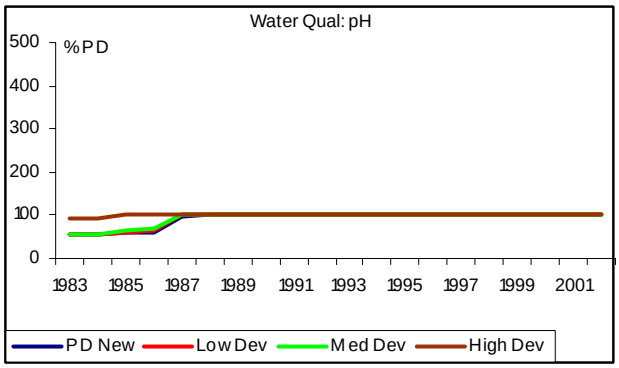
Site 5: Okavango River @ Popa Falls



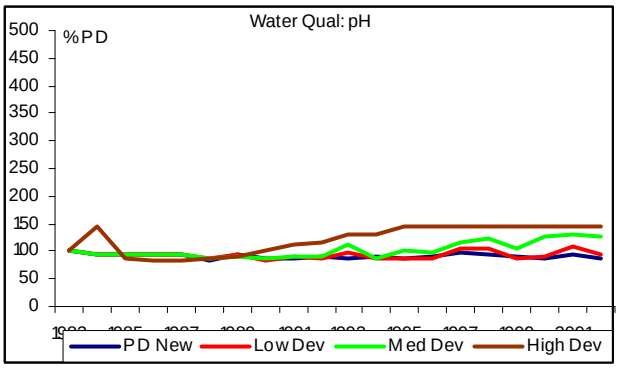
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

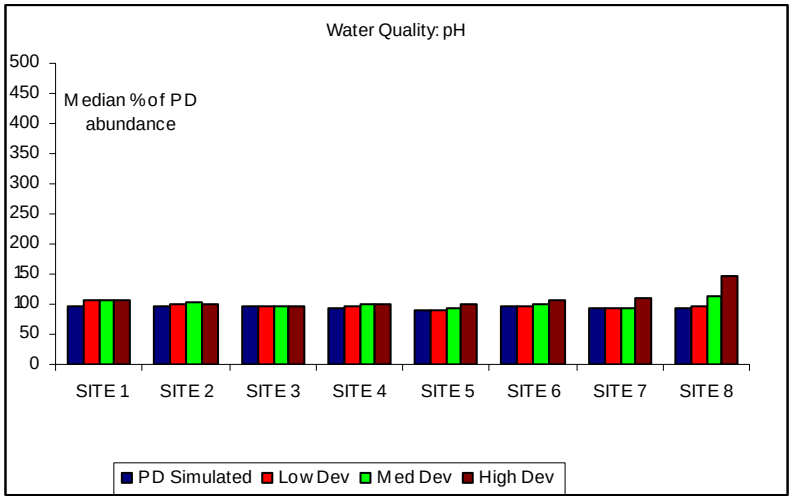


Site 8: Boteti River



Summary change per scenario

Generally increasing with decreasing flow. In the simulated Present Day, values range between 34% and 268% of the PD median, increasing in drier years of lower flow.



Low Scenario

pH is not much affected by the low scenario, for all the sites in the main channel.

Moderate Scenario

A slight increase is observed from the present day scenario.

High Scenario

Not much change for the river sites but at Xaxanaka and Boteti there is a significant increase in pH. This is because, during low flow, the evaporative concentration is more pronounced due to the high concentration of carbonates and bicarbonates in the water.

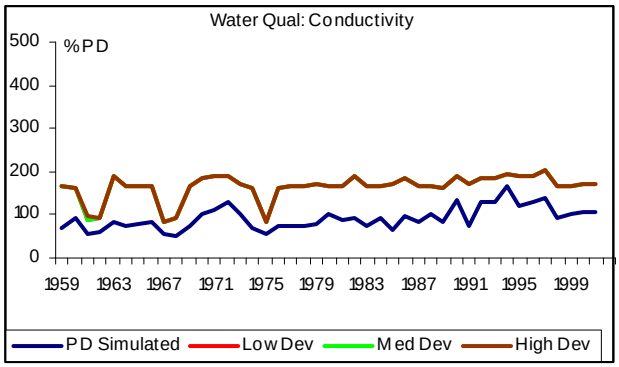
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

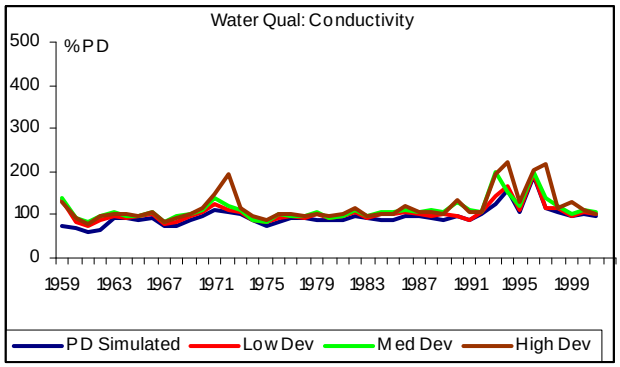
4.3. Conductivity

(In channel)- us/cm.

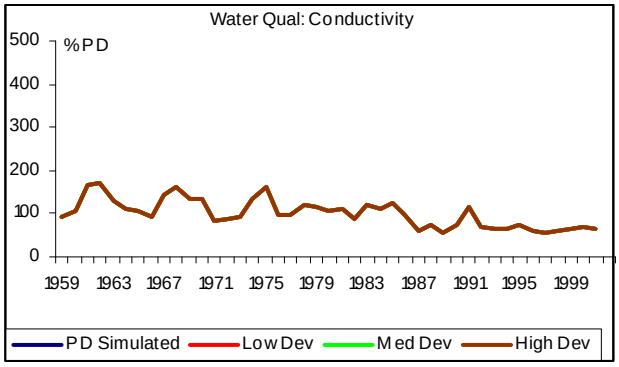
Site 1: Cubango River @ Capico



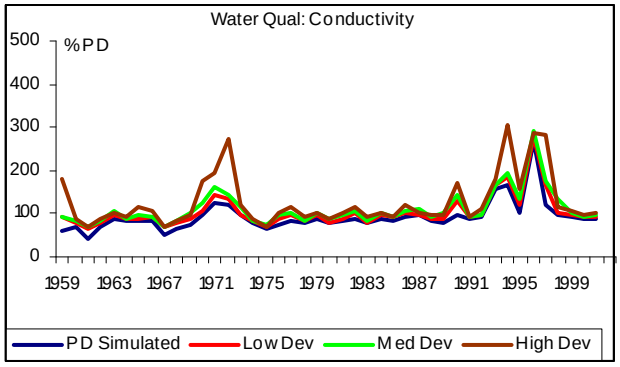
Site 2: Cubango River @ Mucundi



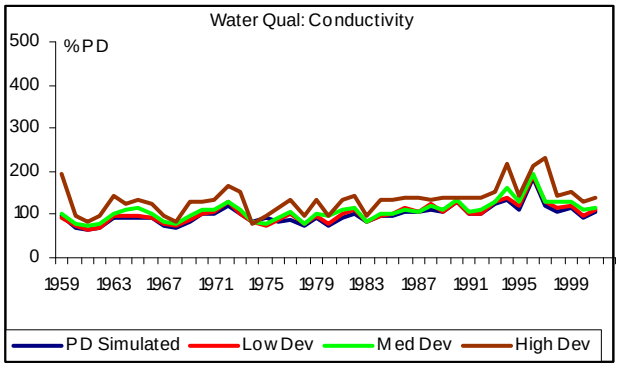
Site 3: Cuito River @ Cuito Cuanavale



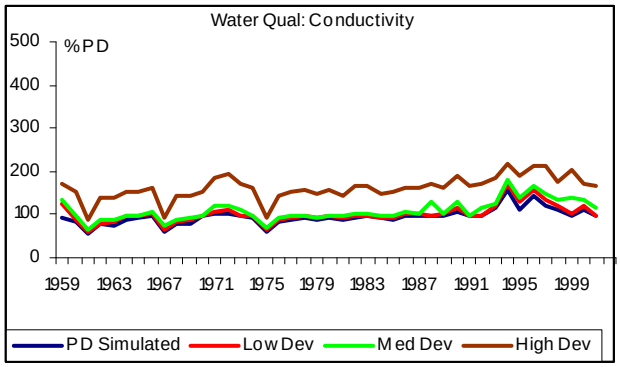
Site 4: Okavango River @ Rundu



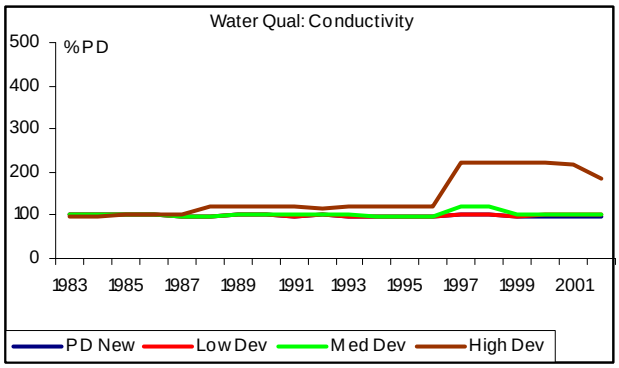
Site 5: Okavango River @ Popa Falls



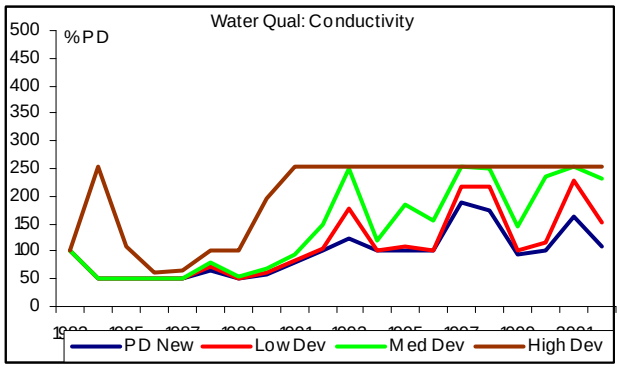
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

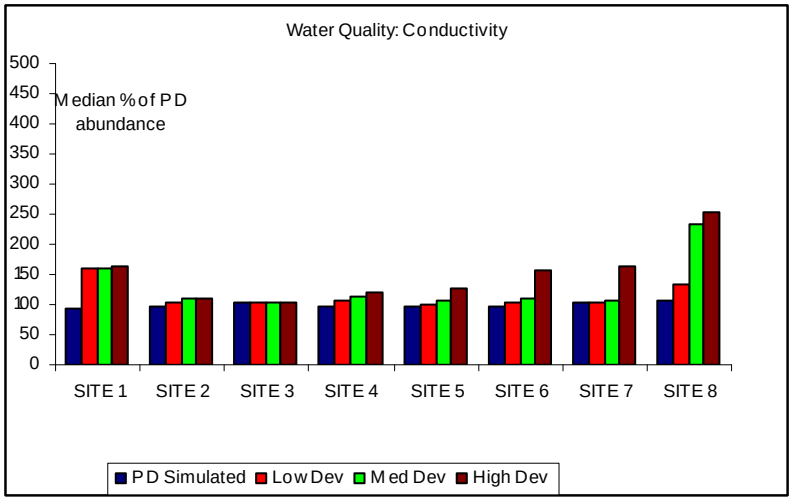


Site 8: Boteti River



Summary change per scenario

Values decrease with increasing flow.



Low Scenario

Not much change is expected at any of the sites for the low scenario.

Moderate Scenario

Not much change is expected at any of the sites for the medium scenario.

High Scenario

Most scenario predictions remain within the PD range, but it is worth noting that there is tendency for the range to progressively shift upwards through the scenarios, with Site 4 (Kapako) showing values higher than the PD range up to 307% under the High Scenario.

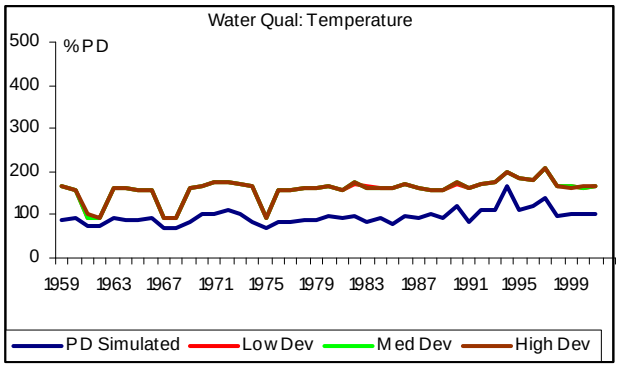
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

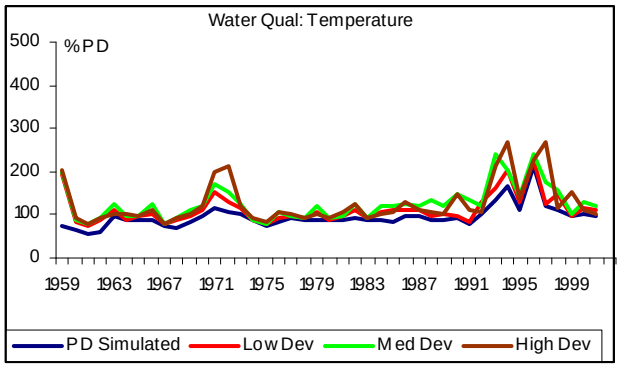
4.4. Temperature

(In channel) - diel range.

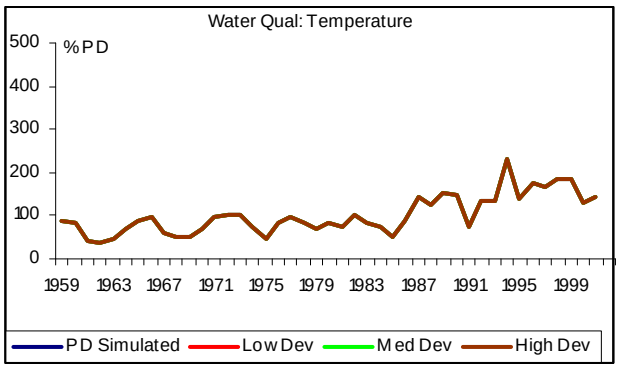
Site 1: Cubango River @ Capico



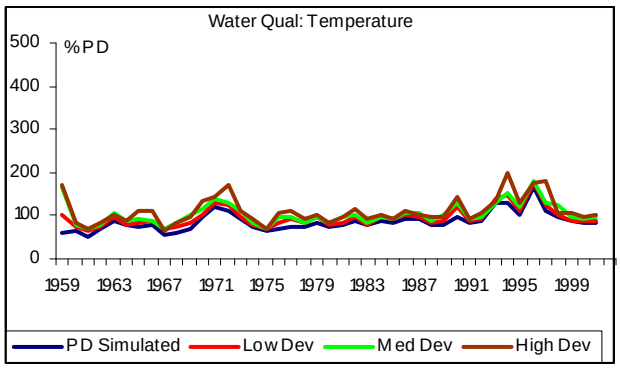
Site 2: Cubango River @ Mucundi



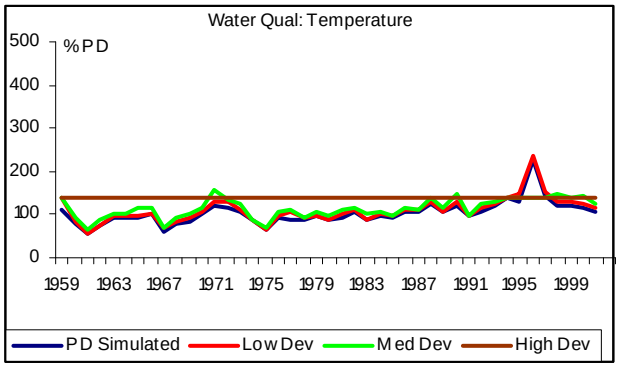
Site 3: Cuito River @ Cuito Cuanavale



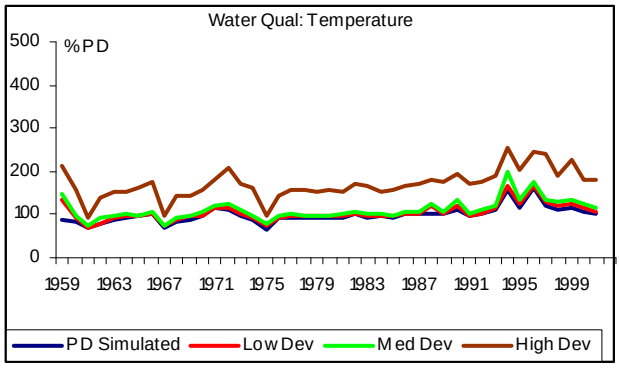
Site 4: Okavango River @ Rundu



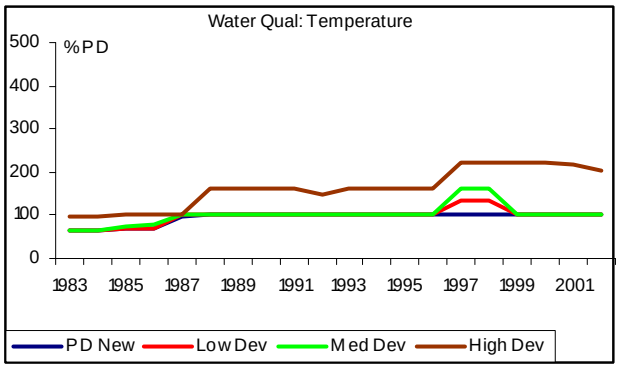
Site 5: Okavango River @ Popa Falls



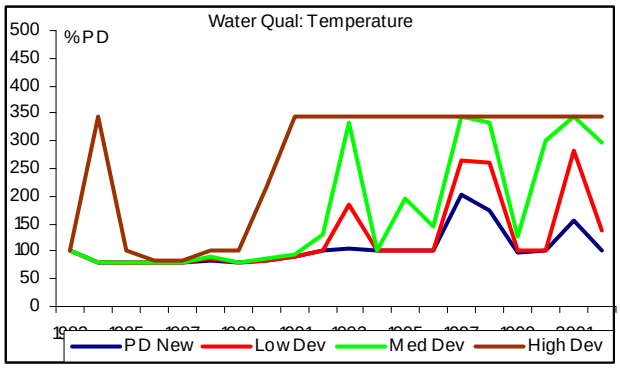
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

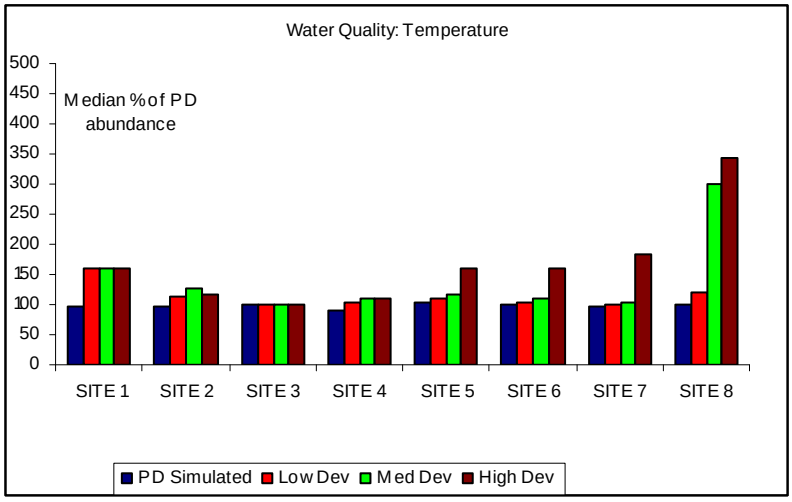


Site 8: Boteti River



Summary change per scenario

Generally the Diel Temperature Range increases with decreasing flow.



Low Scenario

At site 1 there will be a significant increase in diel temperature ranges under the low scenario (and thus also under median and high). The remaining sites are not affected.

Moderate Scenario

No significant changes are expected for the medium scenario for Sites 2-8.

High Scenario

The High Scenario pushes the diel range permanently into the higher end of the range – that is - higher than the present median - at Sites 5, 6 and 7, and maintains a greater range for longer in the Boteti.

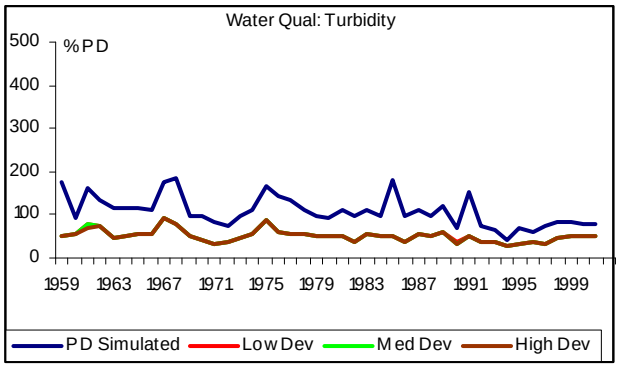
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

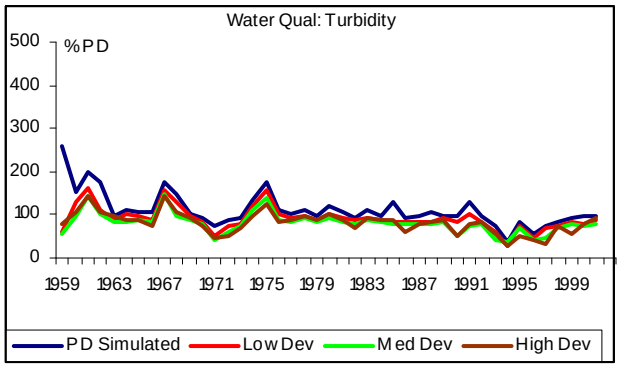
4.5. Turbidity

(In channel)- mg/l.

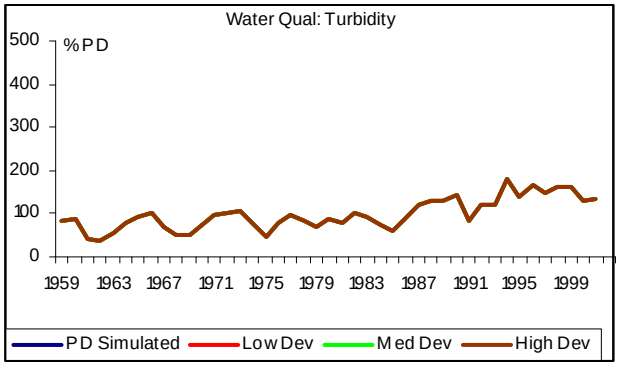
Site 1: Cubango River @ Capico



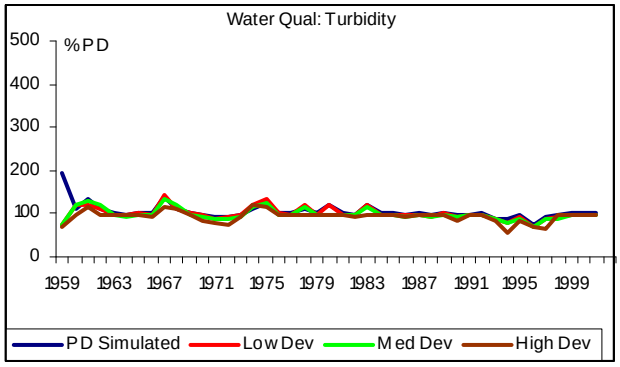
Site 2: Cubango River @ Mucundi



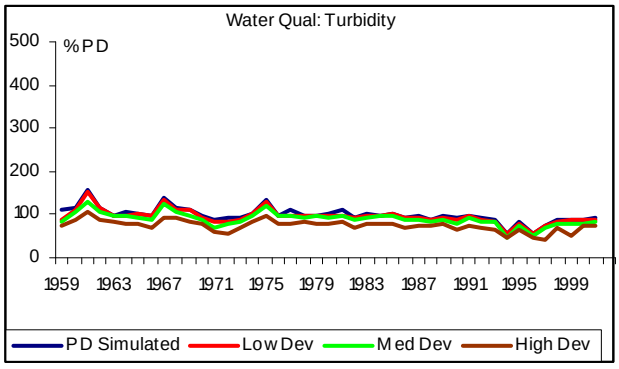
Site 3: Cuito River @ Cuito Cuanavale



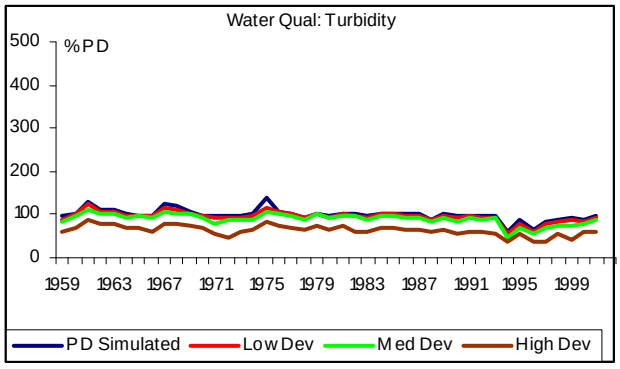
Site 4: Okavango River @ Rundu



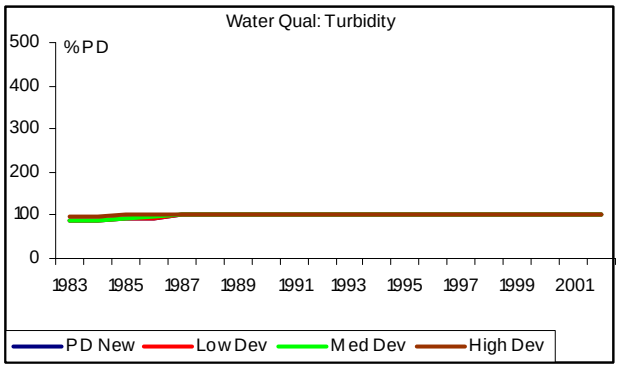
Site 5: Okavango River @ Popa Falls



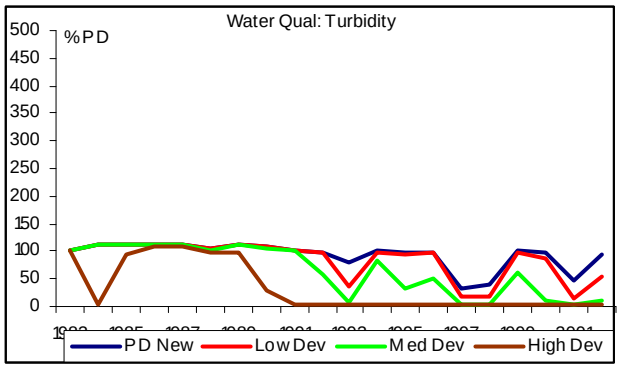
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

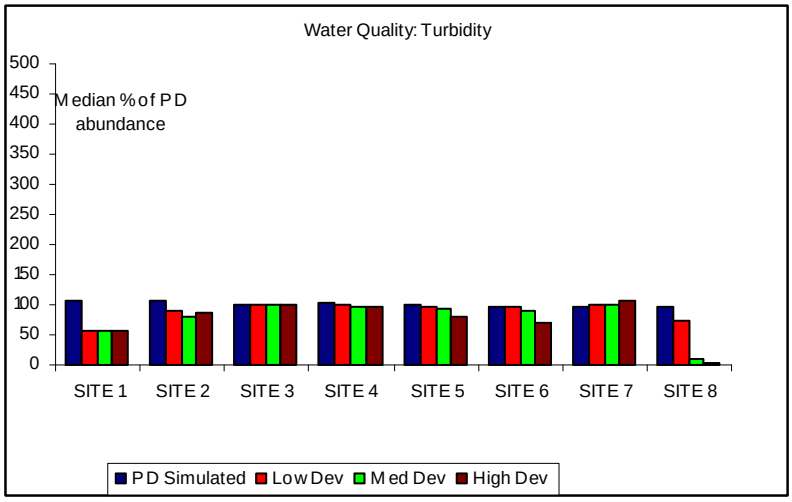


Site 8: Boteti River



Summary change per scenario

In general turbidity increases with increasing flows. The exception to this is Site 7 where turbidity decreases with increasing depth. In the case of the Boteti (Site 8), the inundated (and sometimes flowing) channels tend to have higher turbidity than the isolated pools. However when the Boteti dries up, there is 'no turbidity'.



Low Scenario

No significant changes are expected for the low scenario at sites 2-6. At site 1, however, turbidity is expected to drop by c. 40%.

Moderate Scenario

No significant changes are expected for the medium scenario for Sites 2-8.

High Scenario

Turbidity is expected to decrease by about 20% at sites 5, 6 and 7 under the high scenario. The Boteti (Site 8) will be mostly dry.

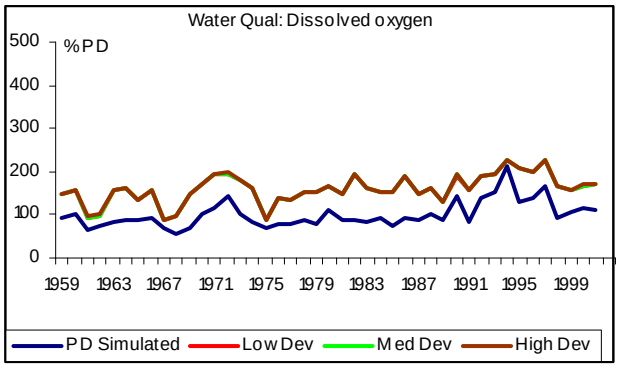
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

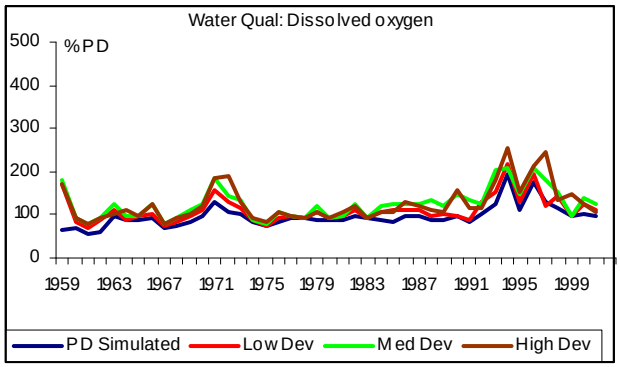
4.6. Dissolved oxygen

(In channel)- NTU.

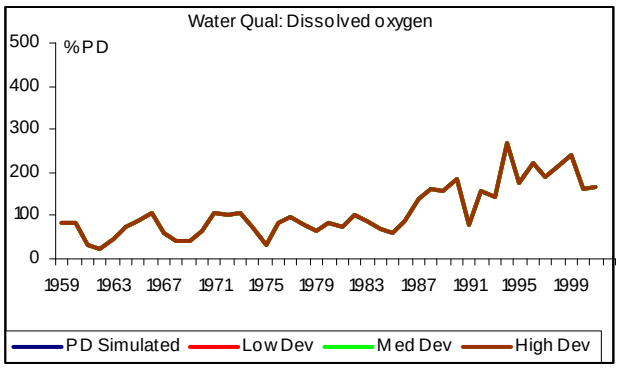
Site 1: Cubango River @ Capico



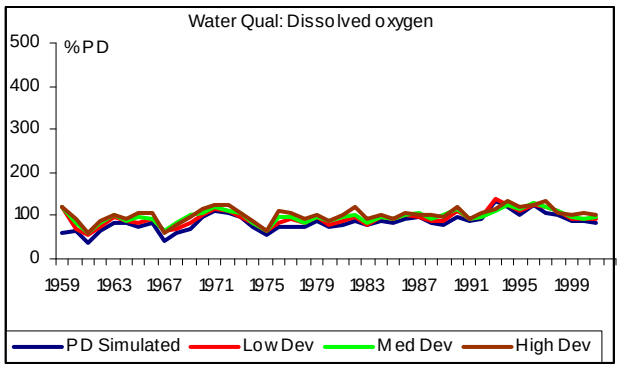
Site 2: Cubango River @ Mucundi



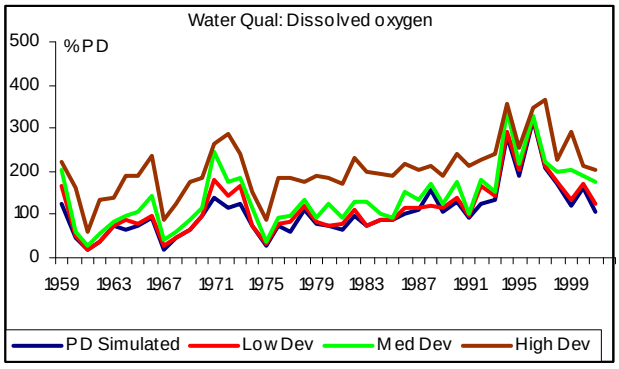
Site 3: Cuito River @ Cuito Cuanavale



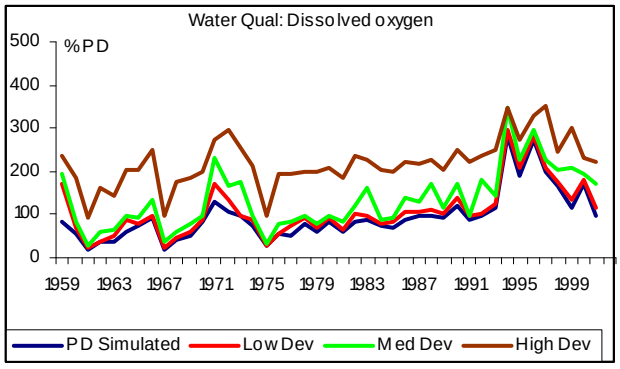
Site 4: Okavango River @ Rundu



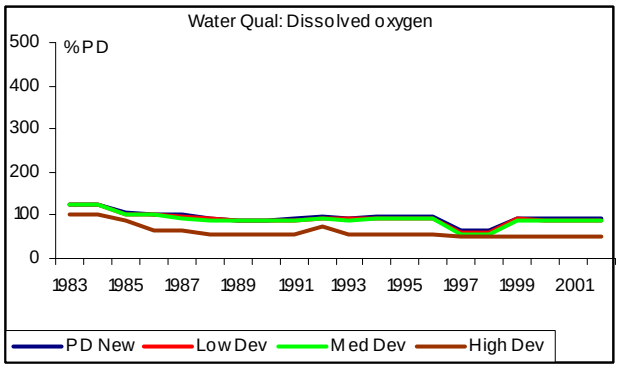
Site 5: Okavango River @ Popa Falls



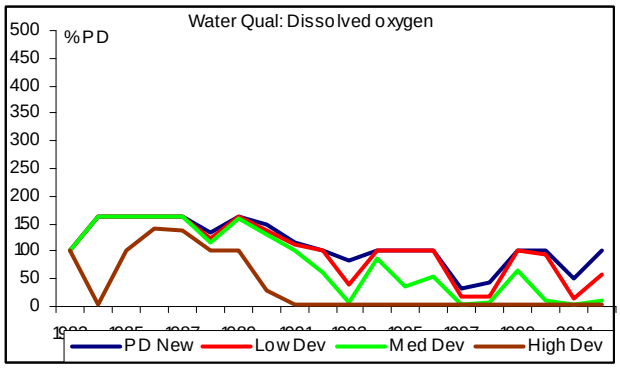
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

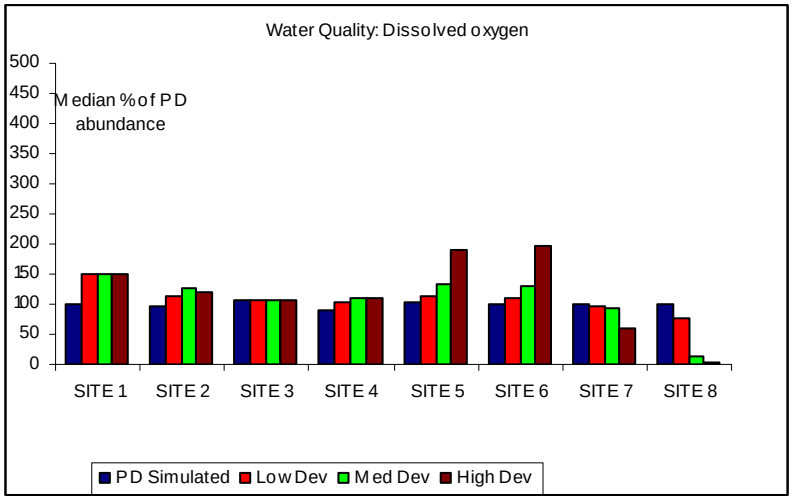


Site 8: Boteti River



Summary change per scenario

Decrease in flow results in increase in Dissolved Oxygen at sites 1 - 6. At sites 7 & 8, the concentrations decrease with decrease in flow



Low Scenario

For sites 2,4,6,7 and 8 there will be no major changes in the low scenario. At site 1, there will be a considerable change for low scenario. A slight change is expected at site 5.

Moderate Scenario

For sites 2,4,6,7 and 8 there will be no major changes in the medium scenario. A slight change is expected at site 5.

High Scenario

At sites 2 and 4 there will be a slight change. At sites 5 and 6, the decrease in concentration will be more significant. Major reduction of oxygen concentration is expected for sites 7 and 8 in the high scenario.

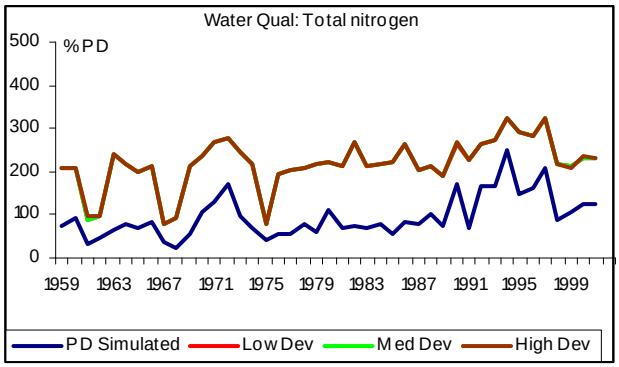
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

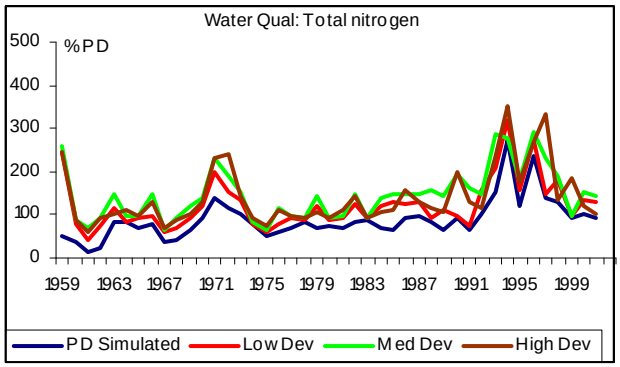
4.7. Total nitrogen

(In channel)- mg/l.

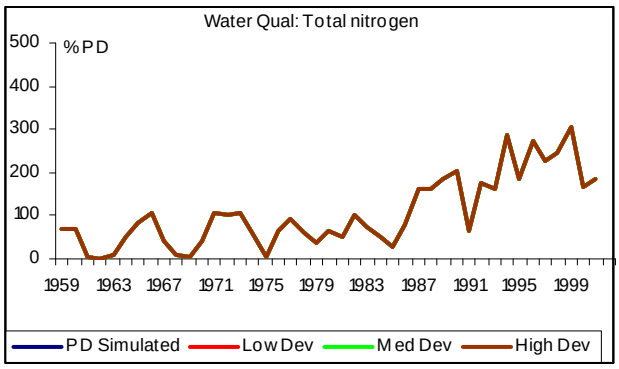
Site 1: Cubango River @ Capico



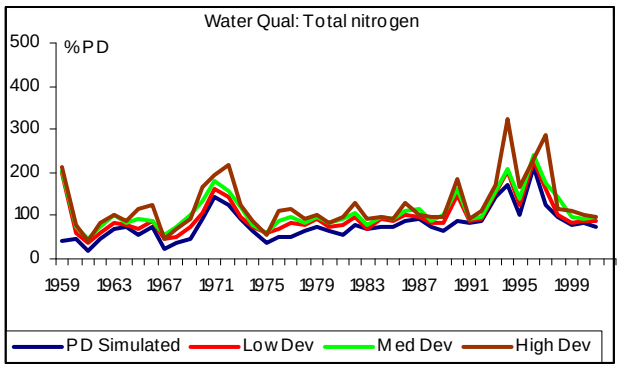
Site 2: Cubango River @ Mucundi



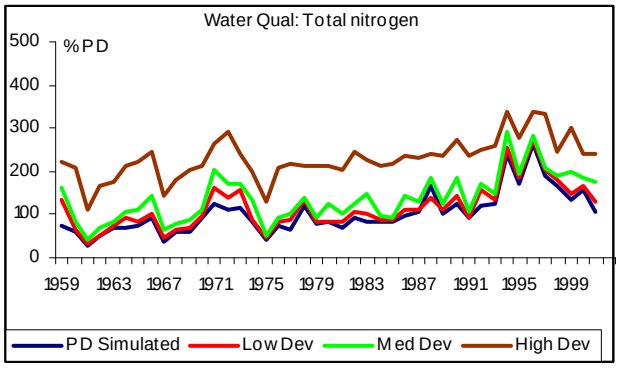
Site 3: Cuito River @ Cuito Cuanavale



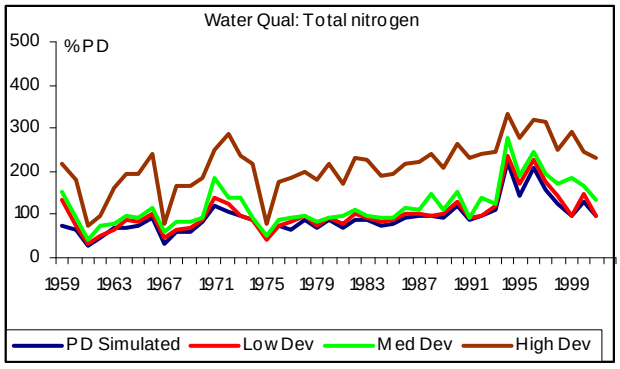
Site 4: Okavango River @ Rundu



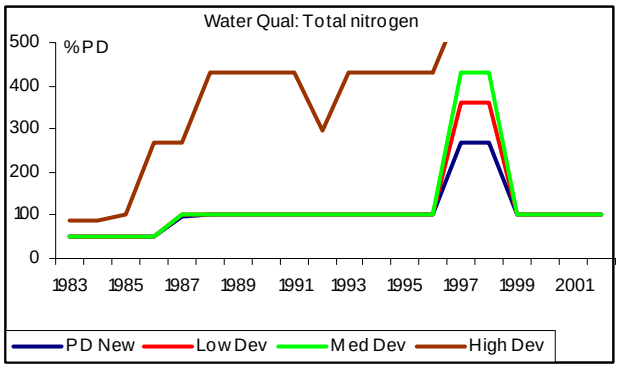
Site 5: Okavango River @ Popa Falls



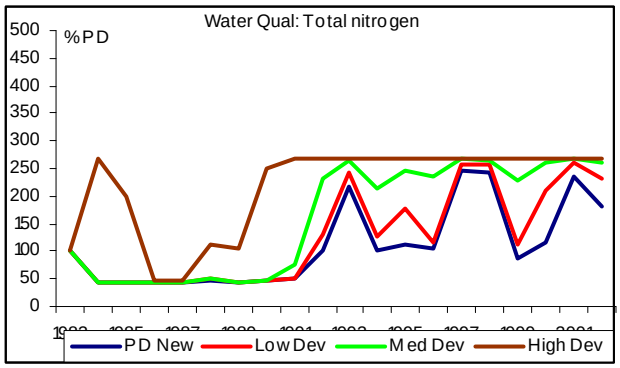
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

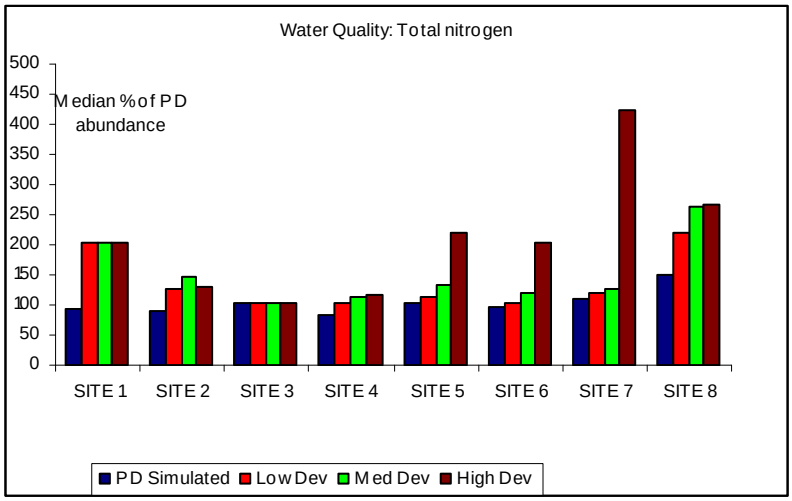


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of nitrogen.



Low Scenario

Slight increase in concentration expected, except for Site 1 where a c. 20% increase is expected under the Low Scenario.

Moderate Scenario

There will only be significant increases in concentration at sites 1 and 8

High Scenario

Considerable increase in concentrations are expected at all sites, but in particular at 5, 6, and 7. In the Boteti, the river channel will be mostly dry but remnant pools and/or wells are expected to have high concentrations of nnitorgen.

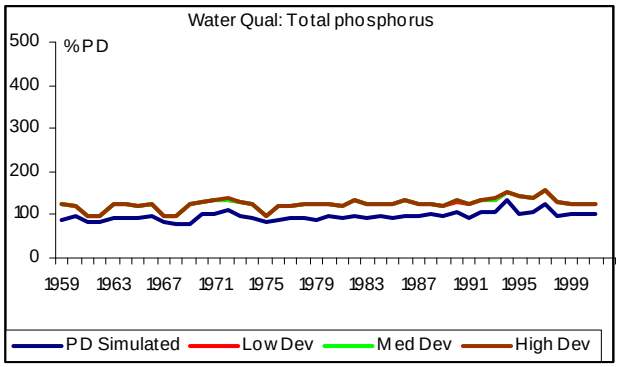
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

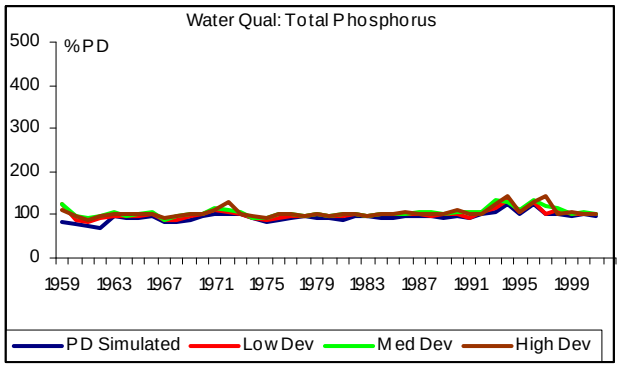
4.8. Total phosphorus

(In channel)- mg/l.

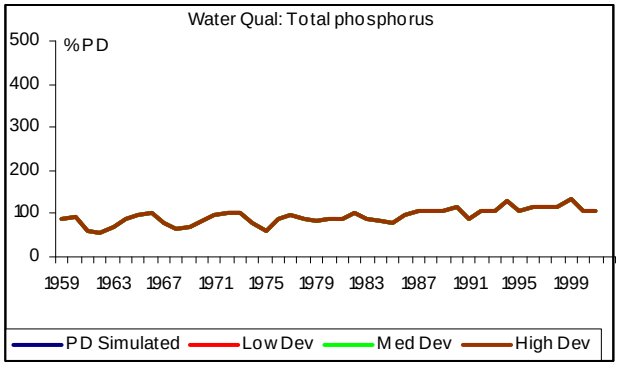
Site 1: Cubango River @ Capico



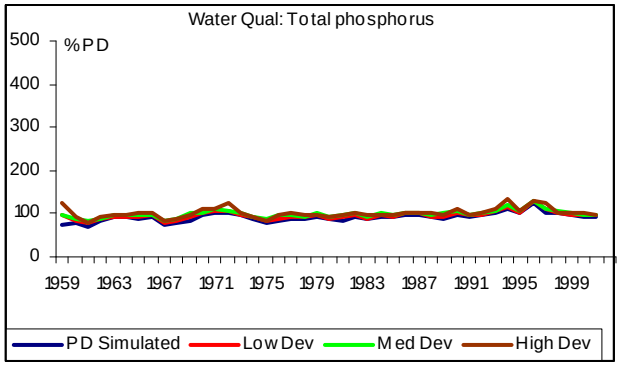
Site 2: Cubango River @ Mucundi



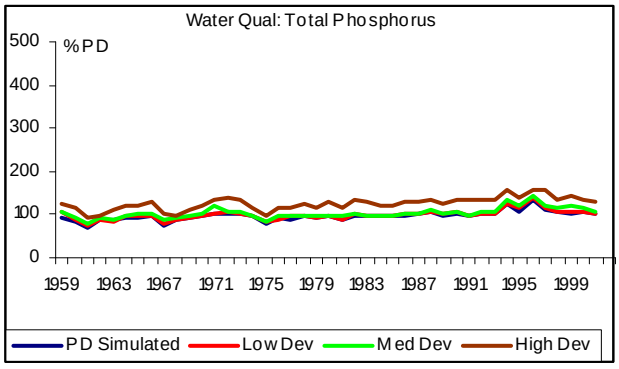
Site 3: Cuito River @ Cuito Cuanavale



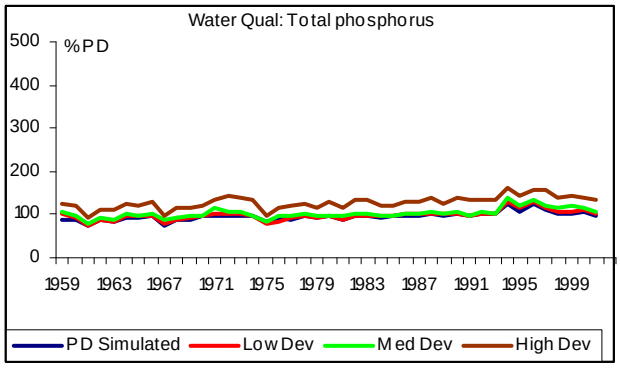
Site 4: Okavango River @ Rundu



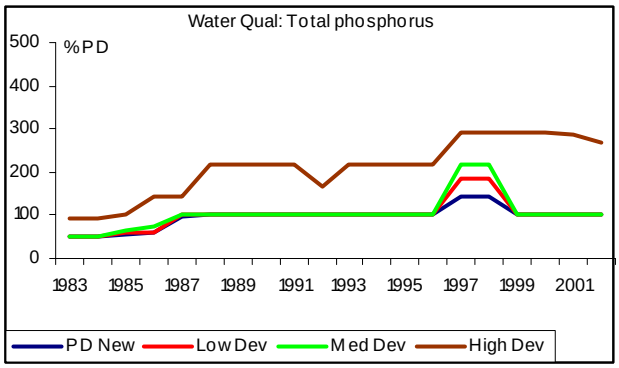
Site 5: Okavango River @ Popa Falls



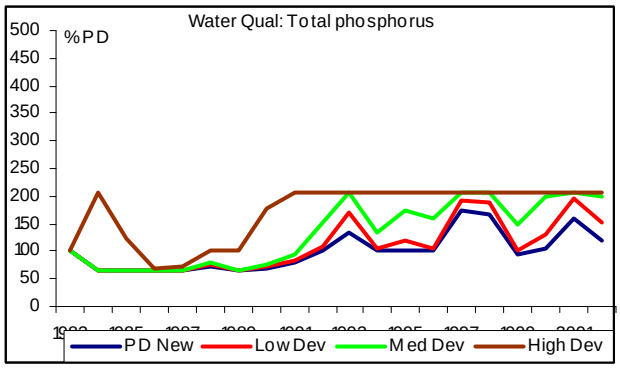
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

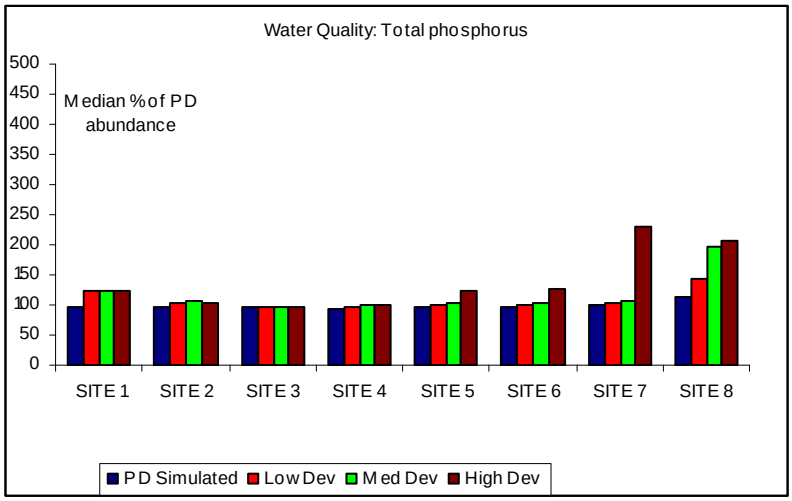


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites, but slightly lower than for total nitrogen. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of phosphorus.



Low Scenario

Slight increase in concentration expected, except for Site 1 where a c. 20% increase is expected under the Low Scenario.

Moderate Scenario

There will only be significant increases in concentration at Sites 1 and 8.

High Scenario

Considerable increase in concentrations are expected at all sites, but in particular at 5, 6, and 7. In the Boteti, the river channel will be mostly dry but remnant pools and/or wells are expected to have high concentrations of phosphorous.

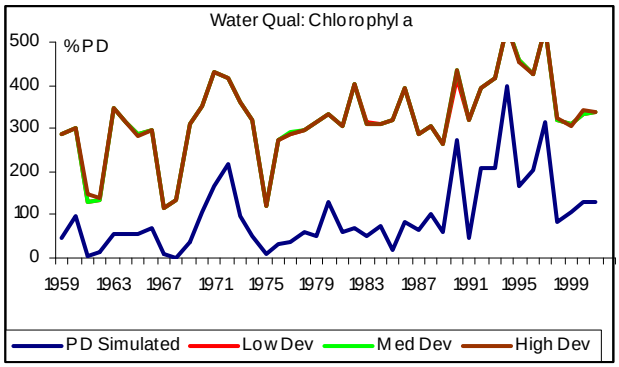
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

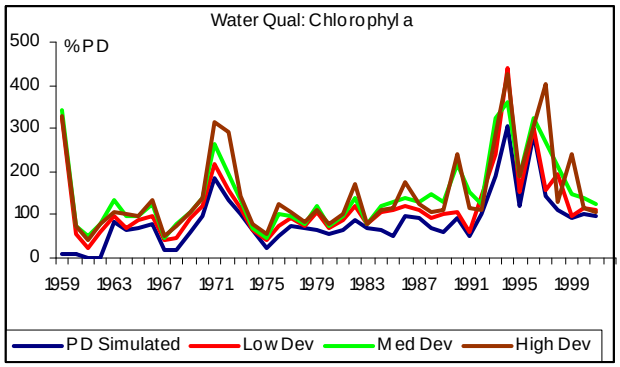
4.9. Chlorophyl a

(In channel)- ug/l,

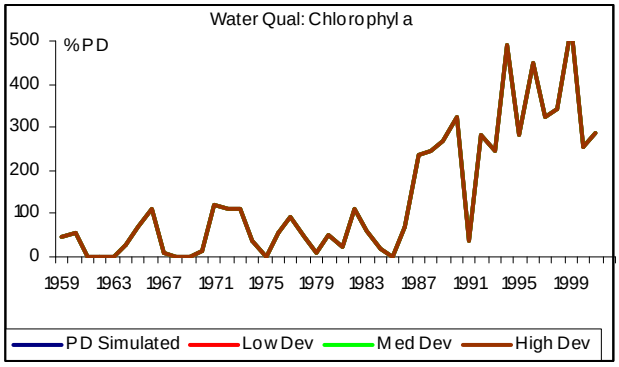
Site 1: Cubango River @ Capico



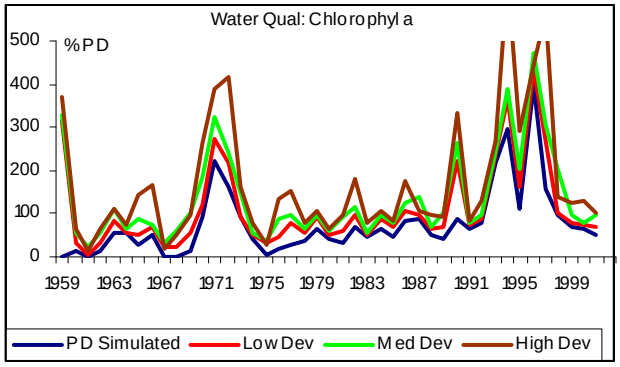
Site 2: Cubango River @ Mucundi



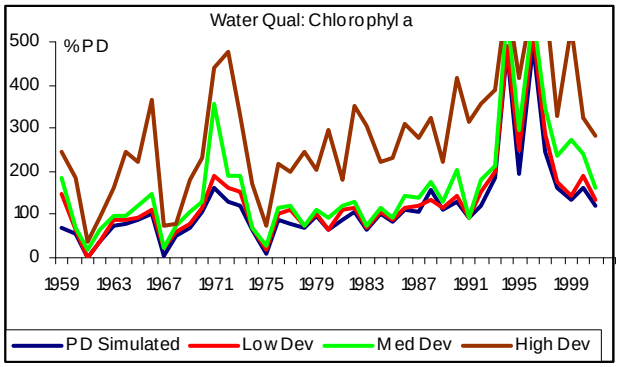
Site 3: Cuito River @ Cuito Cuanavale



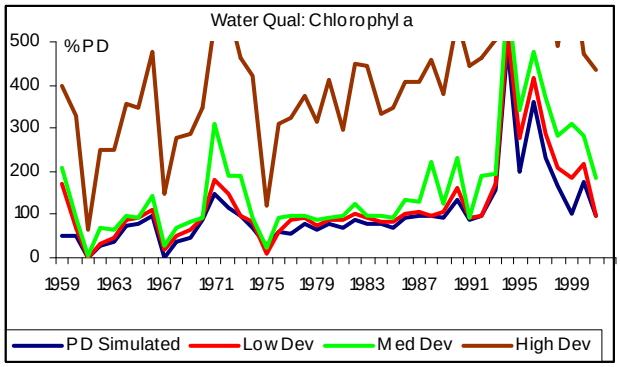
Site 4: Okavango River @ Rundu



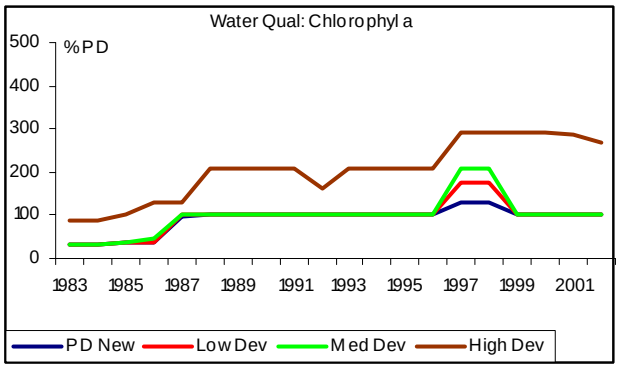
Site 5: Okavango River @ Popa Falls



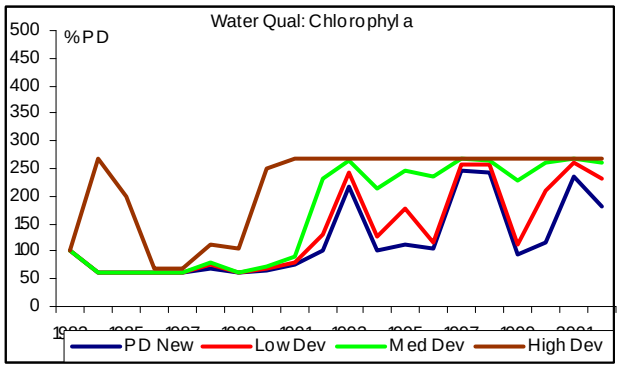
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

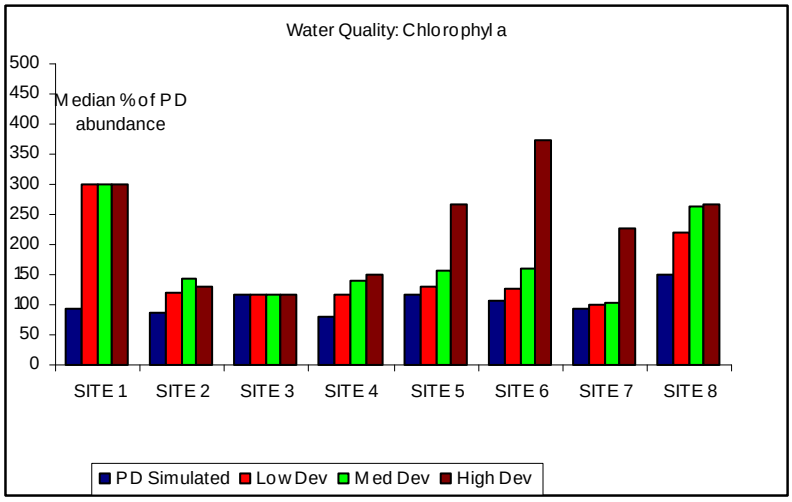


Site 8: Boteti River



Summary change per scenario

The trend of increasing concentration for decreasing flow is general for all the sites. The change in concentration is bigger than for total nitrates. In the case of the Boteti (Site 8), it is expected that remnant pools or wells in the dry sections of the river will have high concentrations of chlorophyll a.



Low Scenario

Slight increase in concentration expected, except for Site 1 where a c. 20% increase is expected under the Low Scenario.

Moderate Scenario

There will only be significant increases in concentration at Sites 1 and 8.

High Scenario

Considerable increase (c. 200-250%) in concentrations are expected at all sites, but in particular at 5, 6, and 7. In the Boteti, the river channel will be mostly dry but remnant pools and/or wells are expected to have high concentrations of Chlorophyll a.

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5. Vegetation

This section provides the time-series for vegetation indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Channel macrophytes
- Lower Wet Bank (hippo grass, papyrus)
- Upper Wet Bank 1 (reeds)
- Upper Wet Bank 2 (trees, shrubs)
- River Dry Bank
- Floodplain Dry Bank
- Floodplain residual pools
- Lower floodplain
- Middle floodplain (grasses)
- Upper floodplain (trees,)
- Open waters
- Permanent swamps
- Lower floodplain
- Upper floodplain
- Occasionally flooded grassland
- *Sporobolus* islands
- Riparian woodland, trees
- Savanna and scrub
- Open water
- Riparian woodland, trees
- Channel-submerged vegetation
- Channel-marginal vegetation.

5.1. Photographs

5.1.1 Channel Macrophytes

Photo: B Curtis

5.1.2 Lower Wet Bank (hippo grass, papyrus)

Photo: B Curtis

5.1.3 Upper Wet Bank 1 (reeds)

Photo: B Curtis

5.1.4 Upper Wet Bank 2 (trees, shrubs)

Photos: B Curtis

5.1.5 River Dry Bank

Photos: B Curtis

5.1.6 Floodplain Dry Bank

Photos: B Curtis

5.1.7 Floodplain residual pools

Photo: B Curtis

5.1.8 Lower Floodplain

Photos: B Curtis

5.1.9 Middle floodplain (grasses)

Photos: B Curtis

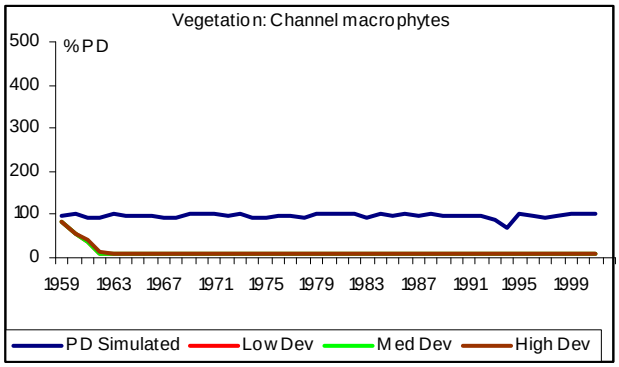
5.1.10 Upper Floodplain (trees)

Photo: B Curtis

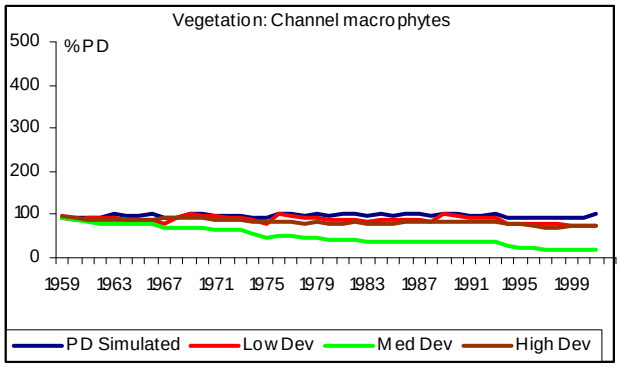
5.2. Channel macrophytes

(Edges of main channel or side channels. All or part of vegetation permanently submerged. Rooted or floating. Moving water.) - *Potamogeton* spp., *Vallisneria, Lagarosiphon.*

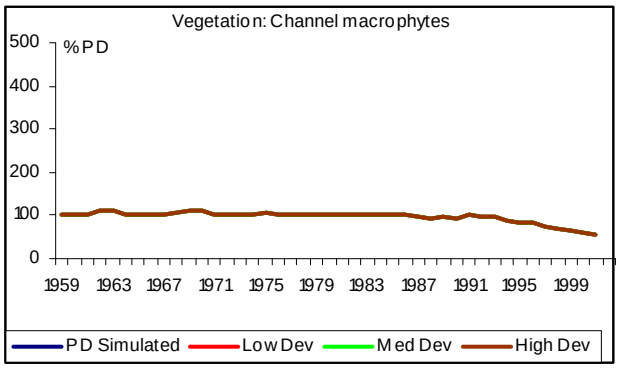
Site 1: Cubango River @ Capico



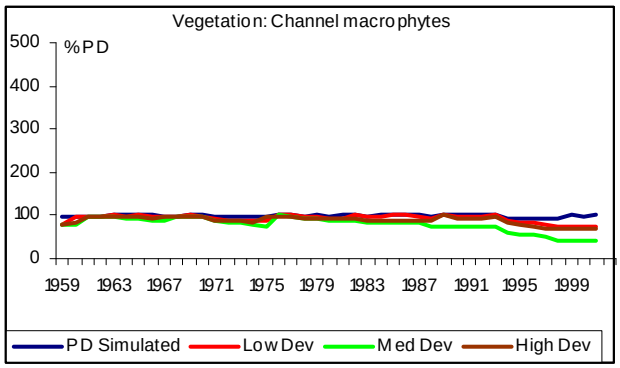
Site 2: Cubango River @ Mucundi



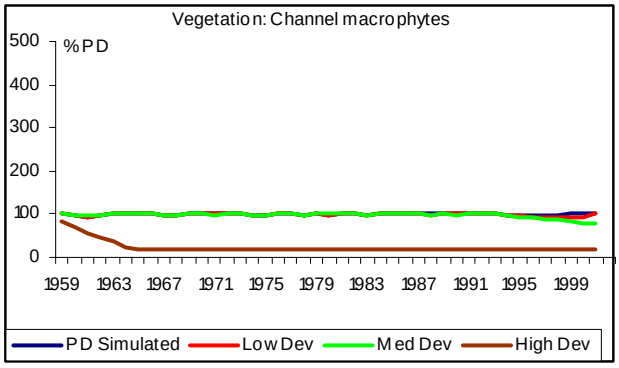
Site 3: Cuito River @ Cuito Cuanavale



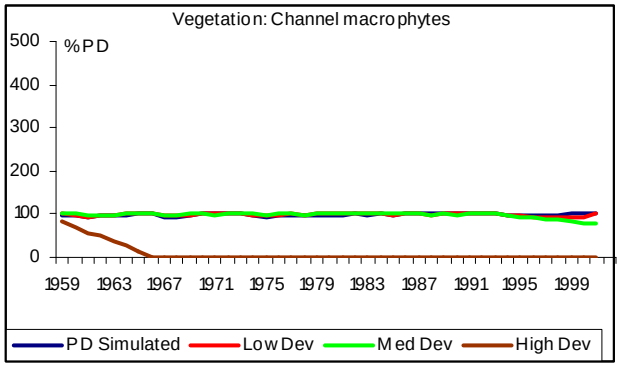
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

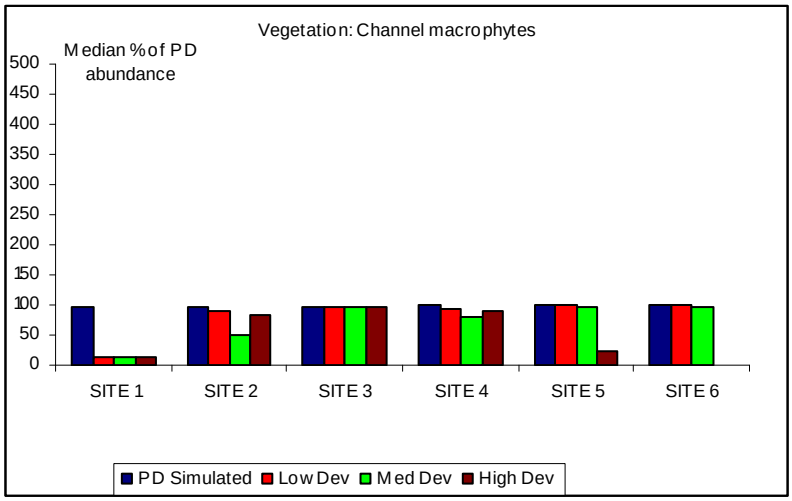


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Cover increases or decreases depending on water volume in dry season and could decline to zero if dry season channel dries. Sudden or very large floods could reduce cover. Changes in the onset or duration of either season are unlikely to have any significant impact.



Low Scenario

At site 1 this falls to very low levels due to marked decrease in low season flows. At the other sites there is only a slight decrease with slight decreases in low season flows.

Moderate Scenario

At site 1 this falls to very low levels due to marked decrease in low season flows. At other sites it decreases in dry years and recovers in wet years. At Sites 2, 4 and 5 it decreases due to low flows and stabilises at 20 - 40% of current levels.

High Scenario

At site 1 this falls to very low levels due to marked decrease in low season flows. Gradual decline to 75% at Site 2. At site 5 there is a dramatic decrease to 20% due to very low dry season discharge and longer dry season discharge, crashing within 8 years.

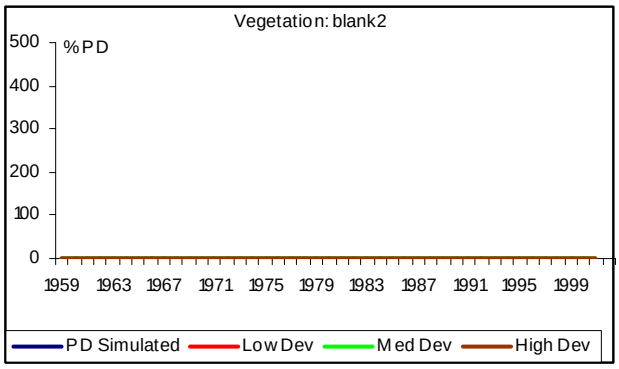
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

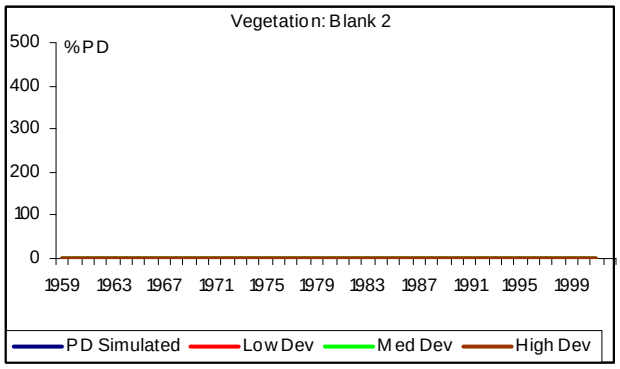
5.3. Lower Wet Bank (hippo, papyrus)

(Permanently wet inner margin in main channel. Floating plants with stems forming dense mat; leaves and flowers above water. Rooted in sand/peat. Moving water.) - *Vossia cuspidata*, *Cyperus papyrus.*

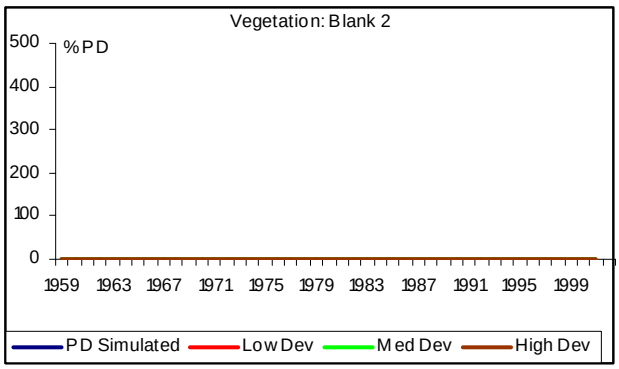
Site 1: Cubango River @ Capico



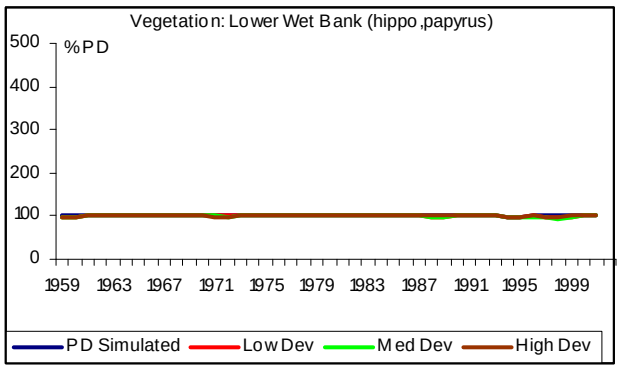
Site 2: Cubango River @ Mucundi



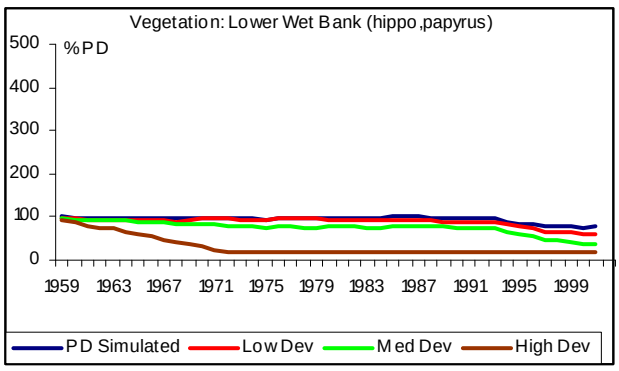
Site 3: Cuito River @ Cuito Cuanavale



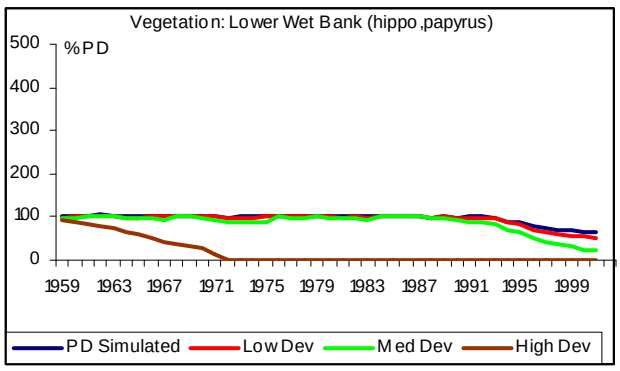
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

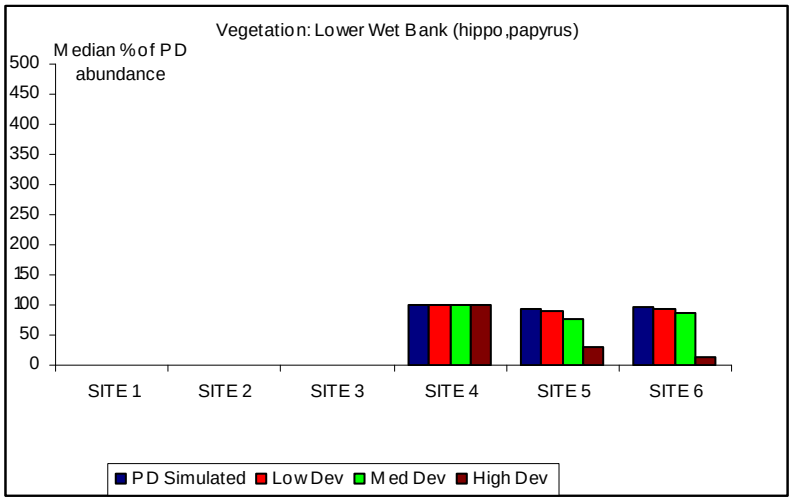


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Vossia will mimic the flow of the river as long as there is water to cover its roots. The leaves will float higher or lower as water level rises or falls. It can tolerate more desiccation than can papyrus. Papyrus roots must also be



Low Scenario

At Sites 4, 5 and 6, *Vossia* will not be affected by changes either in the wet or dry season, as long as there is some flow. Papyrus roots must be permanently inundated, so lower flows have strong negative impacts and dry years gradually reduce papyrus extent. Low scenarios will gradually reduce this indicator.

Moderate Scenario

At Sites 4, 5 and 6, *Vossia* will not be affected by changes either in the wet or dry season, as long as there is some flow. Papyrus roots must be permanently inundated, so lower flows have strong negative impacts and dry years gradually reduce papyrus extent. Medium scenarios will gradually reduce this indicator.

High Scenario

At sites 4, 5 and 6, *Vossia* will not be affected by changes either in the wet or dry season, as long as there is some flow. Papyrus roots must be permanently inundated, so lower flows have strong negative impacts and dry years gradually reduce papyrus extent. The high scenario causes these plants to crash within 15 year at Sites 5 and 6.

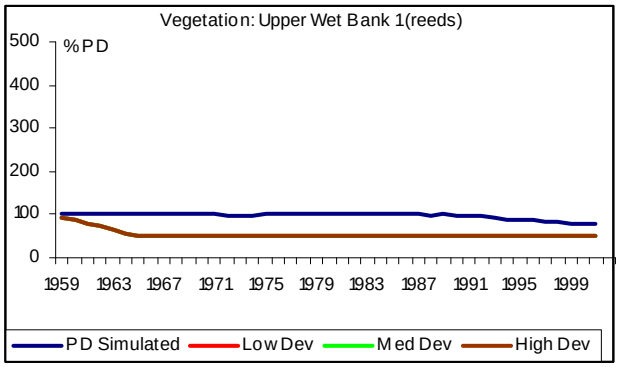
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

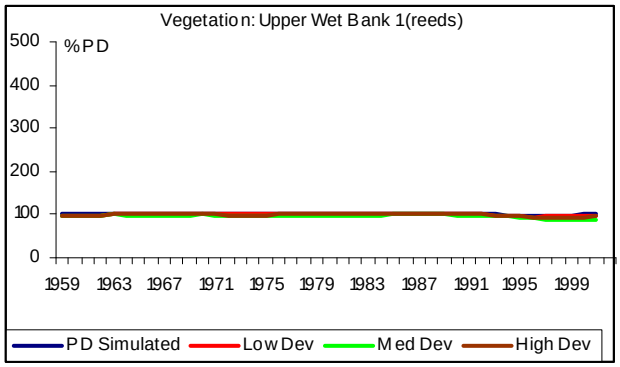
5.4. Upper Wet Bank 1 (reeds)

(Outer edges of the mainstream, beyond inner margin. Emergent vegetation with roots generally wet, but can withstand being out of water. Moving water.) - *Phragmites australis.*

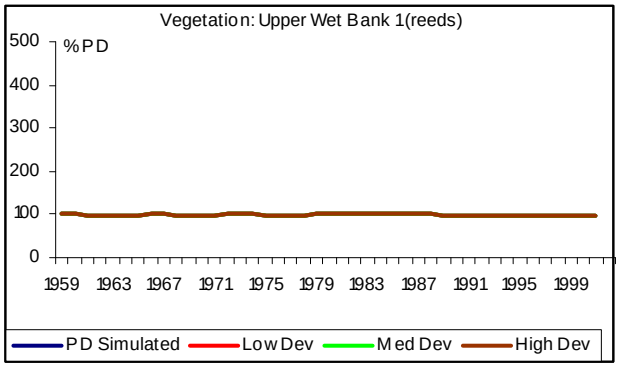
Site 1: Cubango River @ Capico



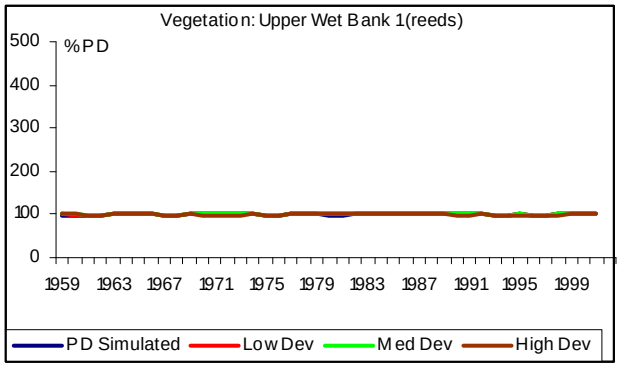
Site 2: Cubango River @ Mucundi



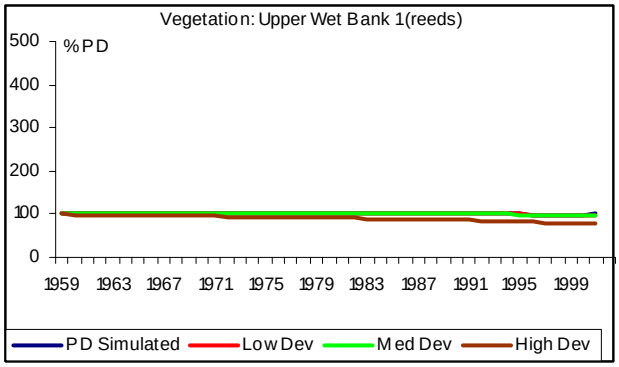
Site 3: Cuito River @ Cuito Cuanavale



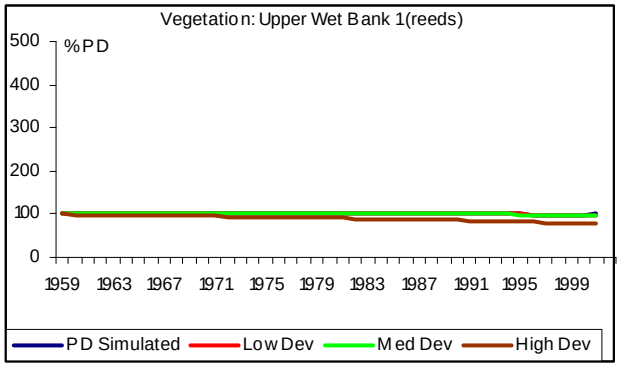
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

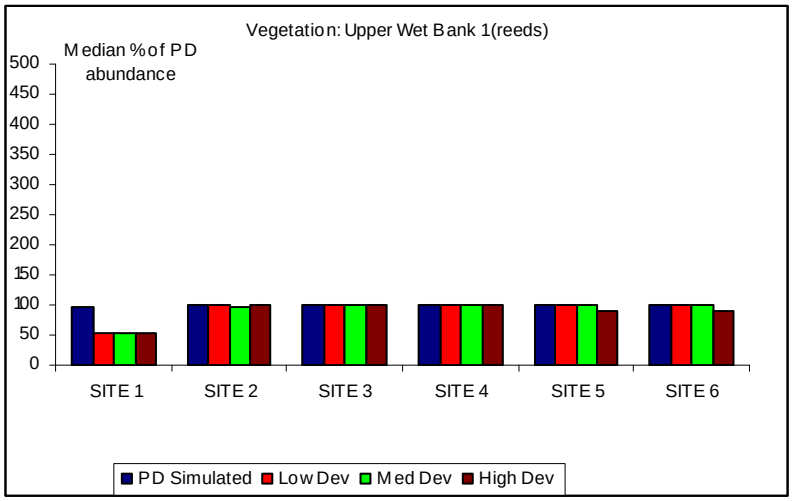


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Water depth (>2 m) inhibits growth in channel. Declines in dry season flows will encourage colonisation of channel bottom with some die-off of the upper margin of reed bed. Flood season has little impact, but new growth could decrease in strong floods.



Low Scenario

As reeds are tolerant of variation, there will be negligible impacts under the low scenario, unless there are successive dry seasons.

Moderate Scenario

As reeds are tolerant of variation, there will be negligible impacts under the medium scenario, unless there are successive dry seasons.

High Scenario

There will be a steady decline under high dev. with time due to very low dry season flows at Sites 5 and 6. Die-off on the outer edges will be greater than colonisation of river bed, as there is a steep drop into the river bed at most sites.

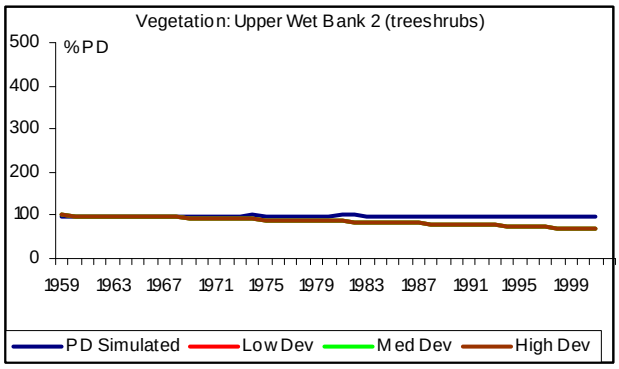
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

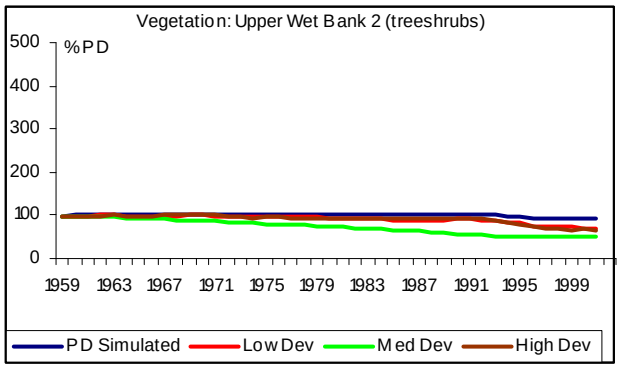
5.5. Upper Wet Bank 2 (treeshrubs)

(Wetted edge of main channel (or river islands) at high flow. Higher than Lower Wet Bank. Trees & shrubs typical of riparian zone. Can be submerged for short periods) - *Searsia* (Rhus), *Syzigium* etc.

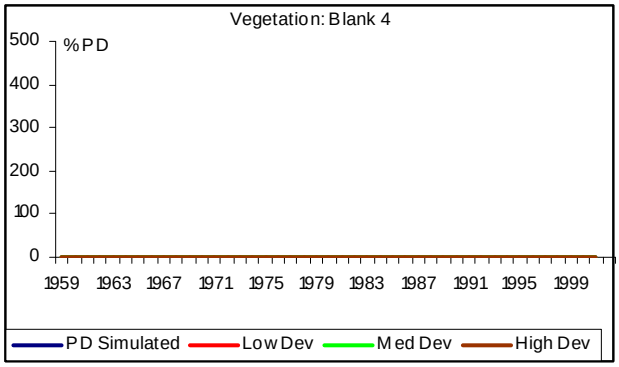
Site 1: Cubango River @ Capico



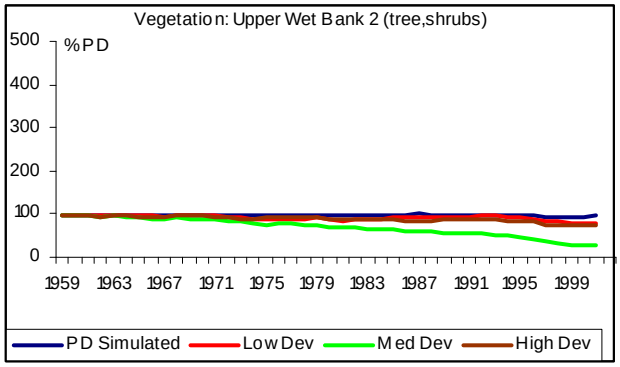
Site 2: Cubango River @ Mucundi



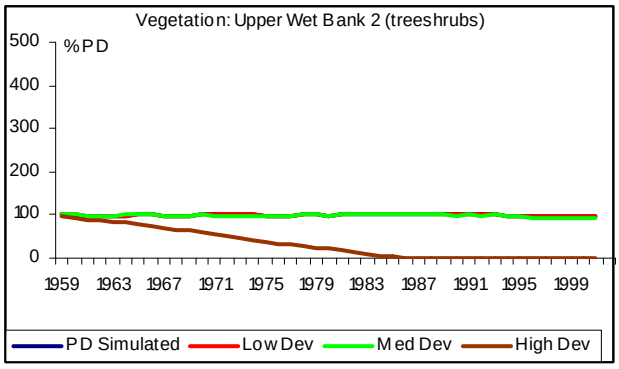
Site 3: Cuito River @ Cuito Cuanavale



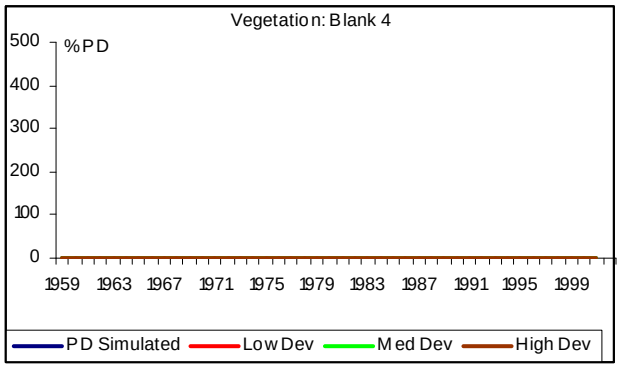
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

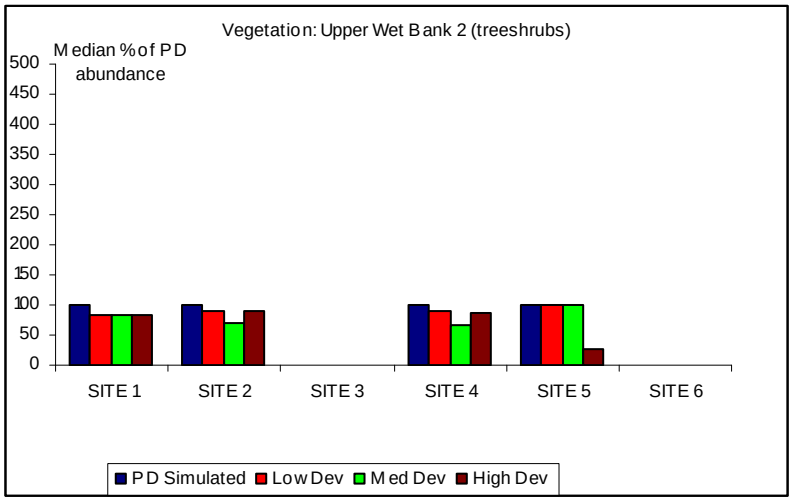


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Can withstand inundation, but too long (>3 months?) will kill trees. Smaller floods will allow colonisation by terrestrial species on the outer edge. These wetbank trees will be squeezed into a smaller zone, decreasing cover. Too long a dry season will reduce recruitment and adult vigour.



Low Scenario

There will be a very gradual decline over time at most sites, with partial recovery in good flood years. At site 1 trees could be reduced to 60% over 10 years.

Moderate Scenario

There will be a gradual decline over time, with partial recovery in good flood years. The longer dry seasons will impact recruitment. At site 1 trees could be reduced to 60% over 10 years, at site 2 it could reduce to 50%, at site 4, 5 and 6 there will be a continuous decline without recovery, even in good years.

High Scenario

For sites 2, 4 there is more dry season discharge therefore this indicator will be less affected than it is a medium dev. At sites 5 & 6, the extreme low dry season flows will cause a crash within 25 years.

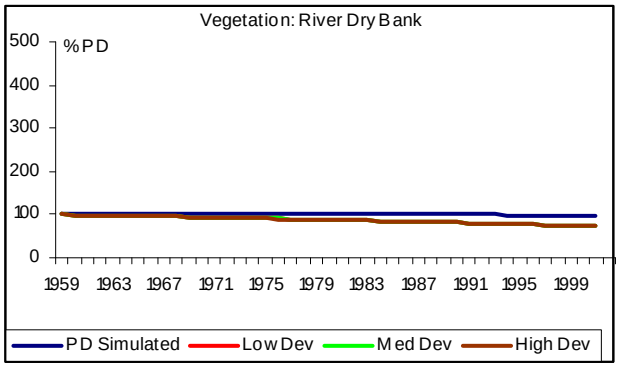
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

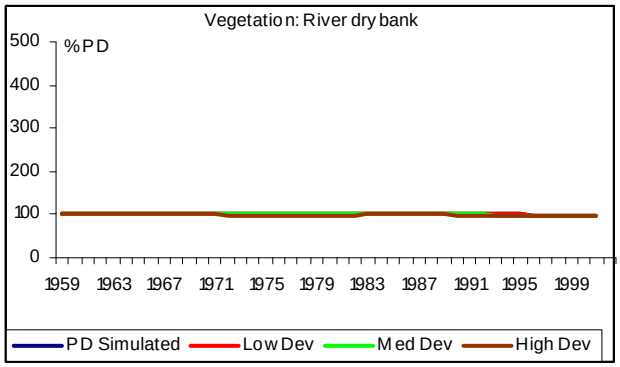
5.6. River Dry Bank

(Riparian woodlands found on the high dry bank of river channels.) - *Diospyros mespiliformis*, with *Acacia nigrescens*, *Combretum imberbe*, *Ficus sycomorus*.

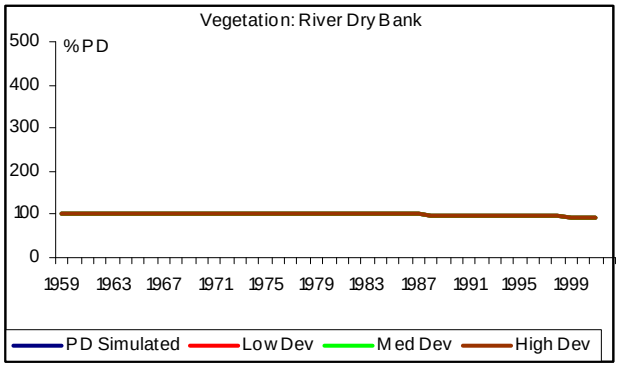
Site 1: Cubango River @ Capico



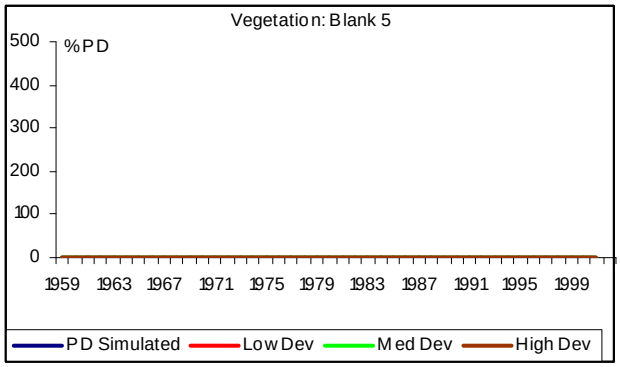
Site 2: Cubango River @ Mucundi



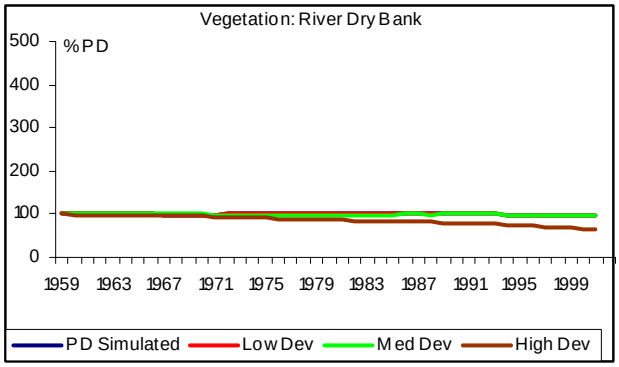
Site 3: Cuito River @ Cuito Cuanavale



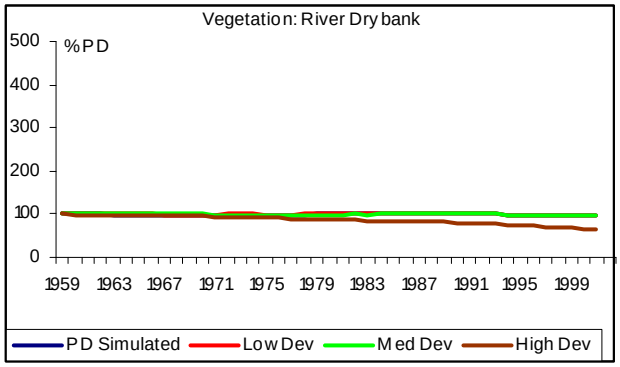
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

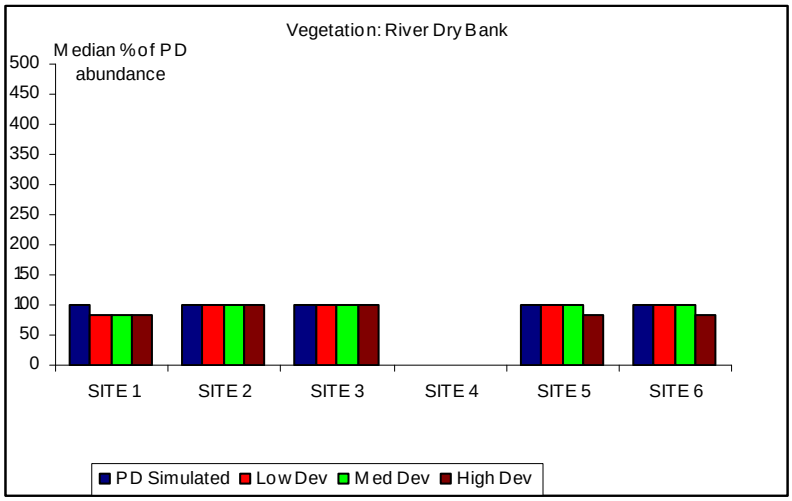


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Stabilises bank. Adults will decrease with very low dry season flow as water table may drop below reach of roots. Seedlings will decline with shorter flood seasons because of lower soil moisture levels. Decline in community could take up to 3 - 4 decades.



Low Scenario

there will be a marked drop in dry season flow and hence a negative impact, with the dry bank vegetation gradually declining over the years At Sites 2, 5 and 6 very little impact is expected, with decreases in occasional stress years but a recover in wetter years.

Moderate Scenario

At Site 1, there will be a marked drop in dry season flow and hence a negative impact, with the dry bank vegetation gradually declining over the years. At Sites 2, 5 and 6 there will be a slight decline.

High Scenario

At Site 1, there will be a marked drop in dry season flow and hence a negative impact, with the dry bank vegetation gradually declining over the years. At Site 2 there will be a slight decline. At Site 5 and 6, there will be a clear, continuous decline due to very low dry season flows.

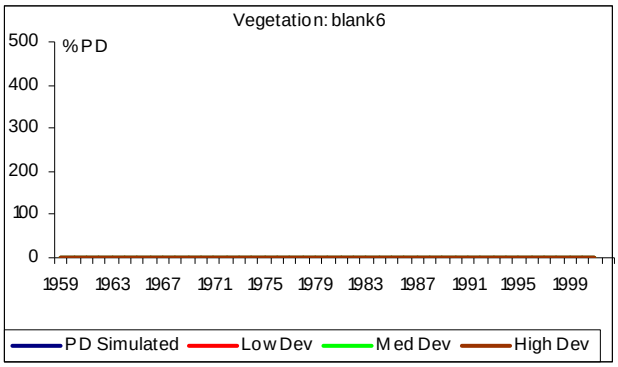
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

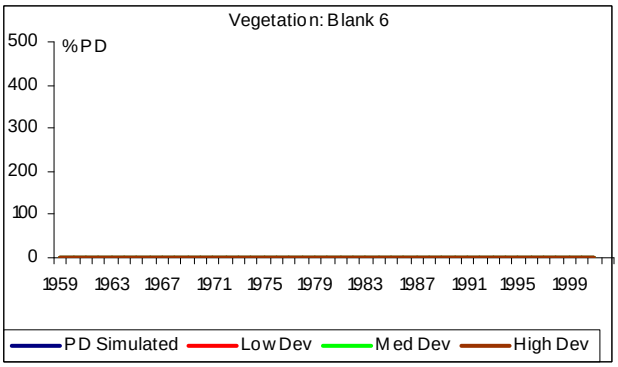
5.7. FP resid pools, Open water (6)

(Permanent floodplain pools. Connected to river during high flow but retain water at normal low flow) - *Nymphaea, Nymphoides, Lagarosiphon, Trapa.*

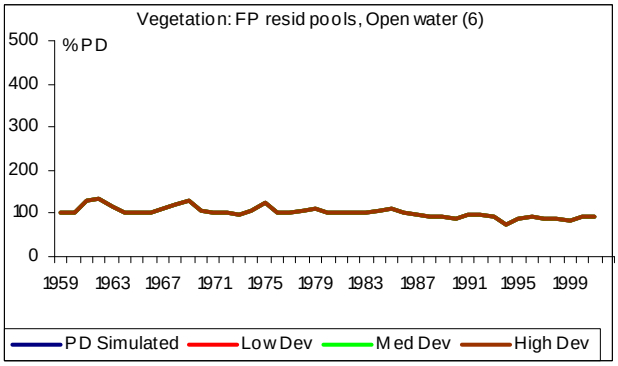
Site 1: Cubango River @ Capico



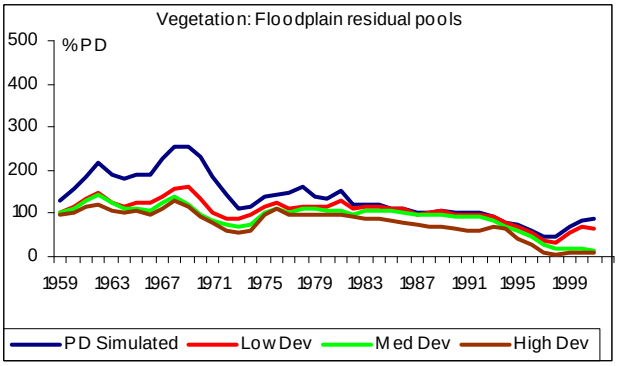
Site 2: Cubango River @ Mucundi



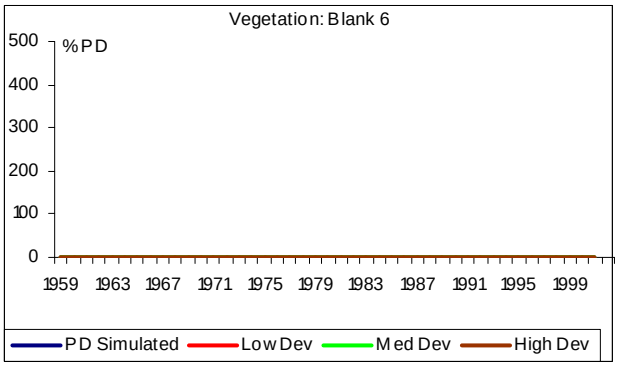
Site 3: Cuito River @ Cuito Cuanavale



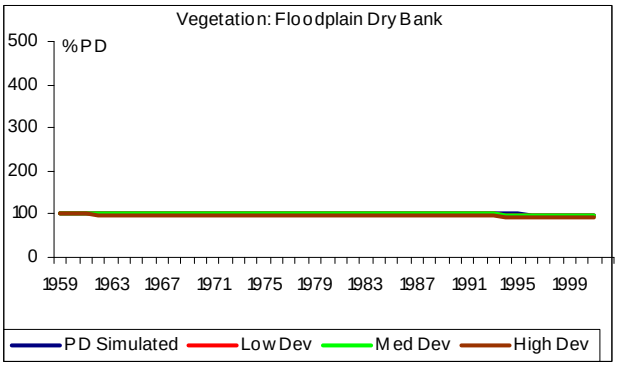
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

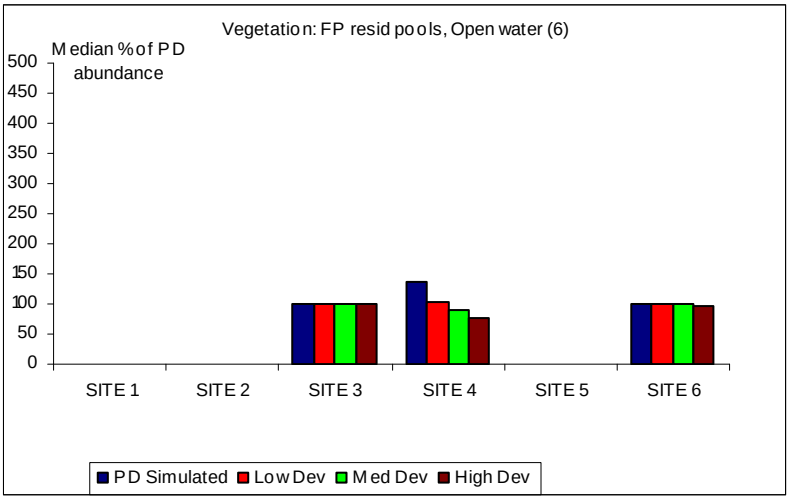


Site 6: Okavango River @ Pan Handle



Summary change per scenario

These are permanent pools that are replenished in the flood and sustained by groundwater during the dry season. Reduced flooding and lower lowflows will result in a decrease in these pools due to evaporation and a lower water table.



Low Scenario

Will decrease with low floods because the size and number of pools will decrease gradually.

Moderate Scenario

At Site 4 there is a dramatic decrease but the pools can recovery quickly in good years. At Site 6 it is less dramatic.

High Scenario

At all sites there is a marked decline in this indicator due to declines in low flows and floods. At Site 6 it will crash within 30 years, but not entirely, due to rainwater input into the system.

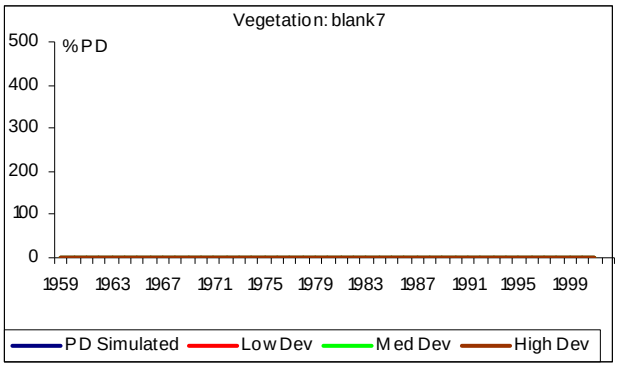
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

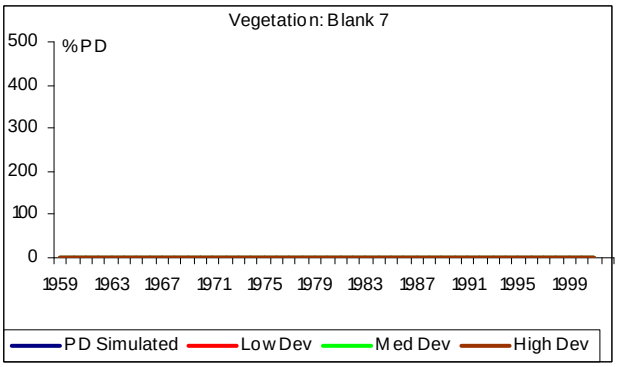
5.8. Lower floodplain

(Lower floodplain with long inundation. The deeper sections of channels between scroll bars that flood and dry out seasonally.) - *Vossia cuspidata* with *Persicaria, Ludwigia*, etc.

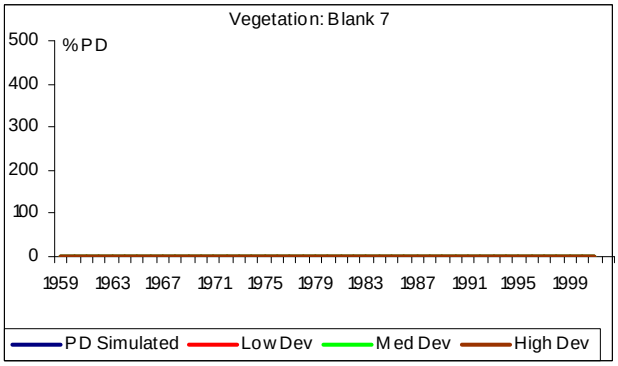
Site 1: Cubango River @ Capico



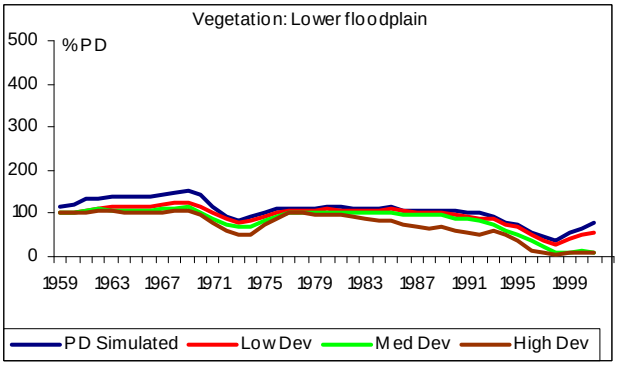
Site 2: Cubango River @ Mucundi



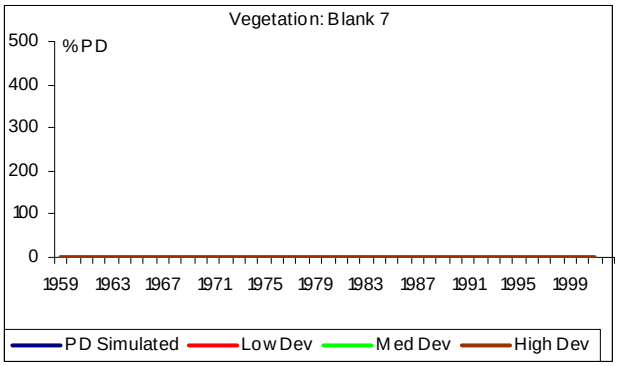
Site 3: Cuito River @ Cuito Cuanavale



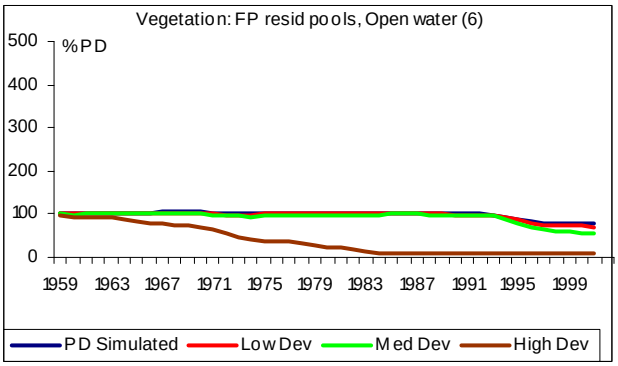
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

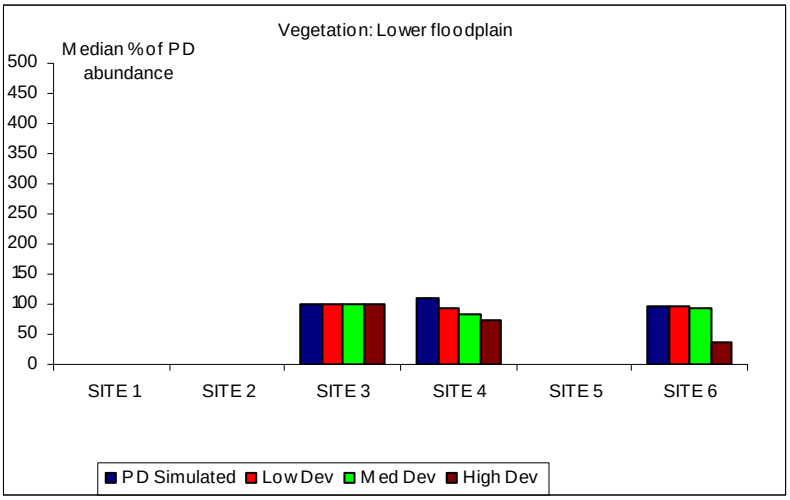


Site 6: Okavango River @ Pan Handle



Summary change per scenario

This is seasonal and dependent on recharge by floods. Their extent mimics the flood levels from year to year. In wet years they it increases in size, in dry years it decreases.



Low Scenario

Very responsive to levels of flooding. Gradual decline in veg with successive dry years. The position of the habitat can shift within the floodplain.

Moderate Scenario

Similar trend, but more pronounced.

High Scenario

Steady decline over time, but will stabliise at around 20% due to input from rainfall.

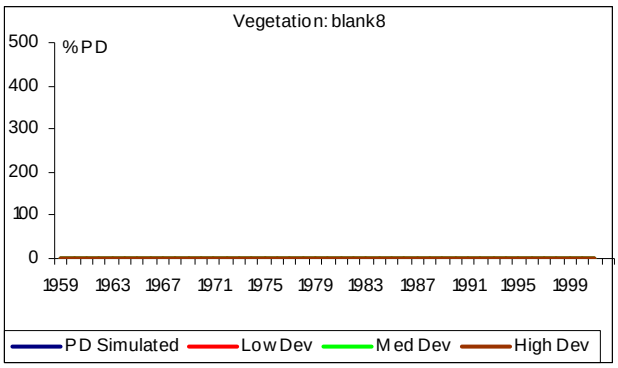
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

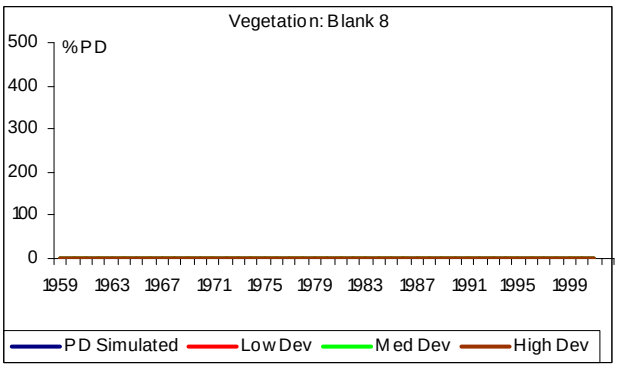
5.9. Middle floodplain (grasses)

(Middle floodplain, clay or sand, with short inundation. Large area with thatching and grazing grasses. Includes portions of upper floodplain (but not islands)) - *Setaria, Panicum*, thatching grasses.

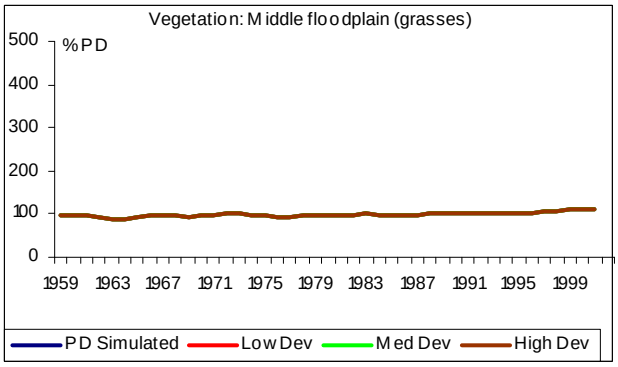
Site 1: Cubango River @ Capico



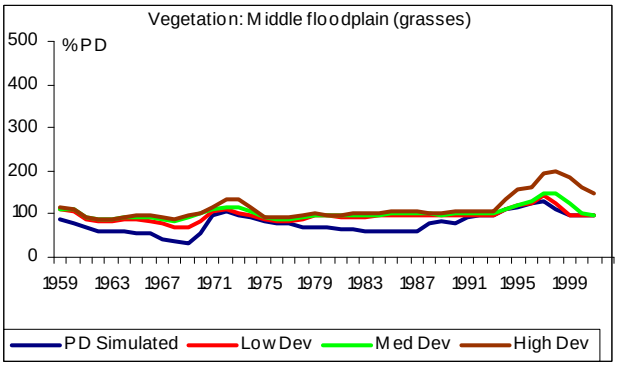
Site 2: Cubango River @ Mucundi



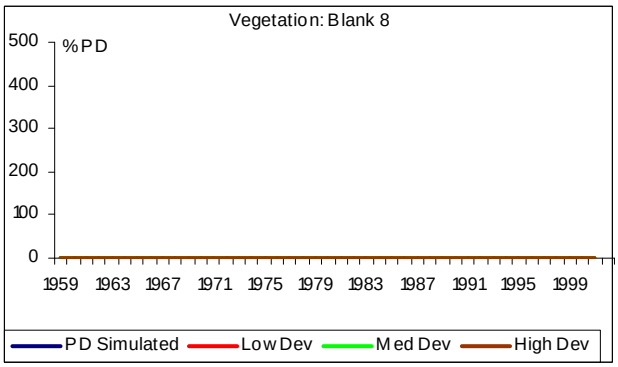
Site 3: Cuito River @ Cuito Cuanavale



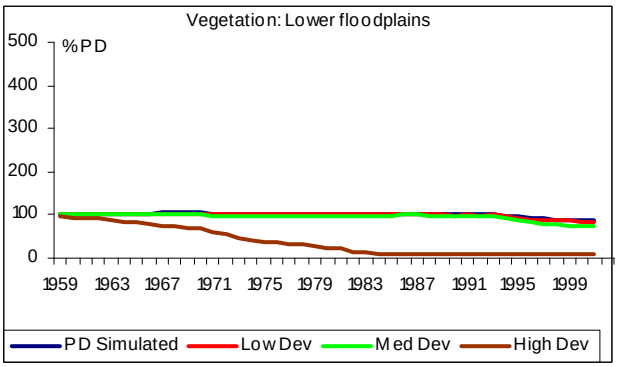
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

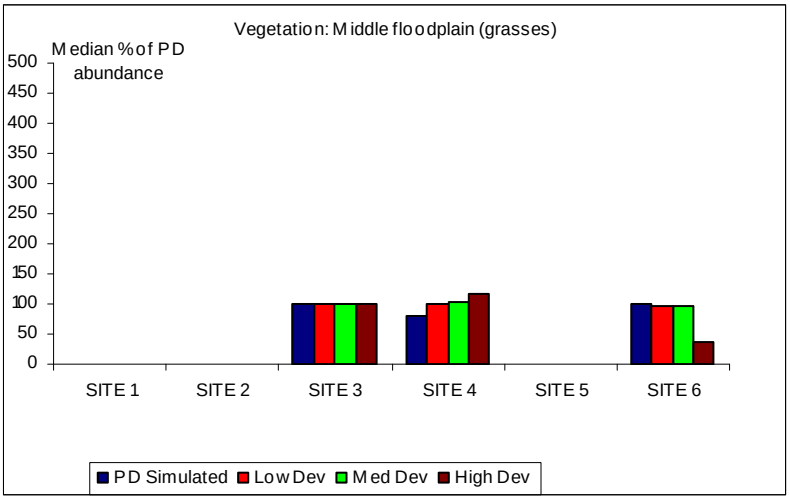


Site 6: Okavango River @ Pan Handle



Summary change per scenario

These are basically terrestrial grasses that can withstand a degree of inundation in the wet season. With a longer wet season, there will be a decrease in area of these plants, and vice versa. Flooding during growing season reduces productivity



Low Scenario

All three scenarios benefit these grasses to varying extents. In wet years grass cover decreases, and increases in dry years.

Moderate Scenario

All three scenarios benefit these grasses to varying extents. In wet years grass cover decreases, and increases in dry years. Overall, there are more of these grasses due to drier conditions.

High Scenario

All three scenarios benefit these grasses to varying extents. In wet years grass cover decreases, and increases up to 10% in successive dry years at site 6.

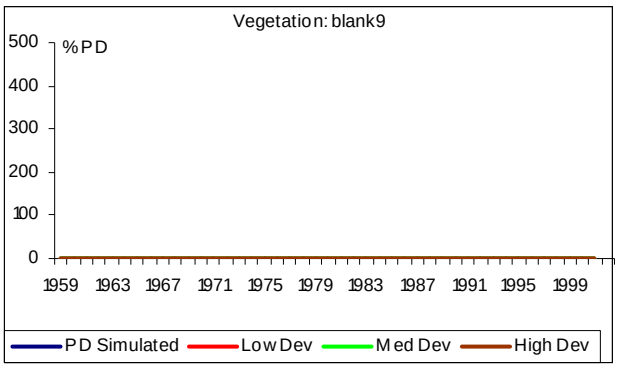
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

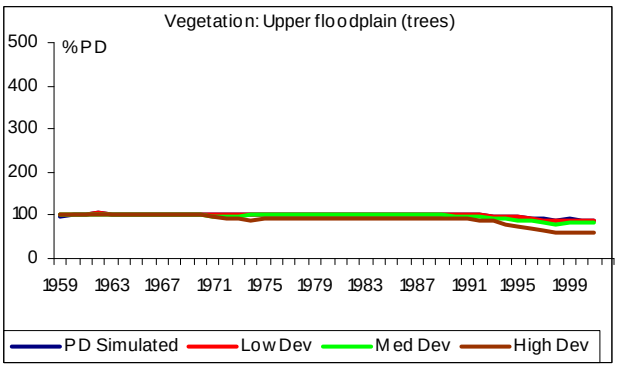
5.10. Upper floodplain (trees)

(The highest points on the floodplain. Only inundated during high flow. Grasses, shrubs, a few trees. Equals wildlife secondary floodplain. Therefore is primarily floodplain islands.) - *Searsia* (Rhus) with *Acacia hebeclada, Acacia sieberiana, Diospyros lycioides*, grasses

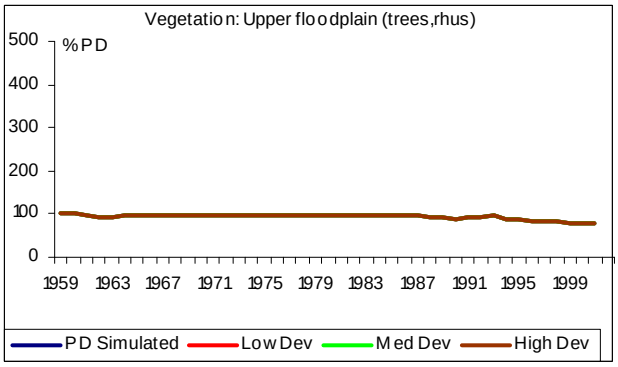
Site 1: Cubango River @ Capico



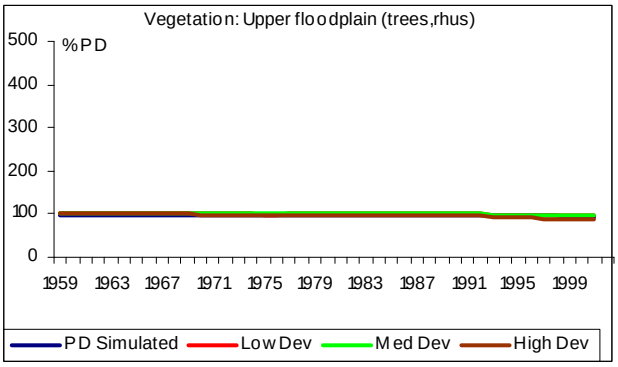
Site 2: Cubango River @ Mucundi



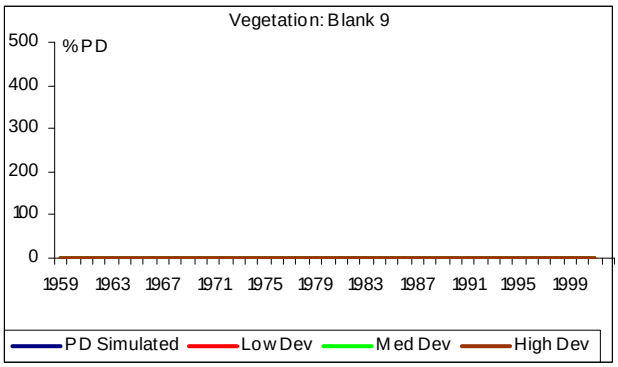
Site 3: Cuito River @ Cuito Cuanavale



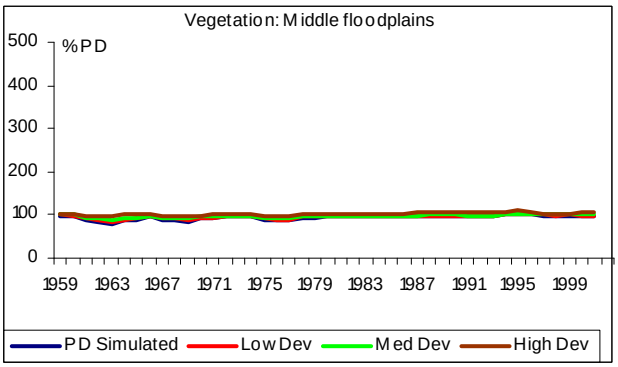
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

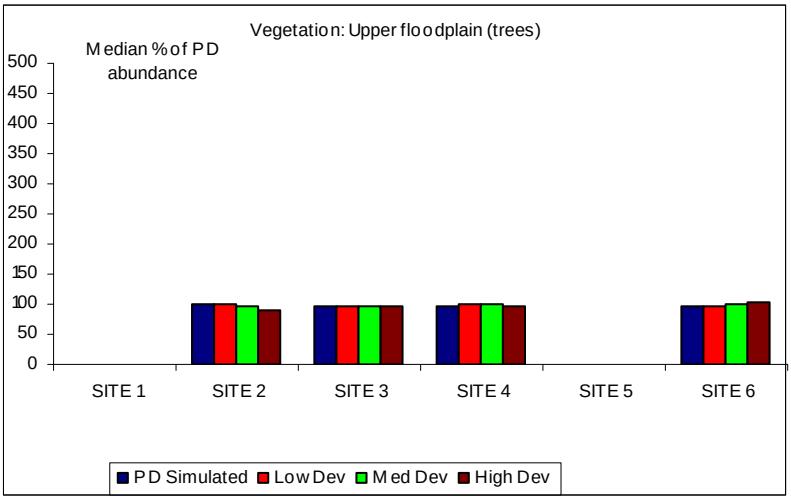


Site 6: Okavango River @ Pan Handle



Summary change per scenario

Seldom inundated. Long inundation is detrimental to these plants. Dependent on some inundation to recharge ground water, and for nutrients.



Low Scenario

Steady, but gradual decline with decrease in dry season flows and duration. Decline is more more dramatic at site 2, because overall flows are less than downstream.

Moderate Scenario

Steady decline with decrease in dry season flows and duration. Decline is more more dramatic at site 2, because overall flows are less than downstream.

High Scenario

More dramatic decline with decrease in dry season flows and duration. Decline is more more dramatic at site 2, because overall flows are less than downstream. The cline is up to about 10%.

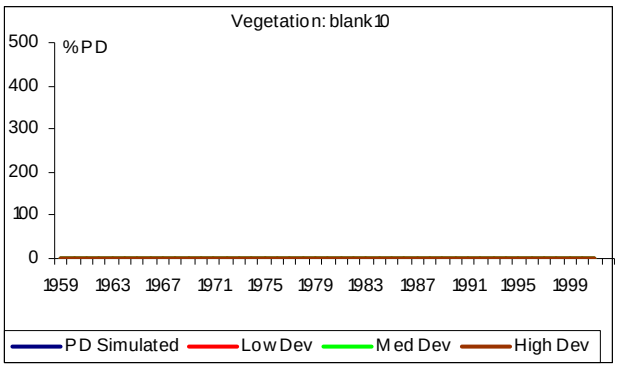
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

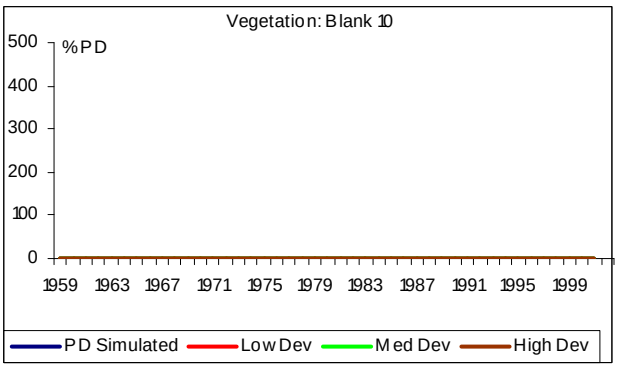
5.11. Floodplain Dry Bank

(Dry river bank on outer edge of floodplain. Seldom to never flooded. Riparian species that need to be close to water.) - *Diospyros mespiliformis*, with *Combretum imberbe*, *Albizia versicolor*, *Acacia hebeclada* & *tortilis*, etc.

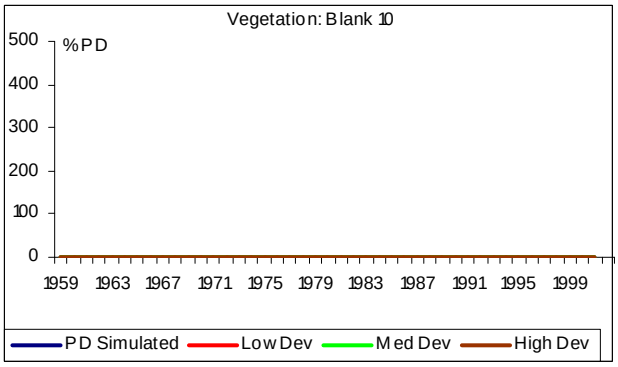
Site 1: Cubango River @ Capico



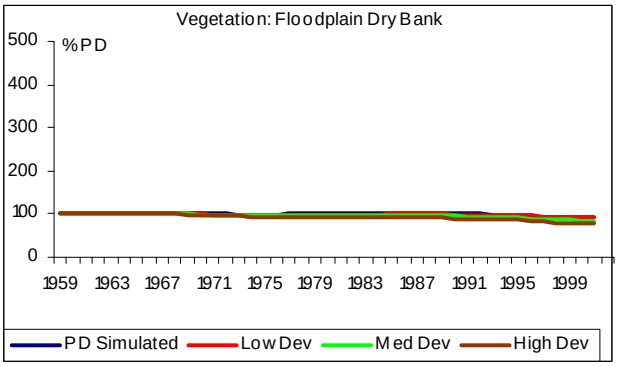
Site 2: Cubango River @ Mucundi



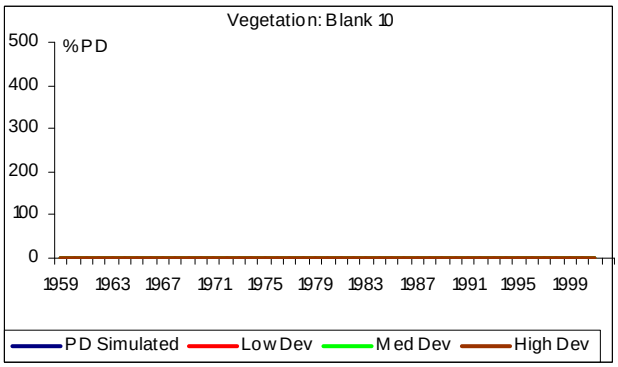
Site 3: Cuito River @ Cuito Cuanavale



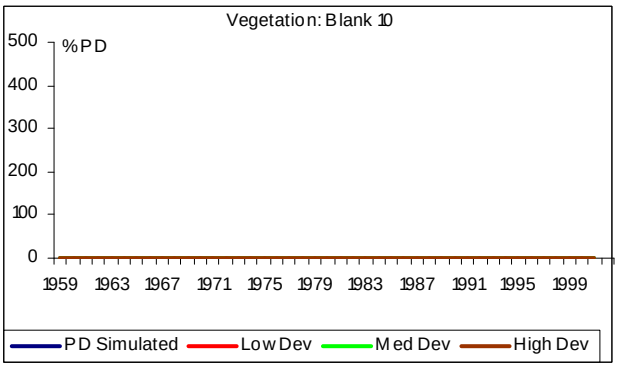
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

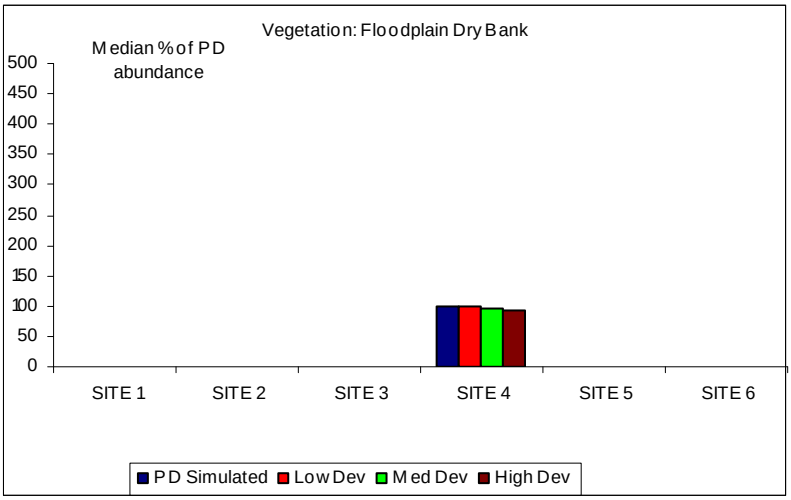


Site 6: Okavango River @ Pan Handle



Summary change per scenario

This vegetation stabilises the bank. More dependent on floods than river dry bank as water has to cross an extensive floodplain to recharge the ground water. Adults will decrease with low floods and long dry seasons as water table may drop below reach of roots. Seedlings will decline with shorter flood seasons because of lower soil moisture levels. Decline in community could take up to two to three decades.



Low Scenario

In years of low floods, there will be a slight negative effect, especially in dry years. Some recovery in good years, but not to previous levels.

Moderate Scenario

There will be a steady decline with time.

High Scenario

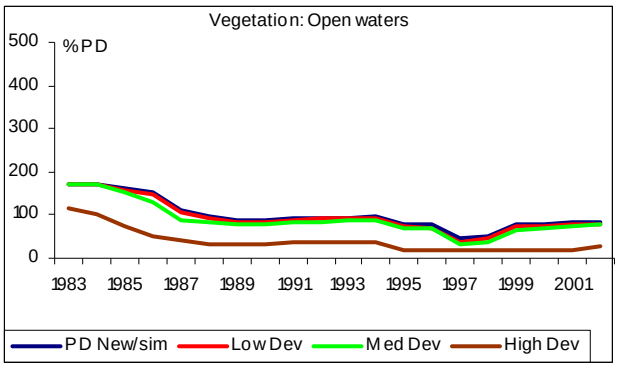
There will be a more severe steady decline with time due to lower dry season flows.

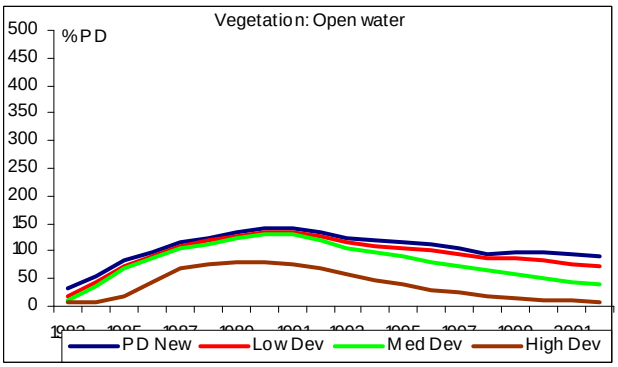
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.12. Open waters

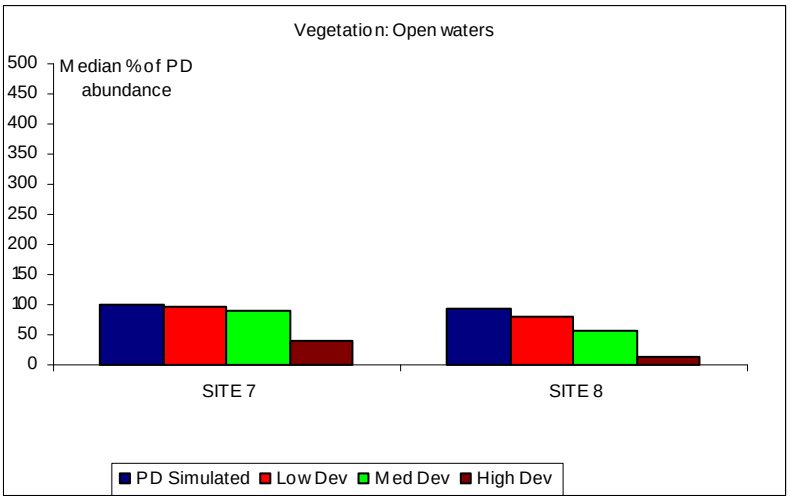
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

Vegetation sensitive to changes in water depth, rate of flow, nutrients and sediments.



Low Scenario

Gradual terrestrialisation of vegetation and encroachment of upper floodplain vegetation with loss of open water.

Moderate Scenario

Gradual terrestrialisation of vegetation and encroachment of upper floodplain vegetation with loss of open water.

High Scenario

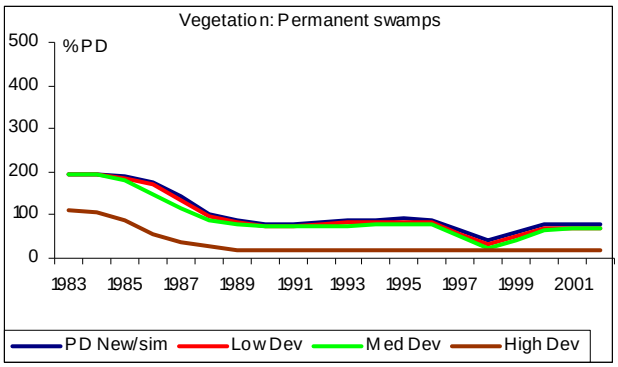
High degree of terrestrialisation; over 50% in dry years. Almost entire loss of open water.

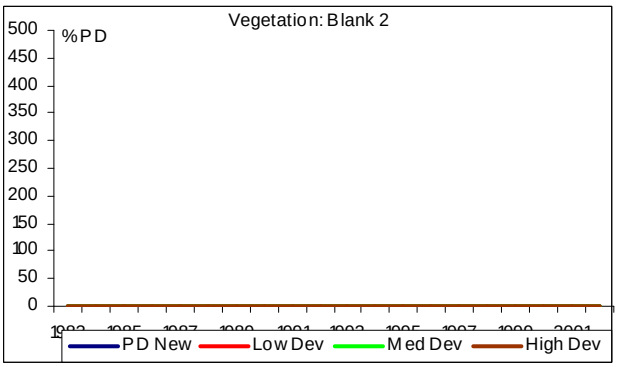
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.13. Permanent swamps

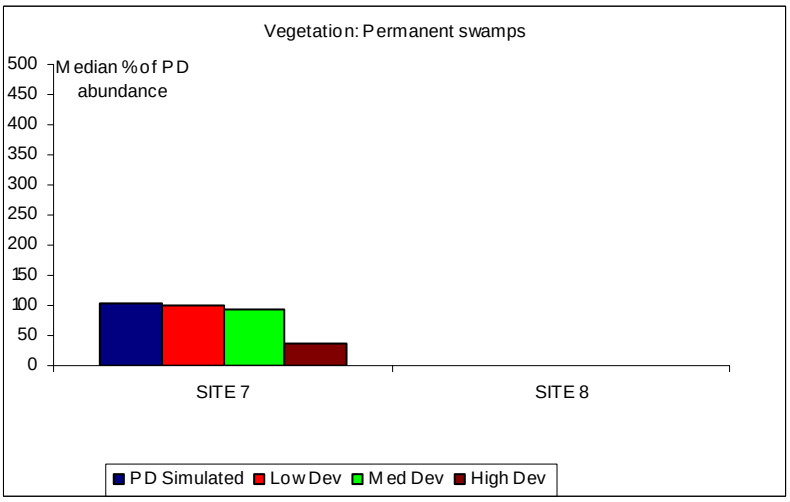
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

More sensitive to soil moisture content. As long as soil is saturated, depth is not important.



Low Scenario

Gradual terrestrialisation of vegetation and loss of swamp.

Moderate Scenario

Increasing terrestrialisation and loss of swamp.

High Scenario

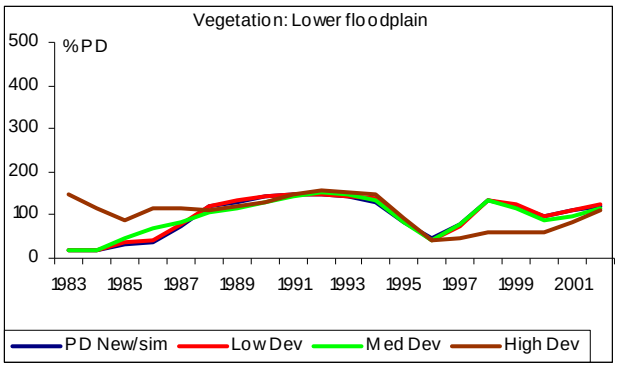
High degree of terrestrialisation; over 80% loss of permanent swamp within 7 years.

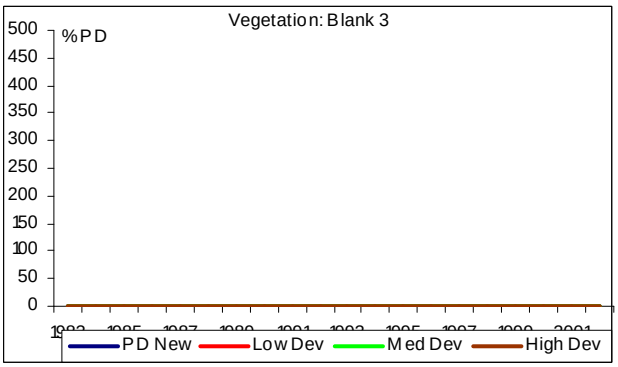
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.14. Lower floodplain

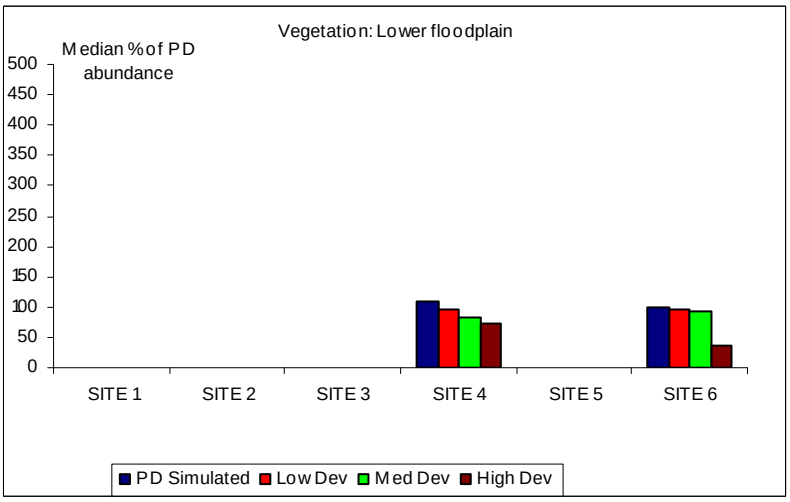
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

Sensitive to duration and frequency of flooding. Long duration of flood correlates with depth of water.



Low Scenario

Slight decrease in this habitat.

Moderate Scenario

Slightly more decrease in this habitat.

High Scenario

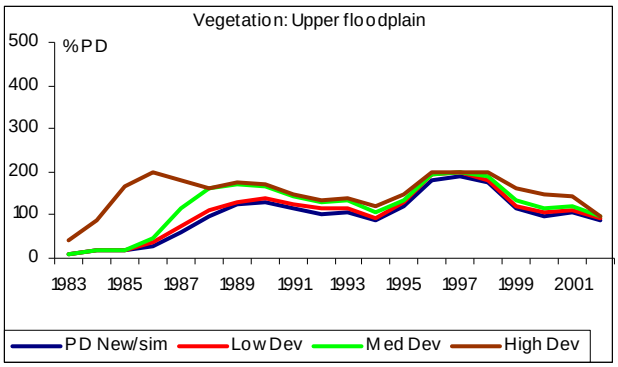
Low flows can still maintain some areas of seasonal floodplains, but reduced.

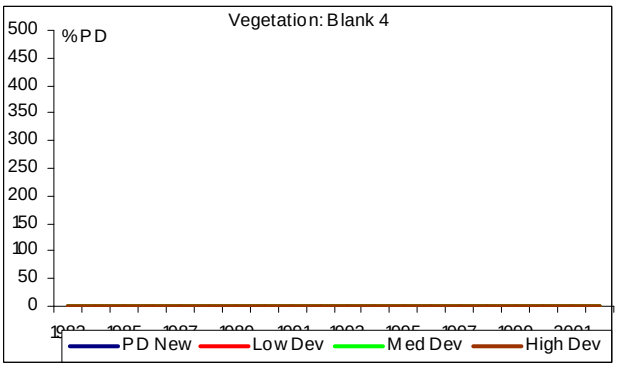
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.15. Upper floodplain

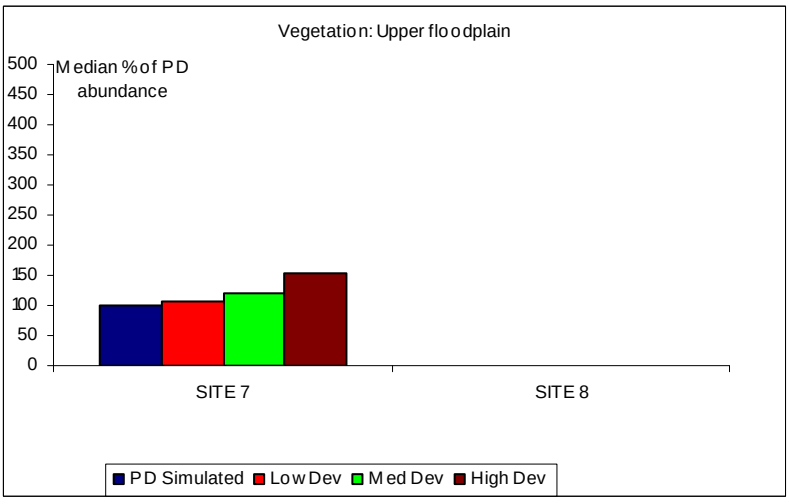
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

Sensitive to duration and frequency of flooding. Long duration of flood correlates with depth of water.



Low Scenario

Slight increase in upper floodplain.

Moderate Scenario

Greater increase in this habitat.

High Scenario

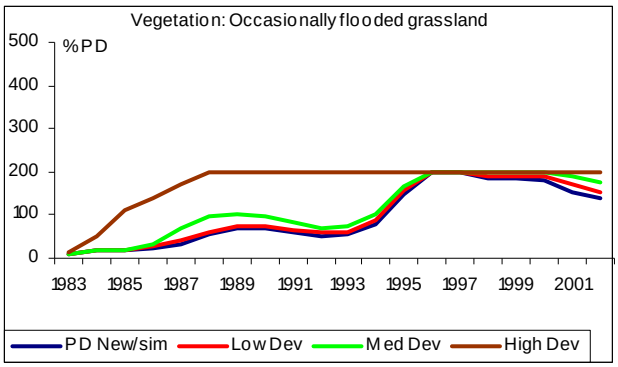
Further increase in this habitat.

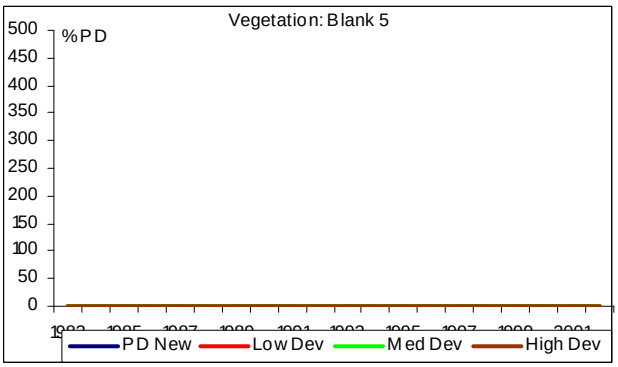
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.16. Occasionally flooded grassland

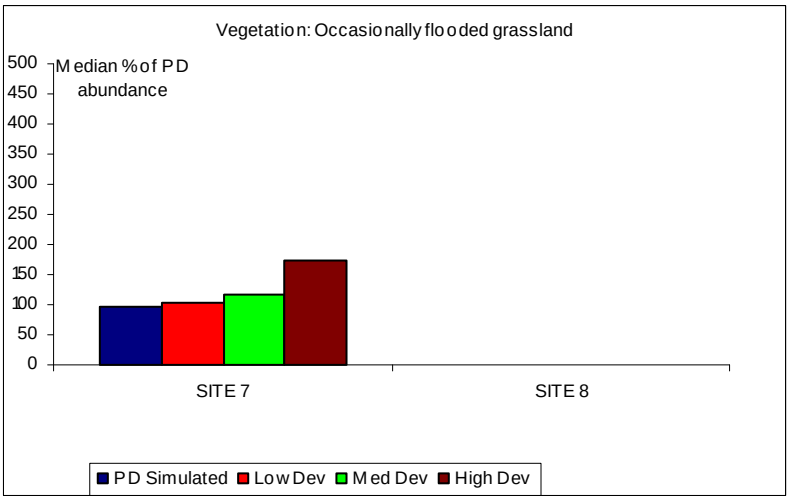
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

Can be turned into savanna in long, dry periods.



Low Scenario

Slight increase in this habitat

Moderate Scenario

Greater increase in this habitat.

High Scenario

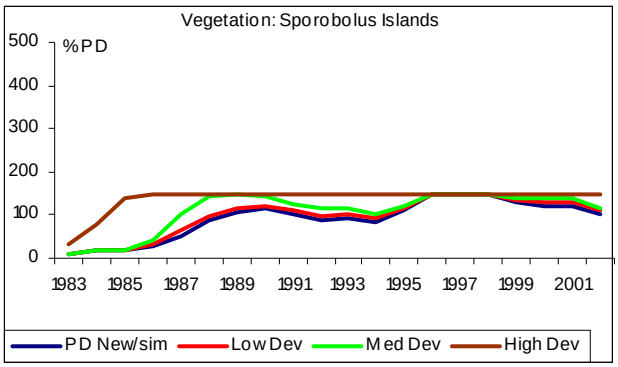
100% increase in this habitat in most years

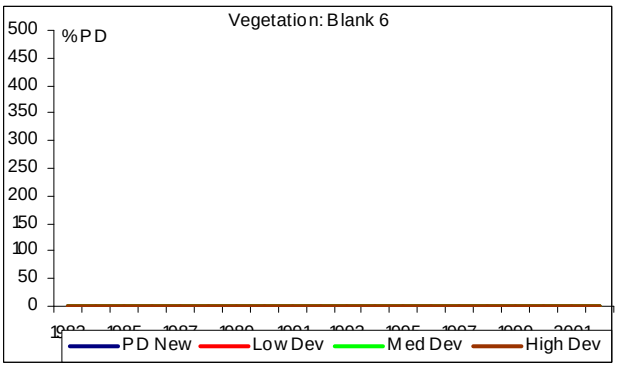
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.17. Sporobolus Islands

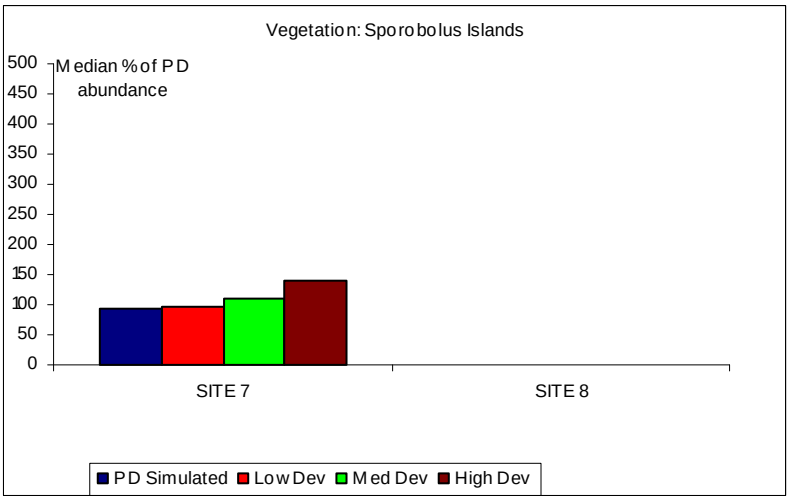
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

They are confined to very elevated areas, and there is a maximum to which they can increase.



Low Scenario

Slight increase in this habitat

Moderate Scenario

Up to 40% increase in some years

High Scenario

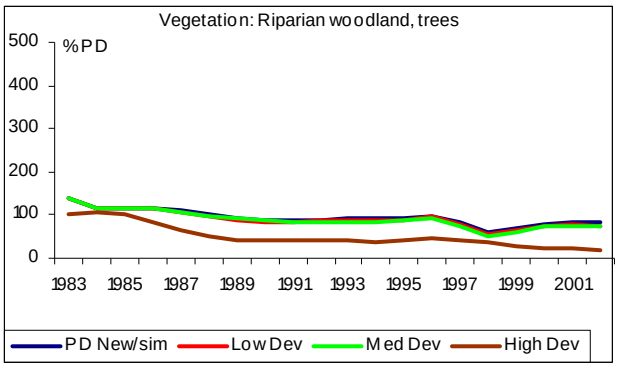
Will increase to the maximum possible.

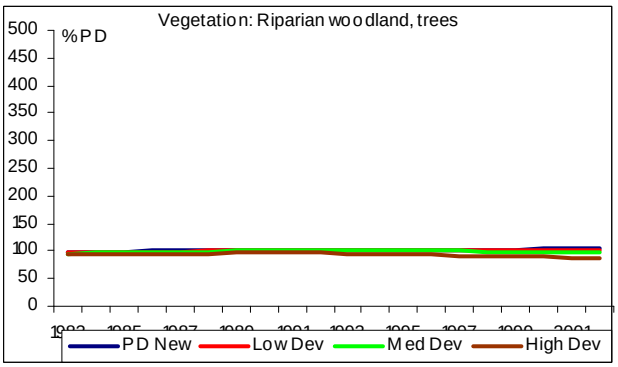
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.18. Riparian woodland, trees

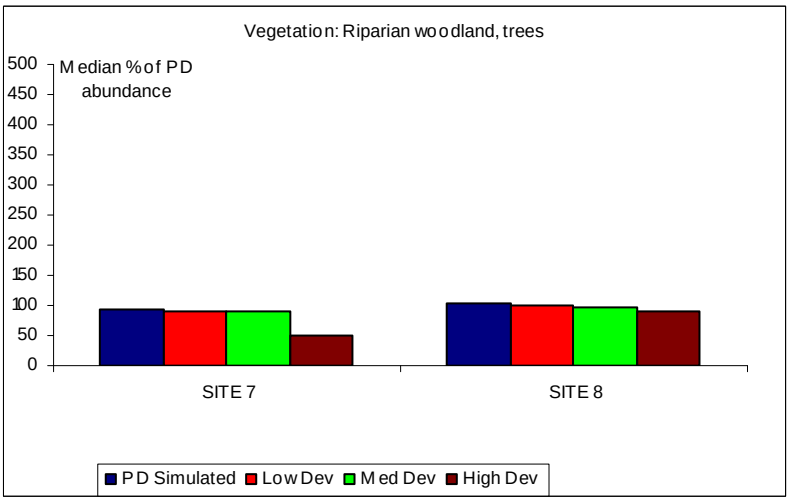
Site 7: Okavango River @ Xakanaxa Site 8: Boteti River





Summary change per scenario

Old trees that will not respond immediately to changes in flows, but will gradually decline in successive dry years if groundwater table drops.



Low Scenario

Very slight change in this habitat

Moderate Scenario

Not much change beyond that of low development

High Scenario

Steady decline in riparian veg due to lack of ground water recharge and soil moisture.

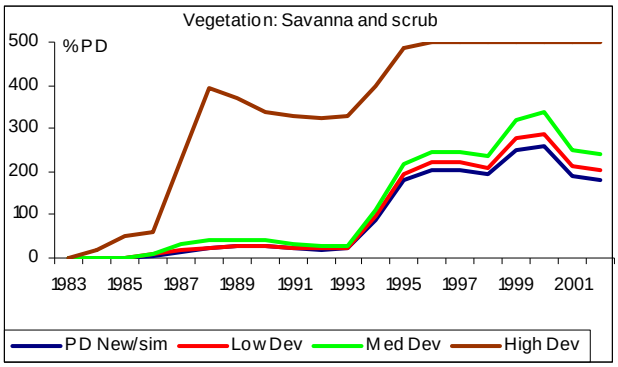
References

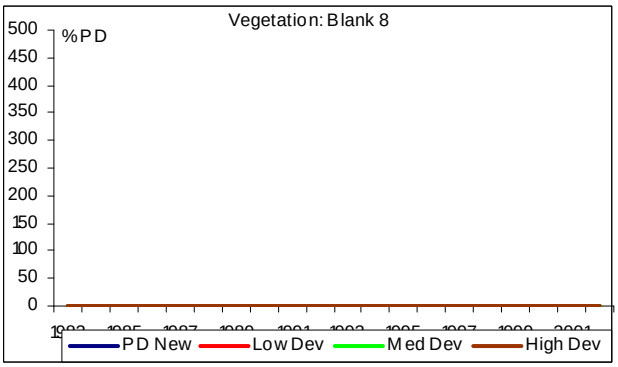
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

5.19. Savanna and scrub

(missing)- missing

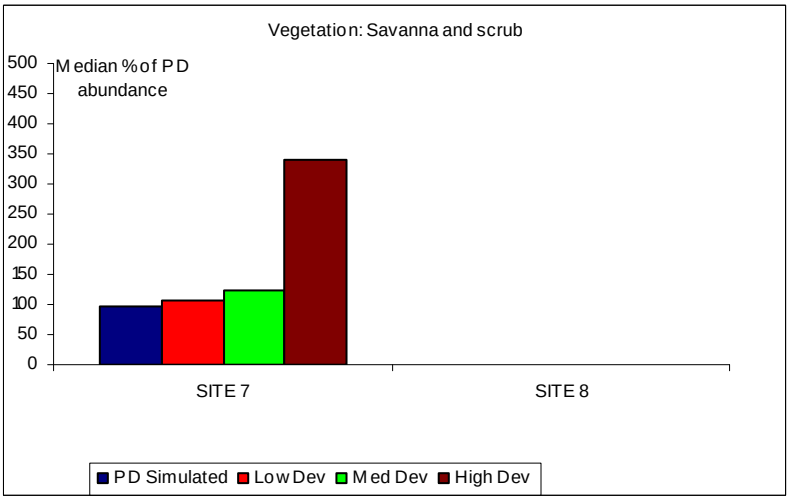
Site 7: Okavango River @ Xakanaxa





Summary change per scenario

Will increase in dry conditions and can encroach on other wetter habitats.



Low Scenario

no change

Moderate Scenario

very slight increase in dry years

High Scenario

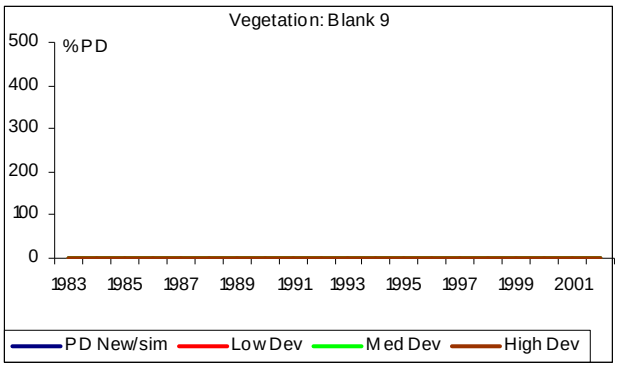
marked increase due to dry conditions

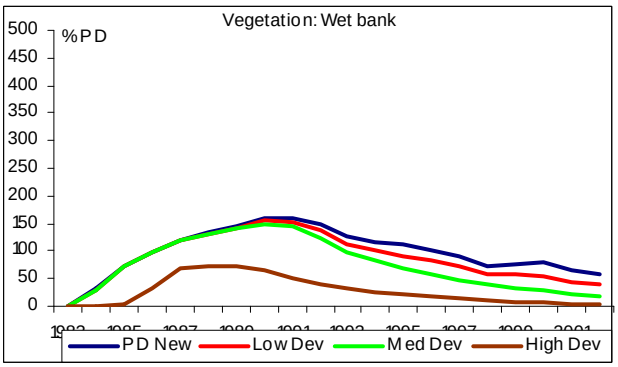
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

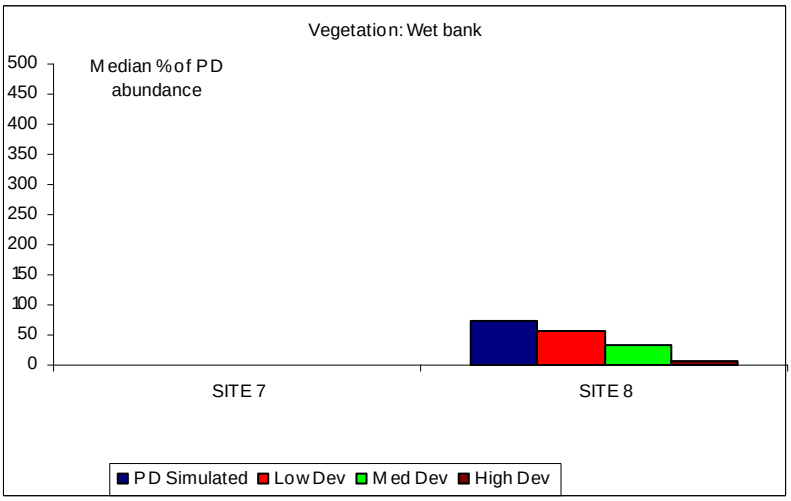
5.20. Wet bank

Site 7: Site 8: Boteti River





Summary change per scenario



Low Scenario

Moderate Scenario

High Scenario

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

6. Macroinvertebrates

This section provides the time-series for aquatic macroinvertebrate indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

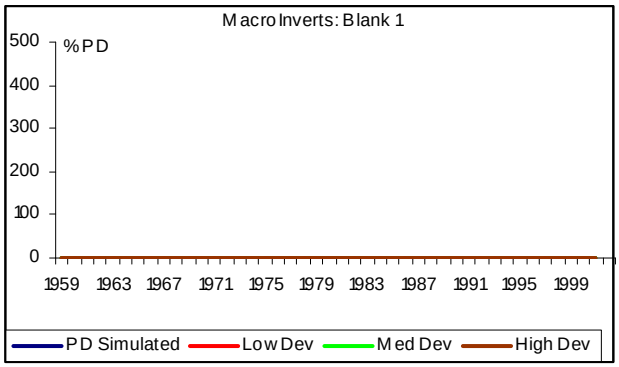
- Channel-submerged vegetation
- Channel-marginal vegetation
- Channel-fine sediments
- Channel-cobbles, boulders
- Channel rapid, fast flowing
- Channel-pools
- Floodplain-marginal vegetation
- Floodplain-pools, backwaters
- Mopane woodland-pools.

6.1. Photographs

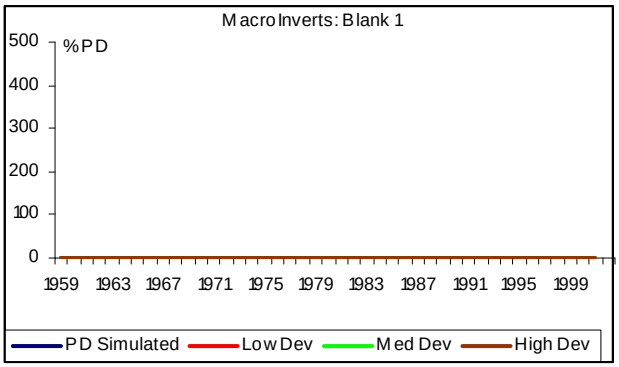
6.2. Channel-submerg veg

(Channel dwellers in submerged vegetation.) - Crustacea (Freshwater shrimps)

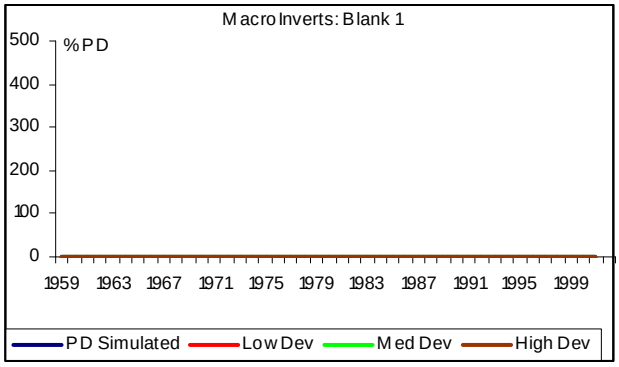
Site 1: Cubango River @ Capico



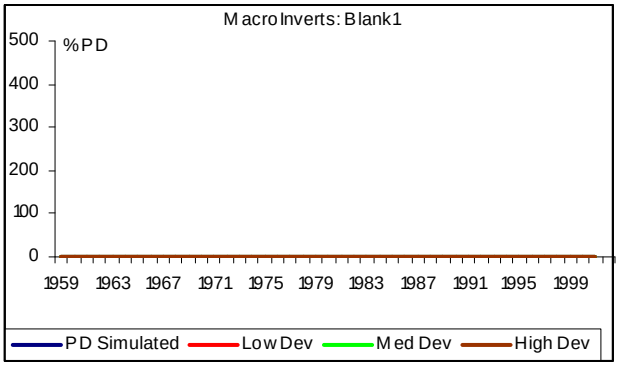
Site 2: Cubango River @ Mucundi



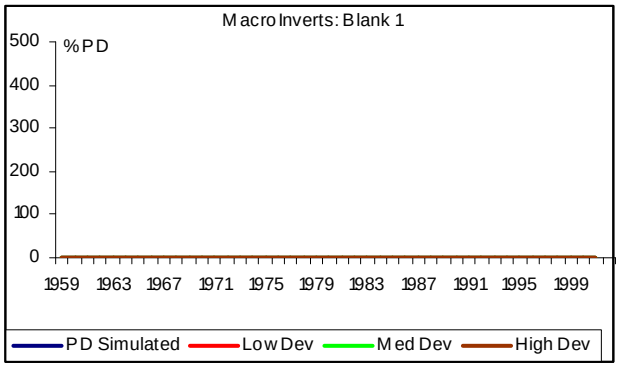
Site 3: Cuito River @ Cuito Cuanavale



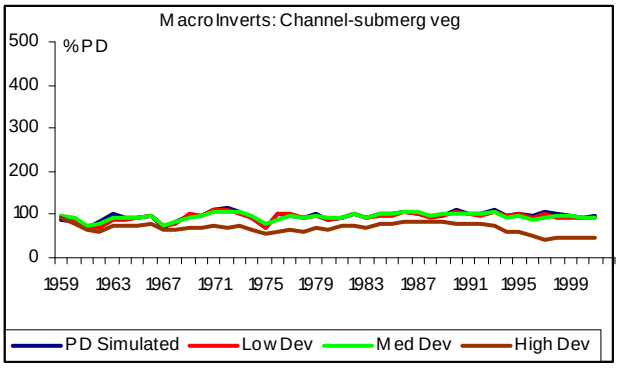
Site 4: Okavango River @ Rundu



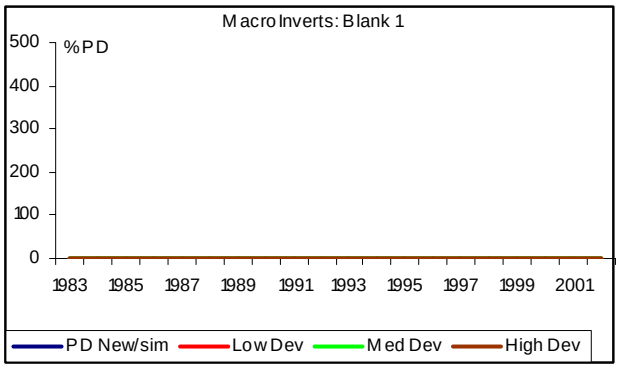
Site 5: Okavango River @ Popa Falls



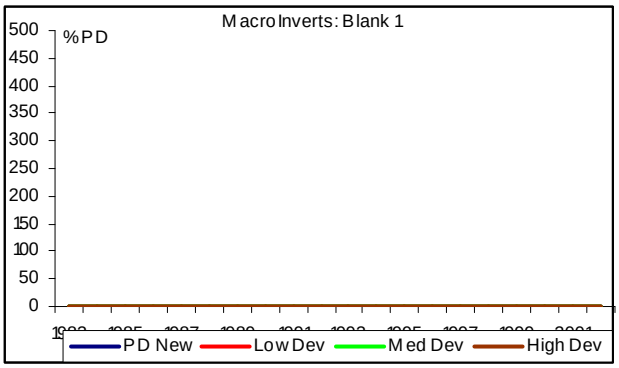
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

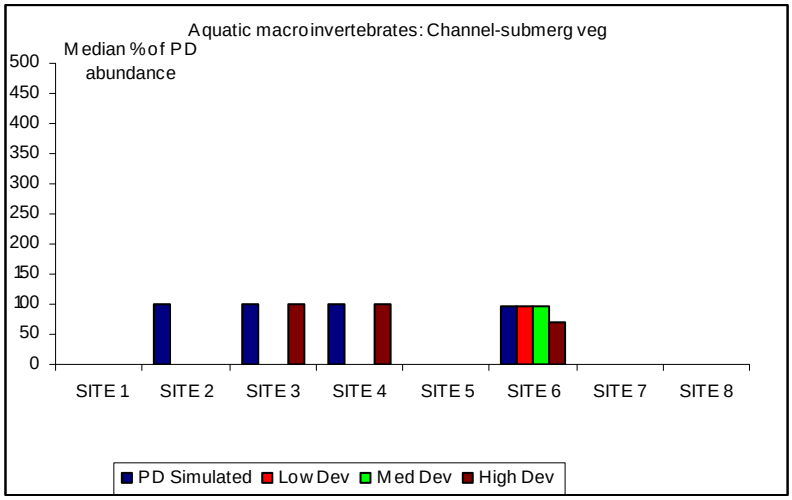


Site 8: Boteti River



Summary change per scenario

Water must always be present. At minimum flow habitat will be greatly reduced leading to population decline as predation increases.



Low Scenario

Not too different from present day.

Moderate Scenario

Not too different from present day.

High Scenario

Abundance of shrimps is expected to reduce by as much as 60% of present day as submerged macrophytes in the Panhandle are confined to the middle of the channel. Predation on shrimps is also expected to be high.

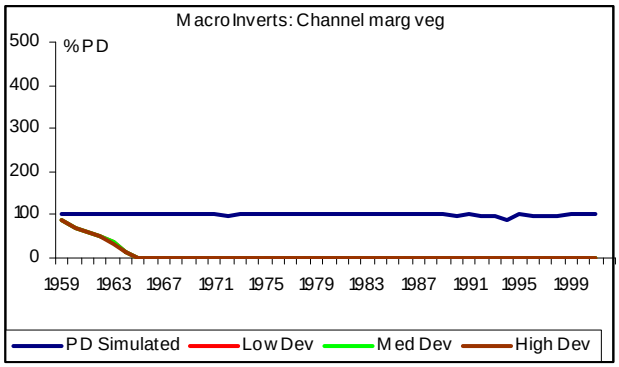
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

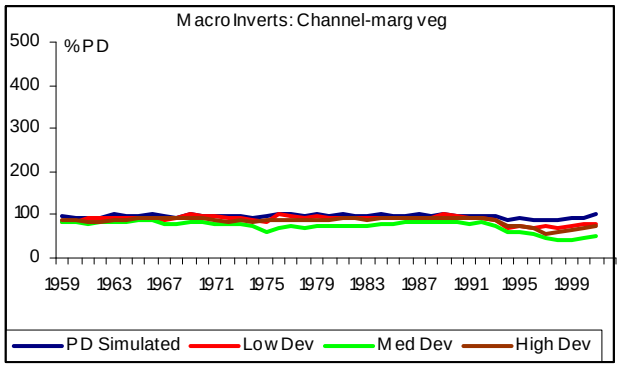
6.3. Channel-marg veg

(Channel dwellers in marginal vegetation.) - Caenidae, Tricorythidae.

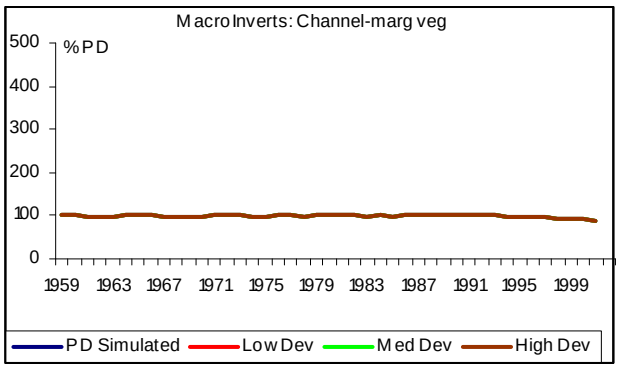
Site 1: Cubango River @ Capico



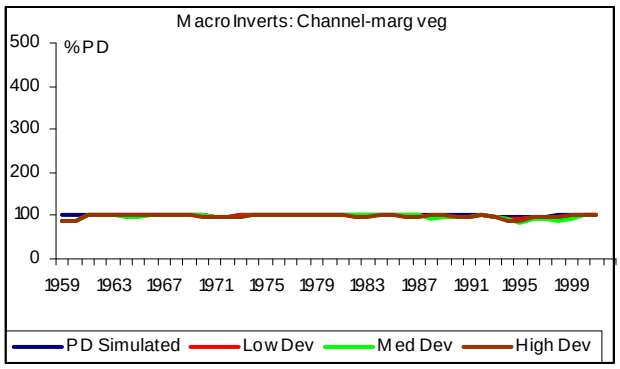
Site 2: Cubango River @ Mucundi



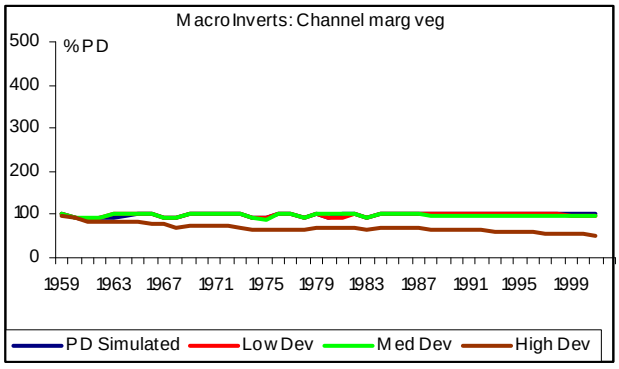
Site 3: Cuito River @ Cuito Cuanavale



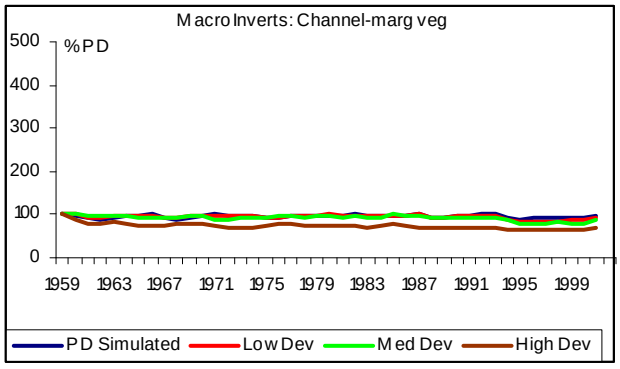
Site 4: Okavango River @ Rundu



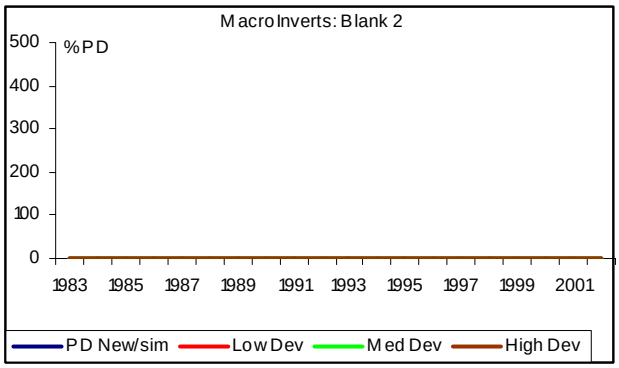
Site 5: Okavango River @ Popa Falls



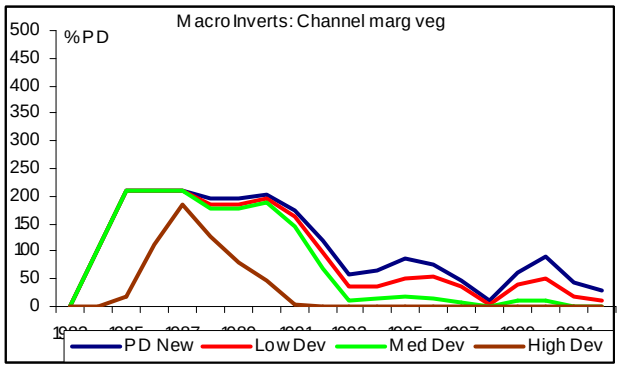
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

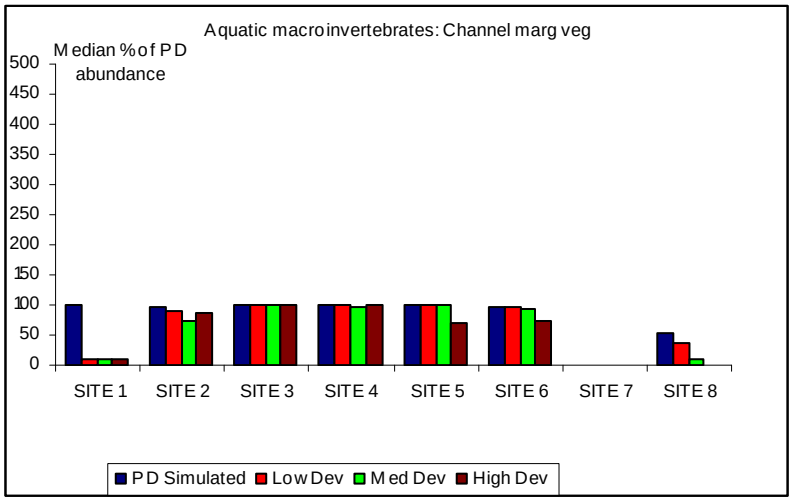


Site 8: Boteti River



Summary change per scenario

Water must always be present. High, long-duration flooding may lead to destruction of habitat and reduction in abundance. Long duration of minimum flows restricted to the river bed may also lead to loss of habitat.



Low Scenario

Populations at Site 1 will be seriously affected. At the other sites, the situation is not expected to be too different from present day except at Mucundi and Boteti sites where abundance may reduce slightly - rapidly at Mucundi and gradually at Boteti.

Moderate Scenario

Populations at Site 1 will be seriously affected. At the other sites, the situation is not expected to be too different from present day except at Mucundi and Boteti sites. At Mucundi abundance is expected to reduce by about 20% of present day in good rainfall periods and by about 50% in drier periods. At Boteti these indicators are expected to double in abundance for a few years followed by a drastic decline to about 10% of present day in 10 years.

High Scenario

Populations at Site 1 will be seriously affected. At Mucundi, Popa and Panhandle, these macroinvertebrates are expected to reduce by as much as 40% in 20 years as the margins of the river get dry.

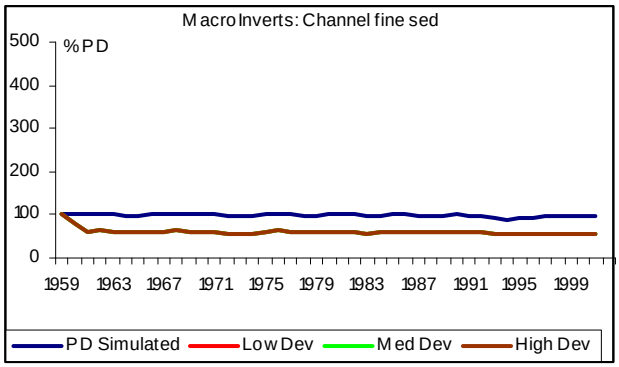
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

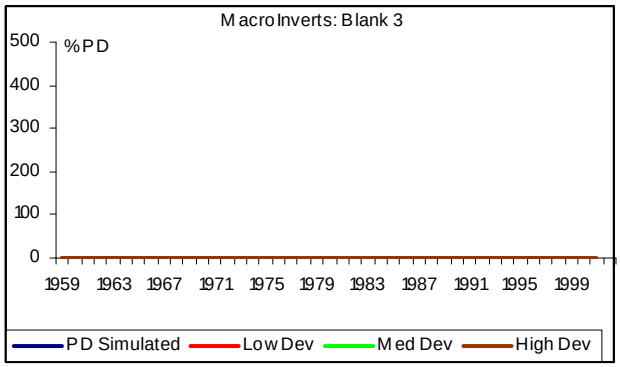
6.4. Channel-fine sed

(Channel dwellers in fine sediment).- Unionidae, Sphaeridae.

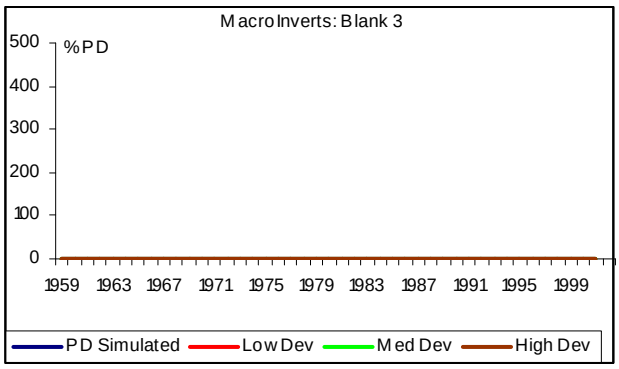
Site 1: Cubango River @ Capico



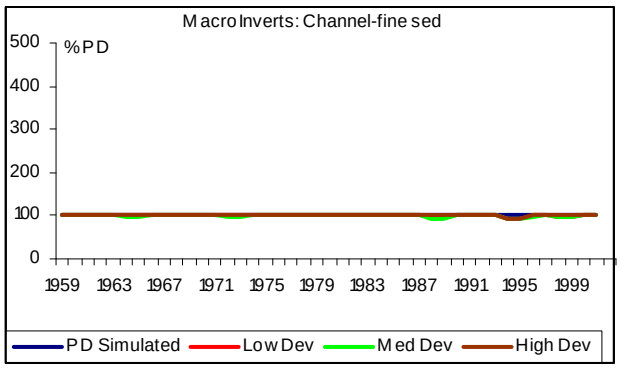
Site 2: Cubango River @ Mucundi



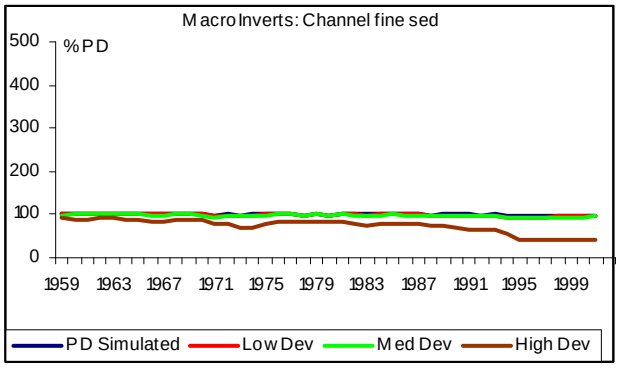
Site 3: Cuito River @ Cuito Cuanavale



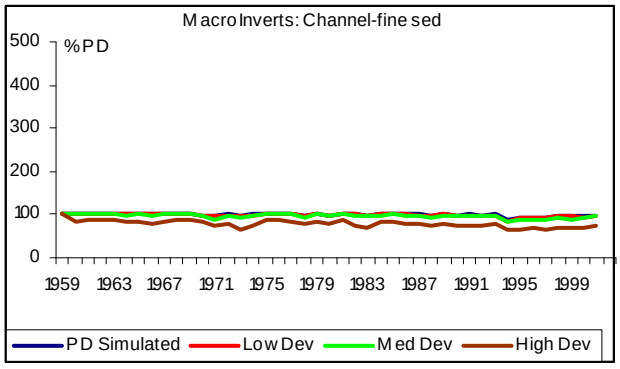
Site 4: Okavango River @ Rundu



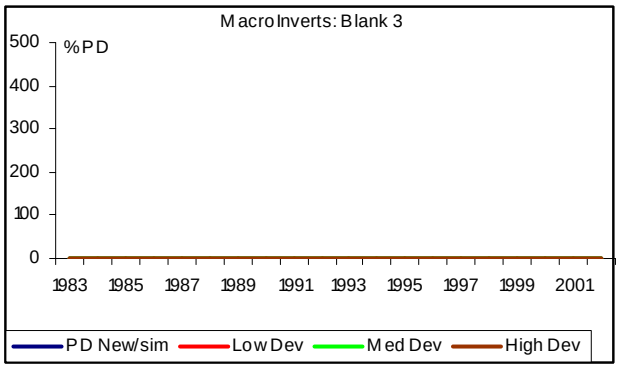
Site 5: Okavango River @ Popa Falls



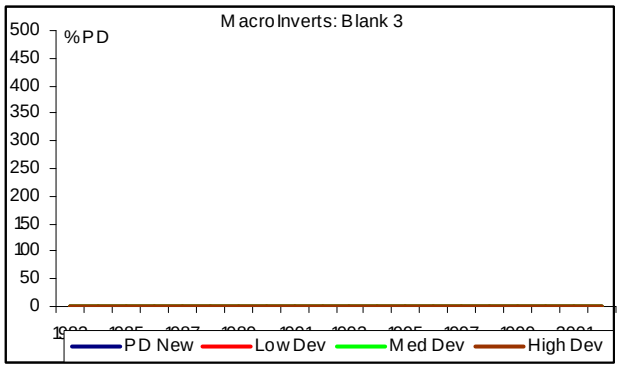
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

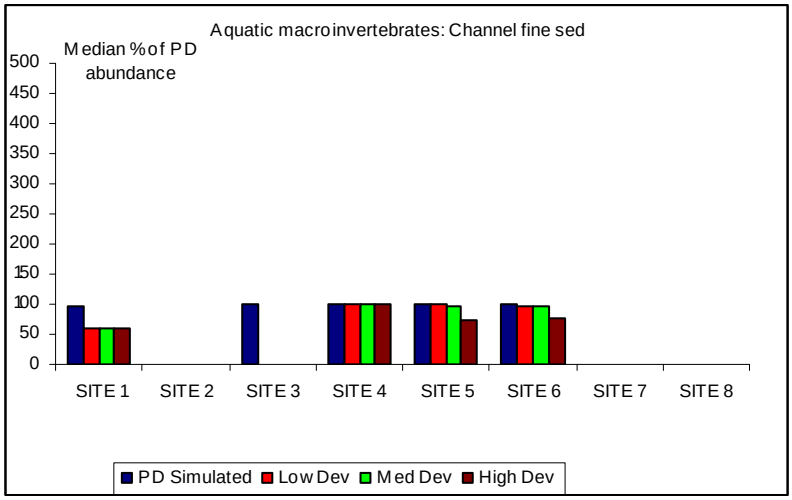


Site 8: Boteti River



Summary change per scenario

Will normally survive as long as there is some water covering the sediment. Long dry spells will reduce abundance or even eliminate these indicators.



Low Scenario

Very significant reductions in abundance at Capico as dry season minimum flow is reduced by about 99.9% of present day. This is expected to dry the river bed so reducing the abundance of these mussels. There are no changes expected at the other sites.

Moderate Scenario

Very significant reductions in abundance at Capico as dry season minimum flow is reduced by about 99.9% of present day. This is expected to dry the river bed so reducing the abundance of these mussels. There are no changes expected at the other sites.

High Scenario

Very significant reductions in abundance at Capico as dry season minimum flow is reduced by about 99.9% of present day. This is expected to dry the river bed so reducing the abundance of these mussels. Reductions of dry season minimum flow to 18% of present day at Popa and Panhandle sites are expected to reduce these indicators by about 20% of present day abundance in 20 years.

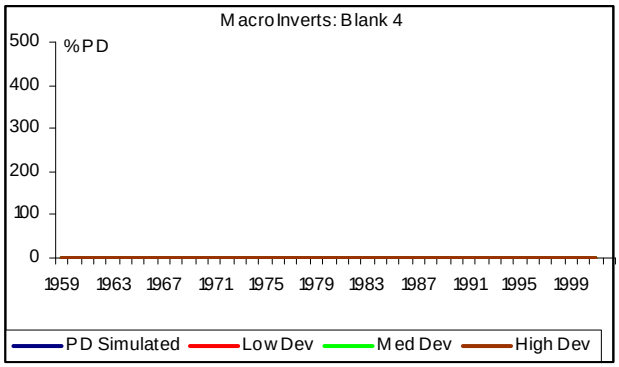
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

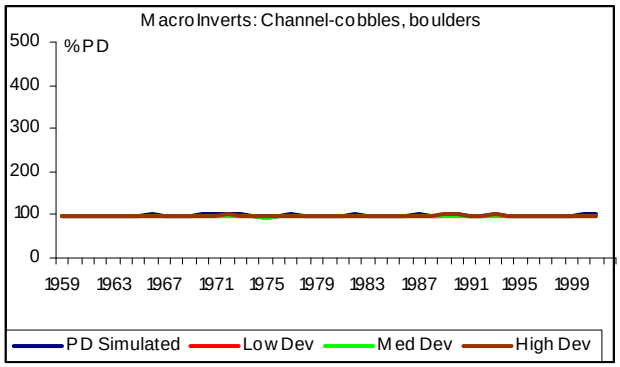
6.5. Channel-cobbles, boulders

(Channel dwellers in stones and rocks) - Hydropsychidae, Ecnomidae.

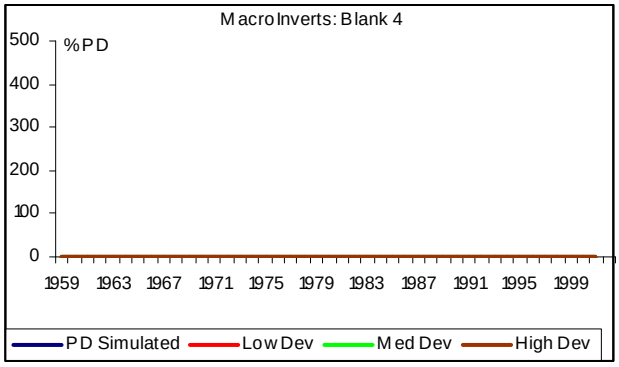
Site 1: Cubango River @ Capico



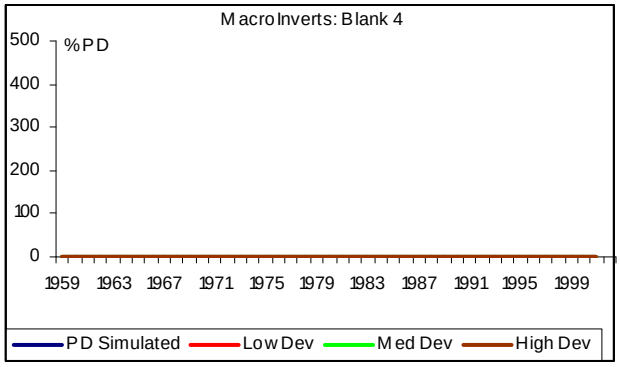
Site 2: Cubango River @ Mucundi



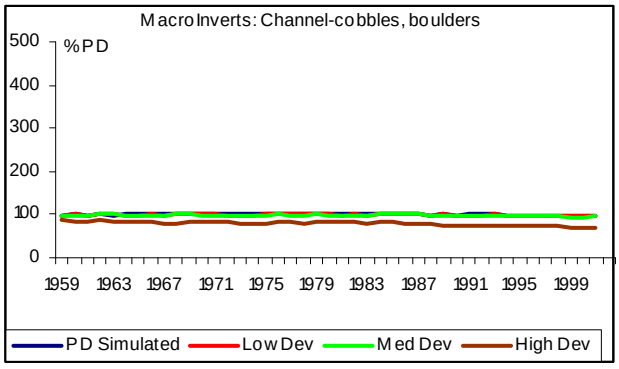
Site 3: Cuito River @ Cuito Cuanavale



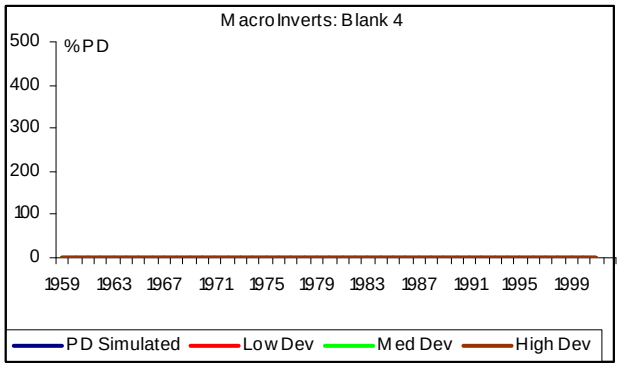
Site 4: Okavango River @ Rundu



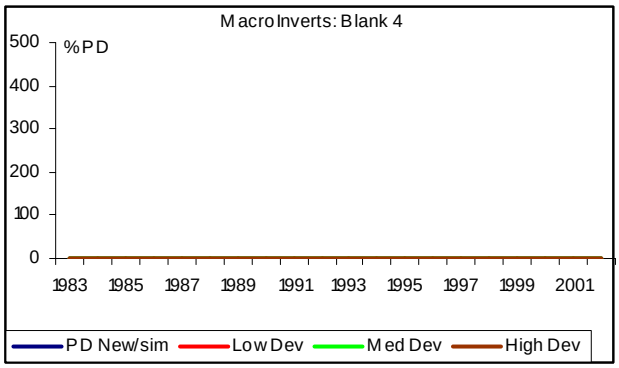
Site 5: Okavango River @ Popa Falls



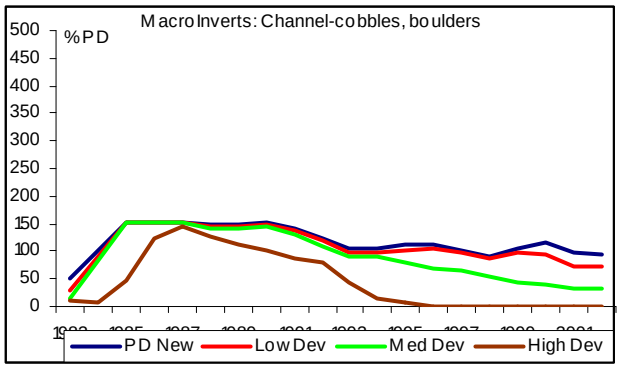
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

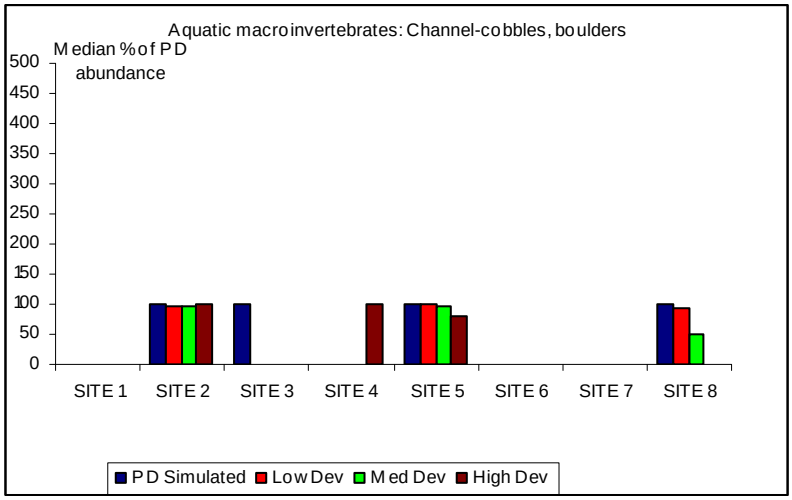


Site 8: Boteti River



Summary change per scenario

Water must always be present. These indicators will reduce and may disappear if exposed to long duration of minimum flows leading to drying of rocks.



Low Scenario

No significant changes

Moderate Scenario

No significant changes

High Scenario

No significant change at Mucundi and Popa but 50% reduction at Boteti. As long as the channel does not dry up, these animals will persist.

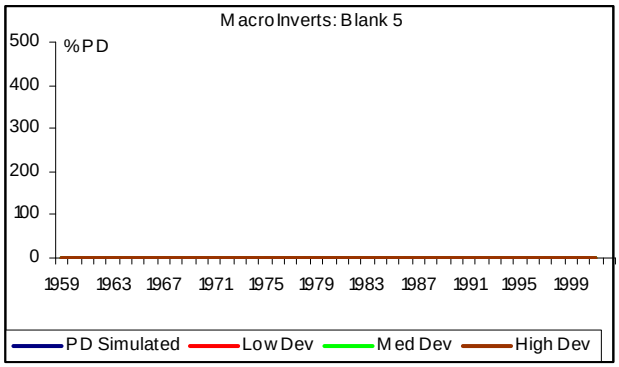
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

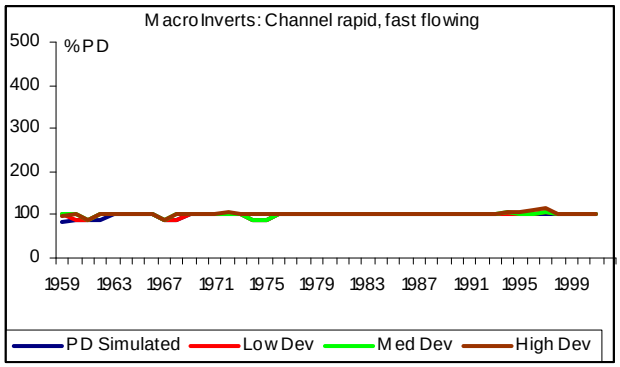
6.6. Channel rapid, fast flowing

(Channel dwellers in rapids or fast flowing waters) - Simuliidae, Hydropsychidae.

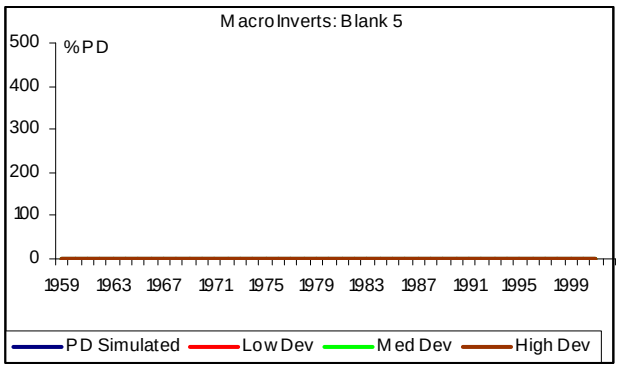
Site 1: Cubango River @ Capico



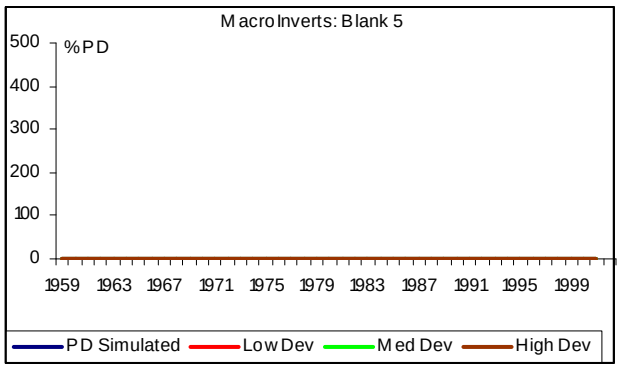
Site 2: Cubango River @ Mucundi



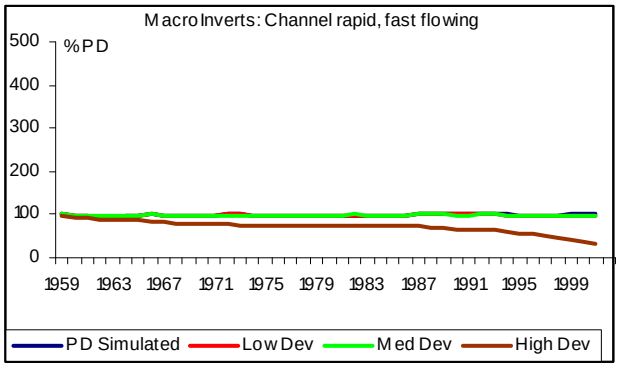
Site 3: Cuito River @ Cuito Cuanavale



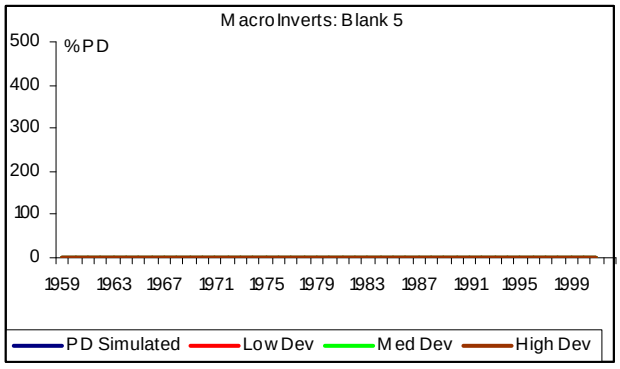
Site 4: Okavango River @ Rundu



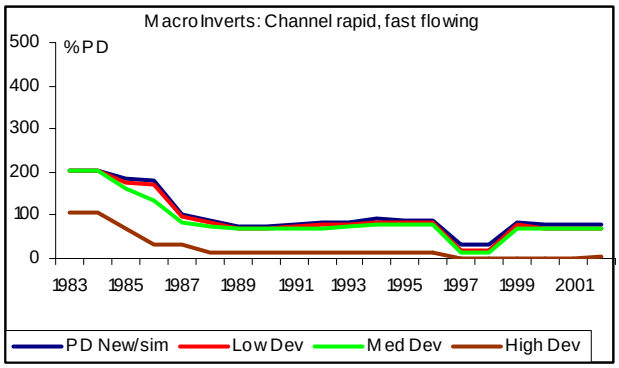
Site 5: Okavango River @ Popa Falls



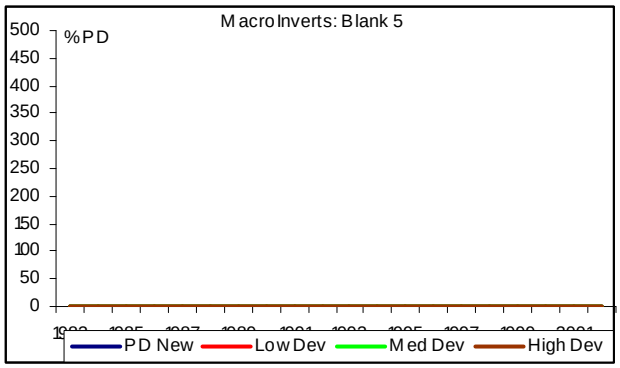
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

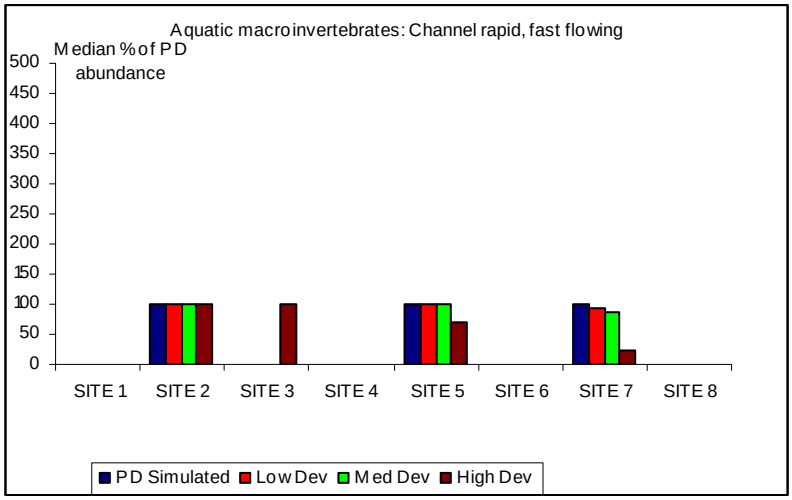


Site 8: Boteti River



Summary change per scenario

Water must always be present. These indicators will reduce and may disappear if exposed to long duration of minimum flows leading to drying of river bed.



Low Scenario

No significant changes at Mucundi and Popa but slight reduction in abundance at Delta site 7 (Xakanaka) especially during drier years.

Moderate Scenario

No significant changes at Mucundi and Popa but slight reduction in abundance at Delta site 7 (Xakanaka) especially during drier years.

High Scenario

No significant changes at Mucundi. With dry season minmum flow reduced to 18% of present day at Popa, these indicators are expected to decline to about 80% of present day abundance over 30 years and to continue to decline therafter. At Xakanaka, in the delta, these animlas aere expected to decline to about 15% of present day abundance.

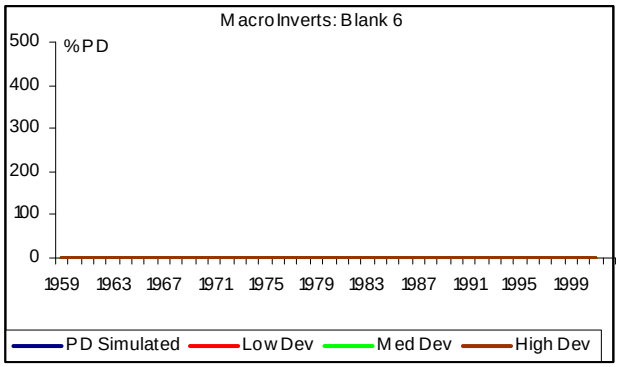
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

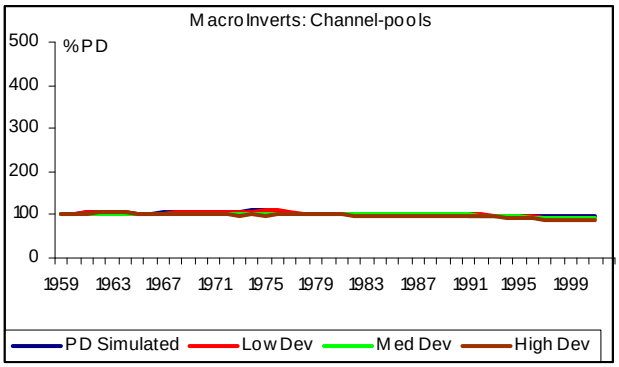
6.7. Channel-pools

(Hollows formed in the bedrock) – Dytiscidae.

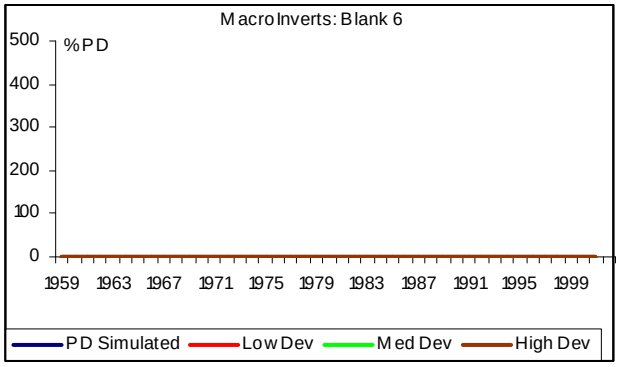
Site 1: Cubango River @ Capico



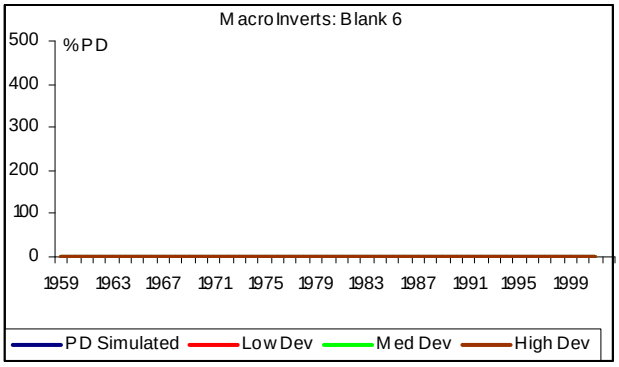
Site 2: Cubango River @ Mucundi



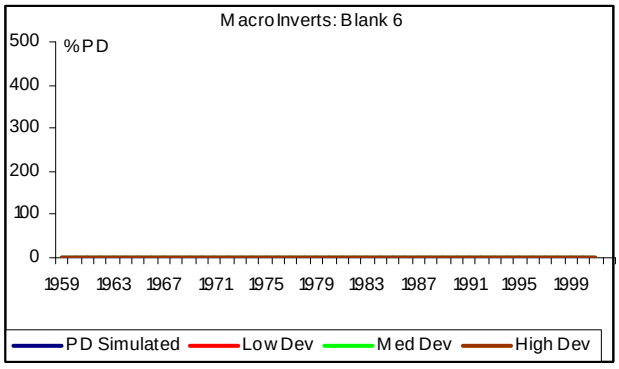
Site 3: Cuito River @ Cuito Cuanavale



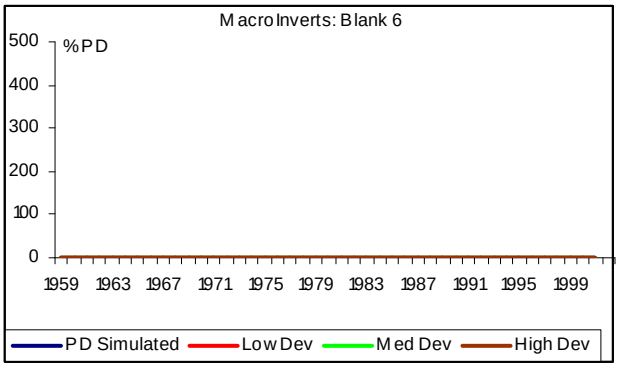
Site 4: Okavango River @ Rundu



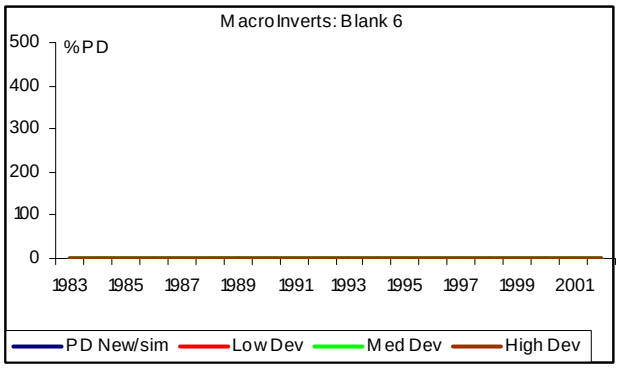
Site 5: Okavango River @ Popa Falls



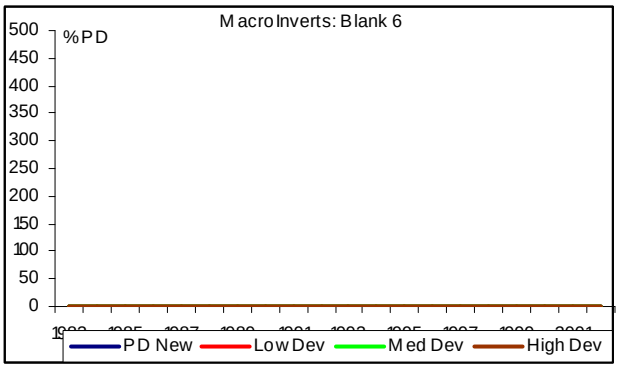
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

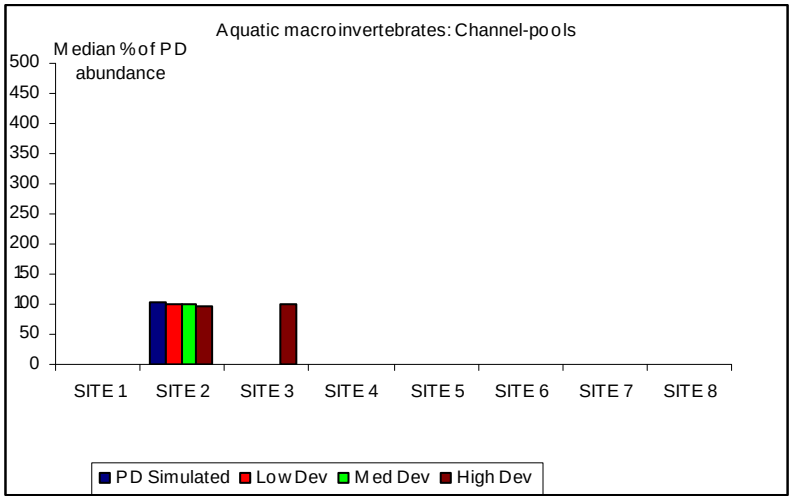


Site 8: Boteti River



Summary change per scenario

Water must always be present. High, long-duration flooding will destroy this habitat while long duration of minimum flows may lead to drying out of the pools also destroying the pools.



Low Scenario

No significant changes.

Moderate Scenario

No significant changes.

High Scenario

No significant changes.

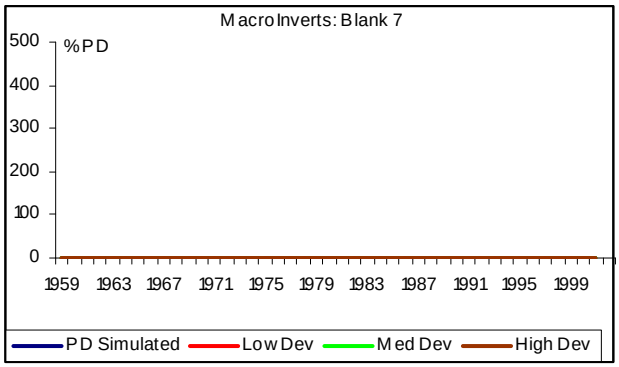
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

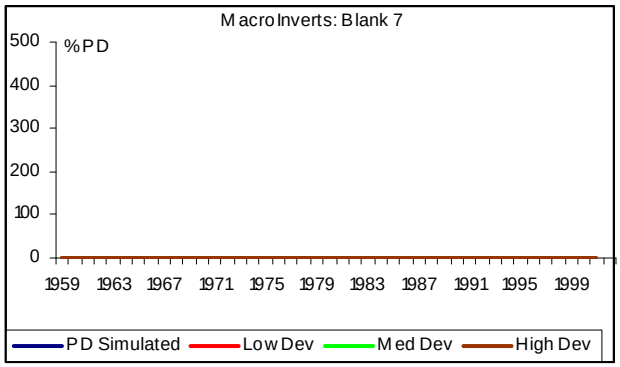
6.8. FP-marg veg

(Floodplain dwellers in marginal vegetation) - Coenagrionidae, Physidae, Planorbidae.

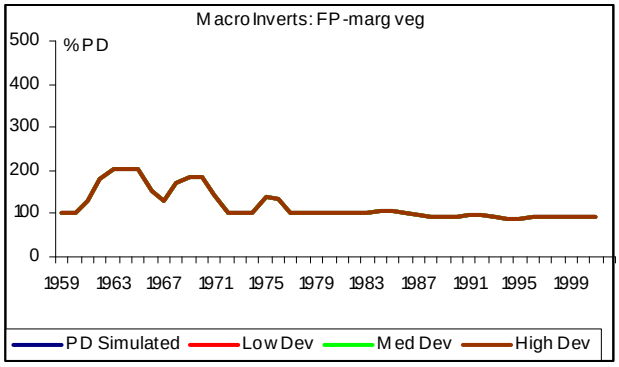
Site 1: Cubango River @ Capico



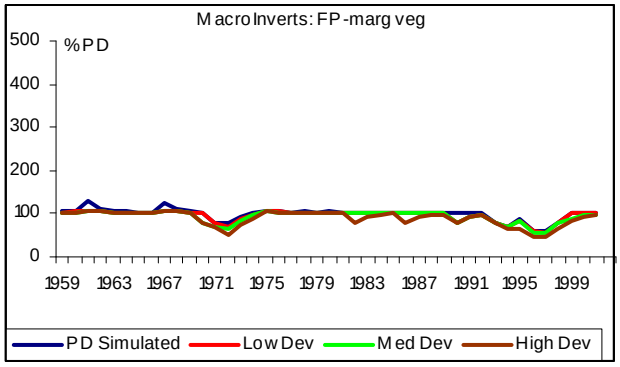
Site 2: Cubango River @ Mucundi



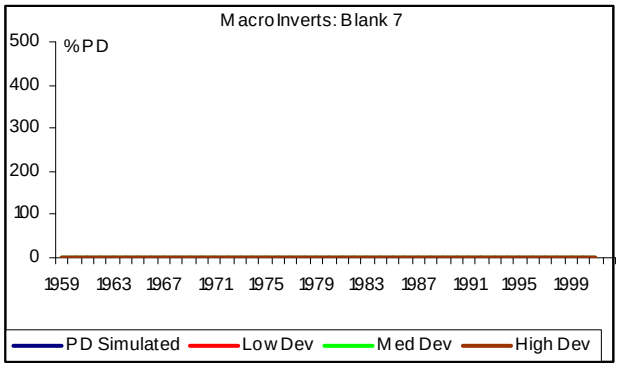
Site 3: Cuito River @ Cuito Cuanavale



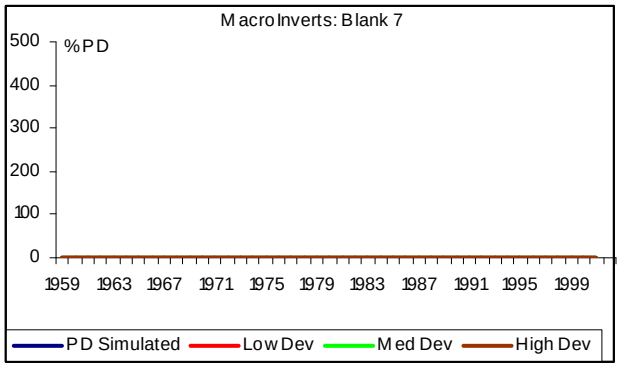
Site 4: Okavango River @ Rundu



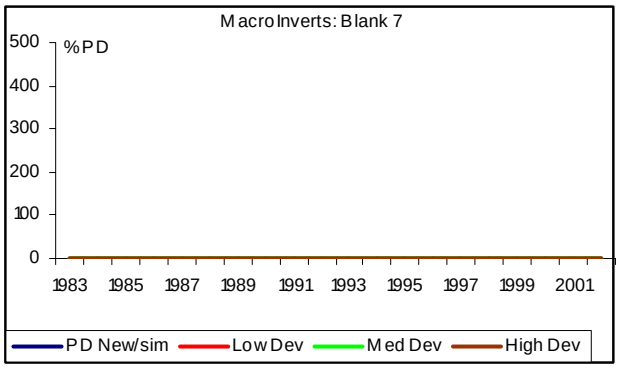
Site 5: Okavango River @ Popa Falls



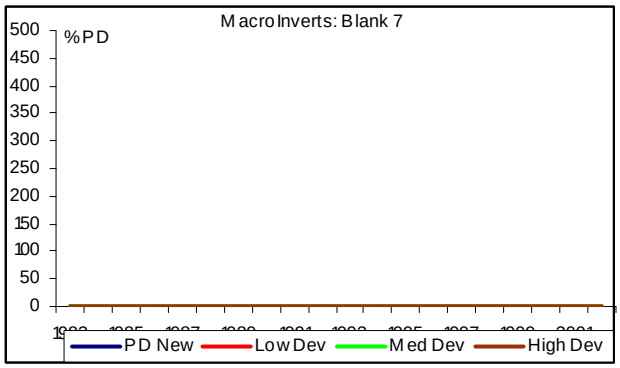
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

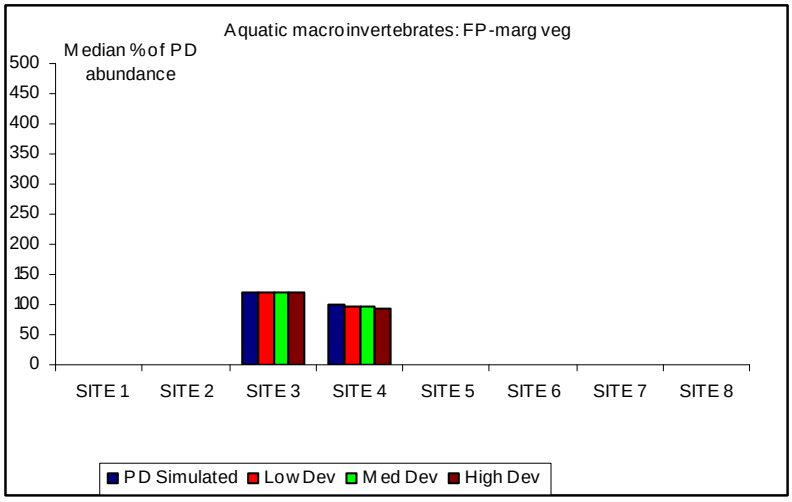


Site 8: Boteti River



Summary change per scenario

Drying out of floodplains consequent to prolonged low flows will reduce or eradicate this habitat.



Low Scenario

No significant changes.

Moderate Scenario

No significant changes.

High Scenario

No significant changes.

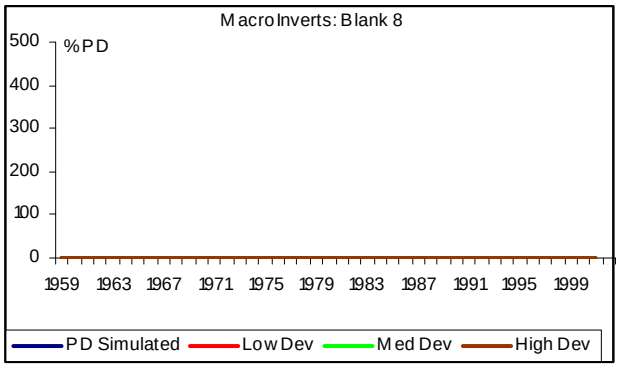
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

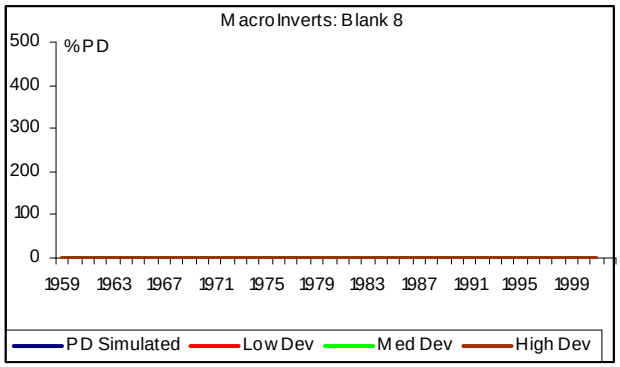
6.9. FP-pools, backw (seasonal fp 7)

(Dwellers in seasonal floodplain backwaters) – Dytiscidae.

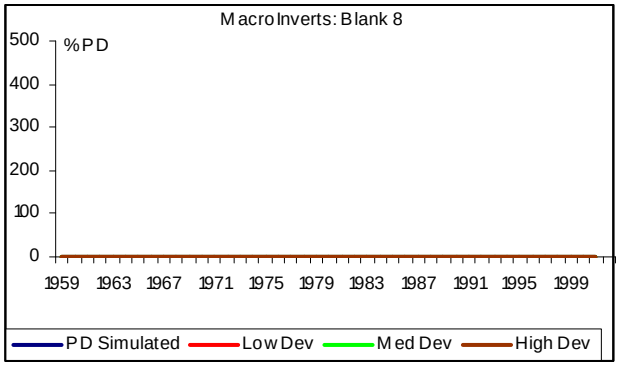
Site 1: Cubango River @ Capico



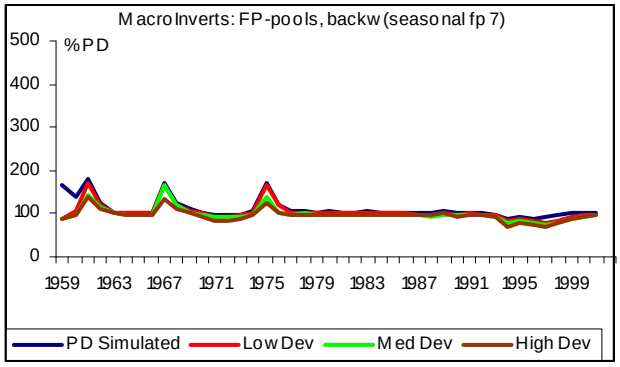
Site 2: Cubango River @ Mucundi



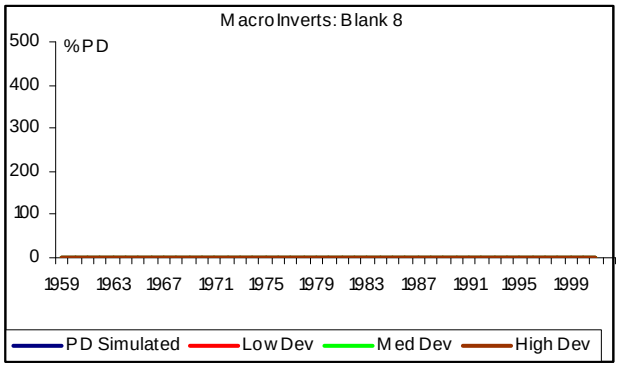
Site 3: Cuito River @ Cuito Cuanavale



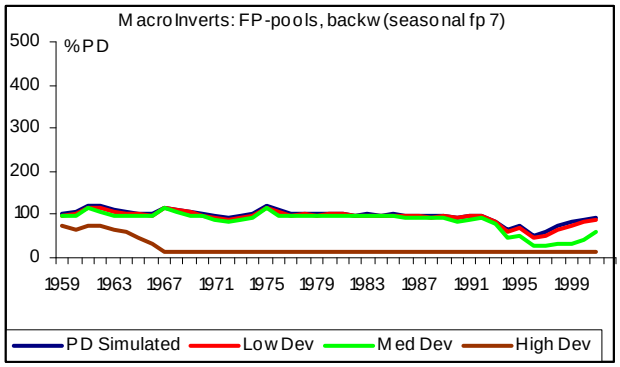
Site 4: Okavango River @ Rundu



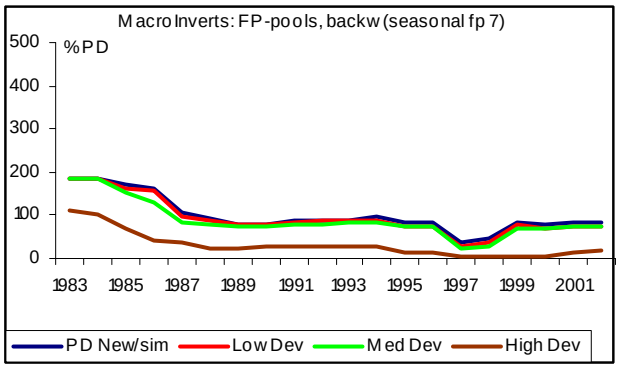
Site 5: Okavango River @ Popa Falls



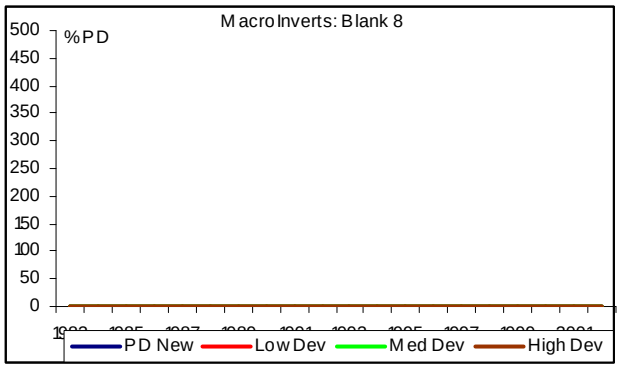
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

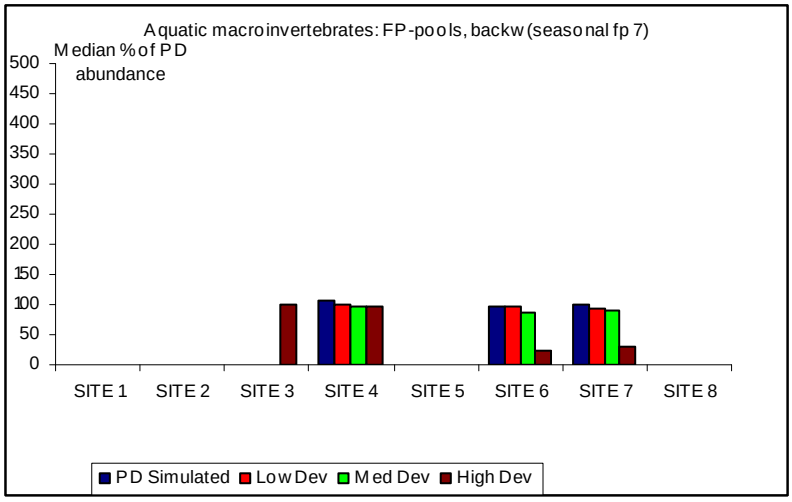


Site 8: Boteti River



Summary change per scenario

Drying out of floodplains consequent to prolonged low flows will reduce or eradicate this habitat.



Low Scenario

No significant changes

Moderate Scenario

Not much change at Kapako. Some reduction in abundance is predicted at Panhandle and at Xaxanaka especially during drier periods.

High Scenario

No significant changes at Kapako because the minimum dry season flows are expected to maintained at this site. At the Panhandle and Xaxanaka sites, very low dry season minimum flows may not refill these pools and backwaters leading to the drying up and drastic reductions of these indicators.

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

7. Fish

This section provides the time-series for fish indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Fish resident in river
- Migrate floodplain small fish
- Migrate floodplain large fish
- Fish-sandbank dweller
- Fish-rock dweller
- Fish-marginal vegetation
- Fish in backwaters.

7.1. Photographs

7.1.1 Fish resident in river

Photo: B de Waal

7.1.2 Migrate floodplain small fish

Photo: B de Waal

7.1.3 Migrate floodplain large fish

Photo: B de Waal

7.1.4 Fish–sandbank dweller

Photo: B de Waal

7.1.5 Fish-rock dweller

Photo: B de Waal

7.1.6 Fish-marginal vegetation

Photo: B de Waal

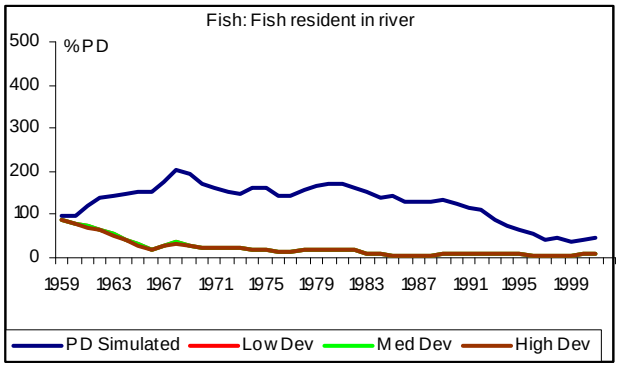
7.1.7 Fish in backwaters

Photo: B de Waal

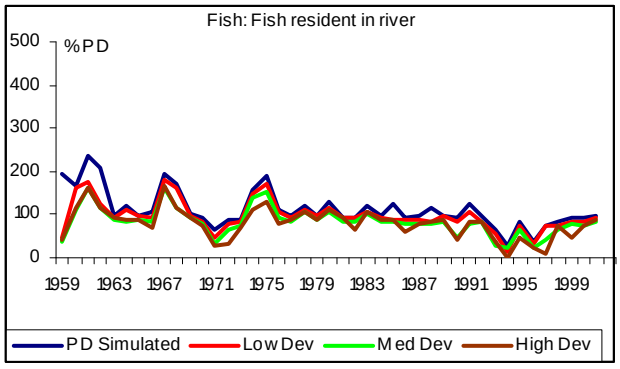
7.2. Fish resident in river

(Fish living in main channels that undertake longitudinal migrations. Spend most time in main channel in deep water but use floodplain.) Example: Tigerfish [*Hydrocynus vittatus*].

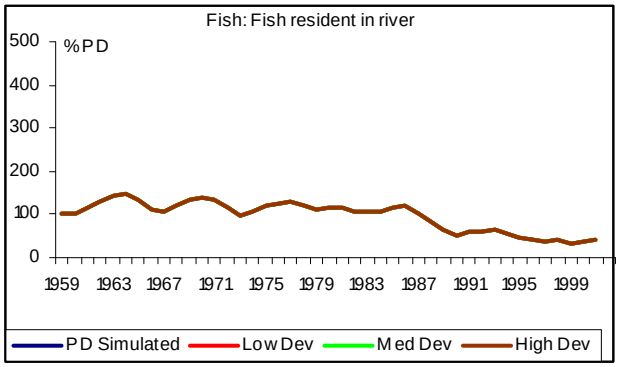
Site 1: Cubango River @ Capico



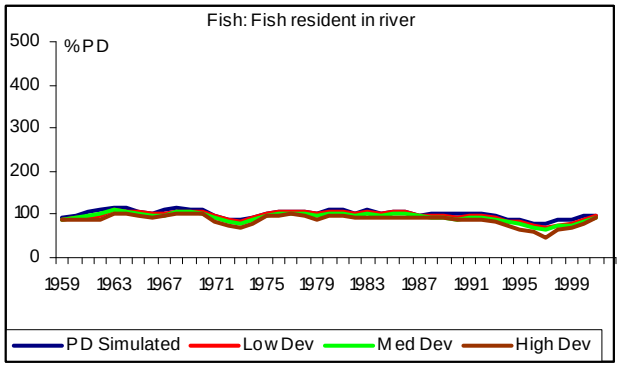
Site 2: Cubango River @ Mucundi



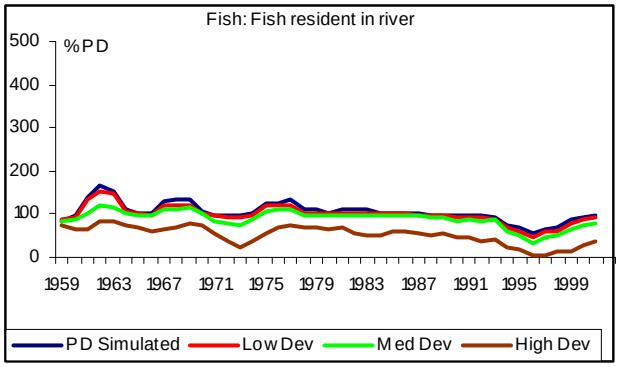
Site 3: Cuito River @ Cuito Cuanavale



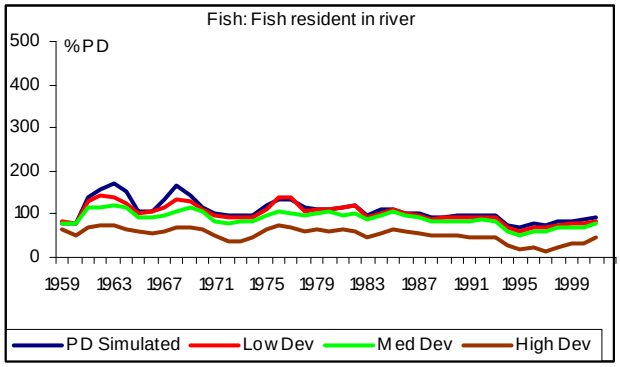
Site 4: Okavango River @ Rundu



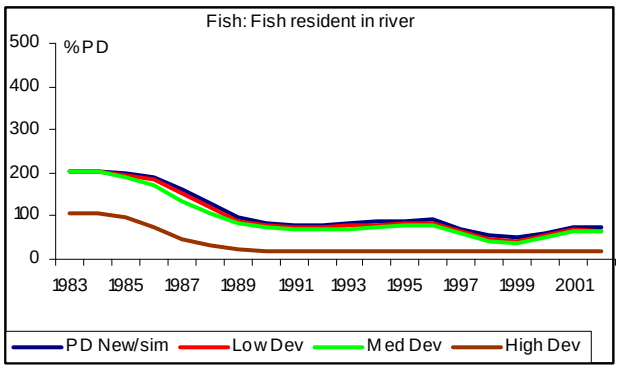
Site 5: Okavango River @ Popa Falls



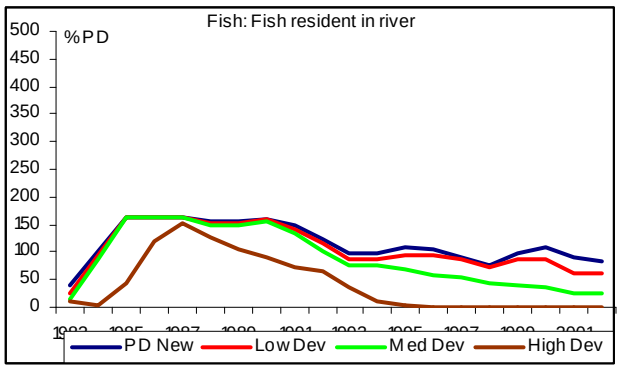
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

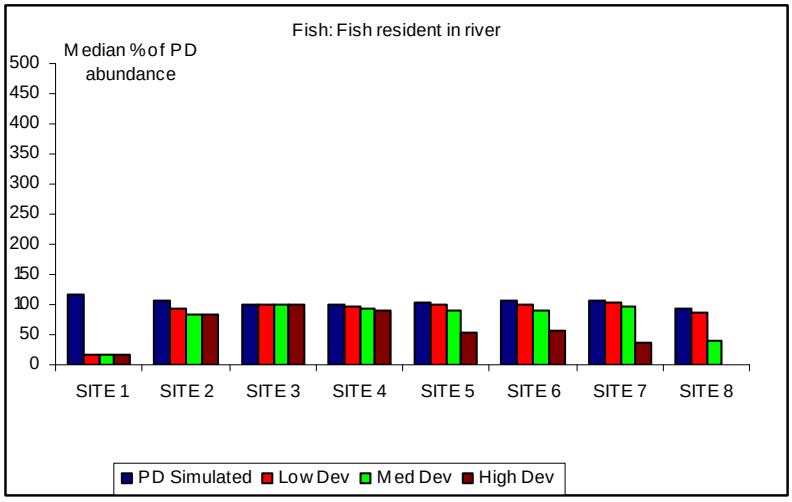


Site 8: Boteti River



Summary change per scenario

Require clear deep, running water and pools throughout the hydrological cycle.



Low Scenario

Especially the tigerfish may be the most affected species in this group while the other species may be moderately affected by changes and decrease in waterflow, flooding patterns or water quality.

Moderate Scenario

Tigerfish and other fish of this group will be affected by changes and decrease in waterflow, flooding patterns or water quality.

High Scenario

Low and unnatural flow patterns as well as increased turbidity and deteriorated water quality affect fish community abundance and composition negatively.

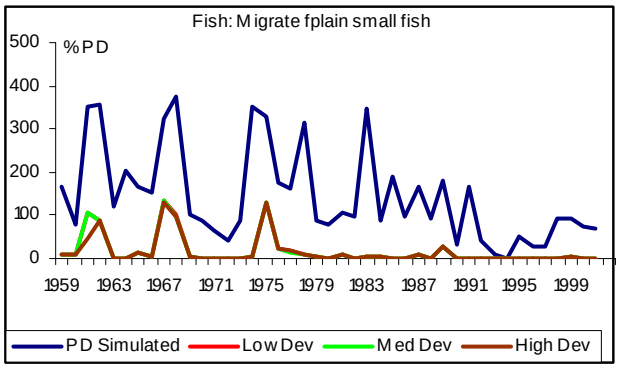
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

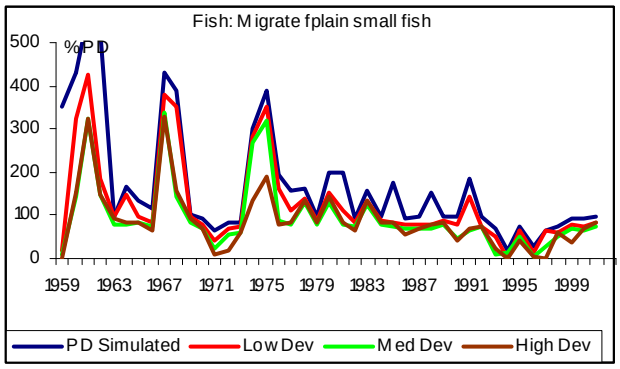
7.3. Migrate fplain small fish

(Fish that are resident in river, migrate into floodplains for feeding, breeding and protection against predation.) - Small species dependent on lateral migration to floodplains for breeding and feeding. Example: Bulldog [*Marcusenius macrolepidotus*].

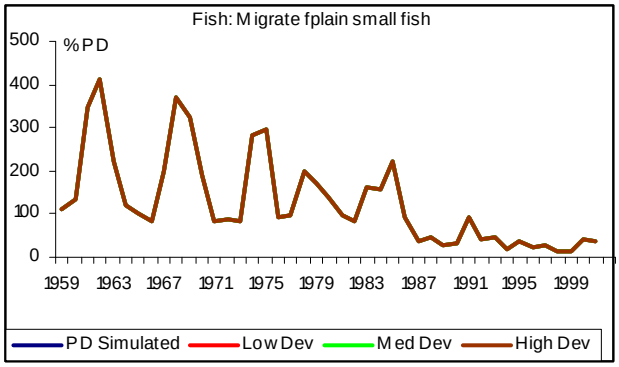
Site 1: Cubango River @ Capico



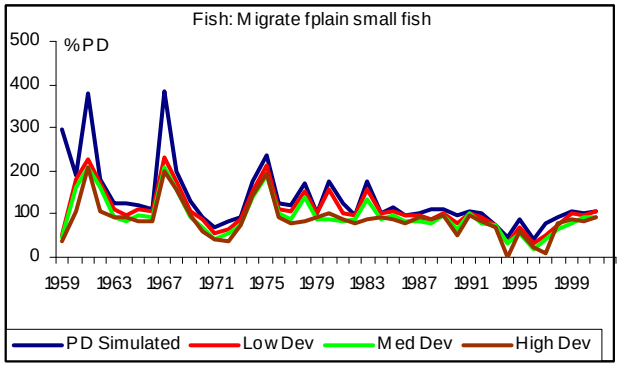
Site 2: Cubango River @ Mucundi



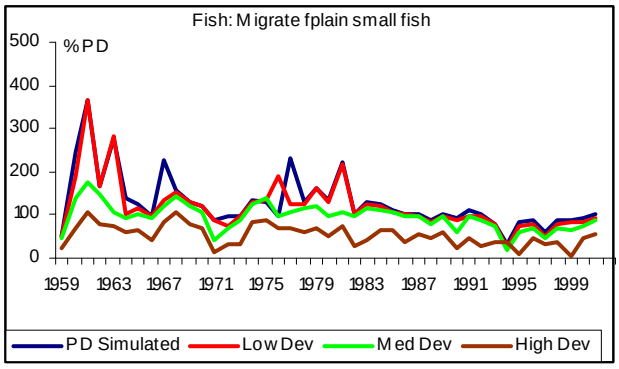
Site 3: Cuito River @ Cuito Cuanavale



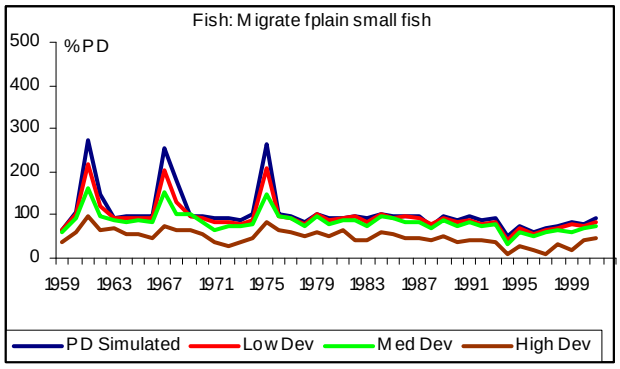
Site 4: Okavango River @ Rundu



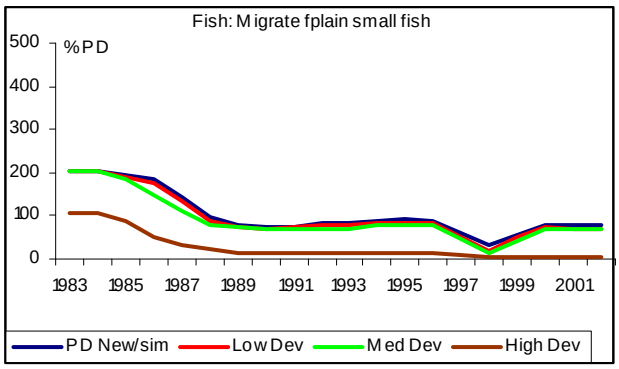
Site 5: Okavango River @ Popa Falls



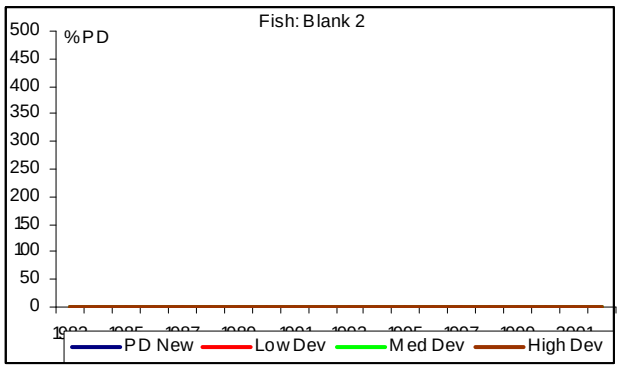
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

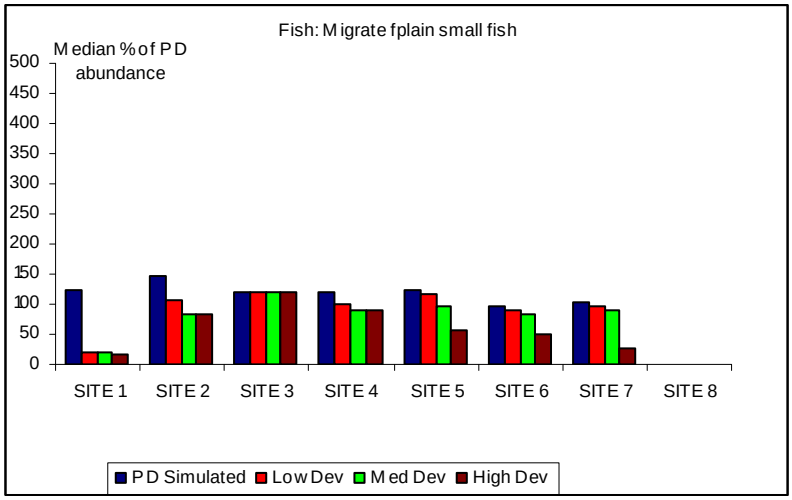


Site 8: Boteti River



Summary change per scenario

Depend on regular flooding of shallow vegetated floodplains and deeper [>50cm] refuges during low flow conditions.



Low Scenario

Any disruption of the normal flooding pattern or sedimentation regime will have a detrimental effect. However, minor changes that may cause variations that fall within the natural variability will not have any major effect on these species.

Moderate Scenario

The expected disruption of the normal flooding pattern or sedimentation regime will have detrimental effect on fish species in this group. If no flooding occurs in the seasonal floodplains, then the migratory behavior of these species, which is a major part of their life history strategy, may be compromised with consequent negative effects on their survival.

High Scenario

Disruption of natural flooding patterns impact negatively on availability of floodplain habitat and migratory movements of this group. Effects will be on breeding success and survival. Increased predation by pioneer predators with declining water quality is possible. Construction of dams will affect sedimentation and replenishment of nutrients and organic material on the floodplains, affecting the foodweb and fish communities.

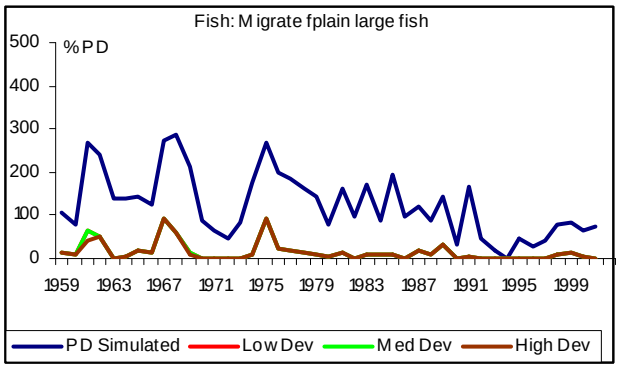
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

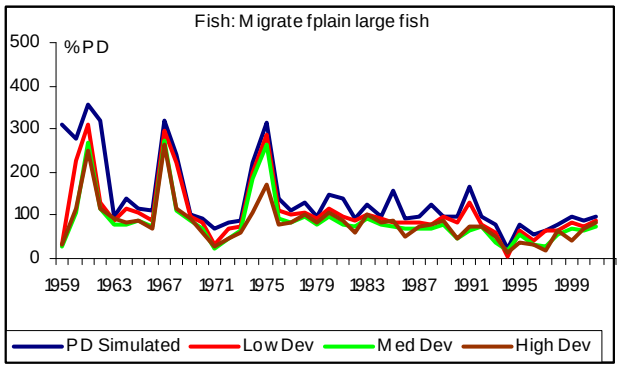
7.4. Migrate fplain large fish

(Fish that are resident in river, migrate into floodplains for feeding, breeding and protection against predation.)- Large species dependent on lateral migration to floodplains for breeding and feeding. Example: Redbreast tilapia [*Tilapia rendalli*].

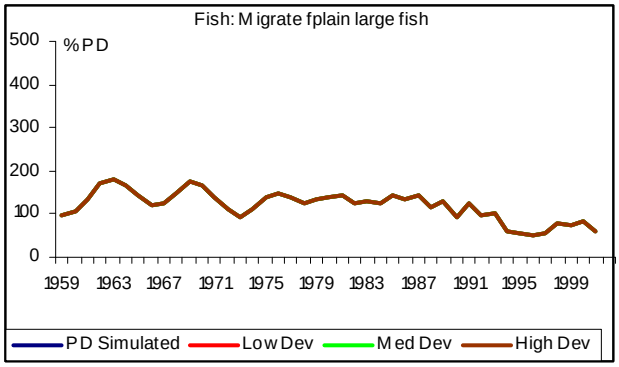
Site 1: Cubango River @ Capico



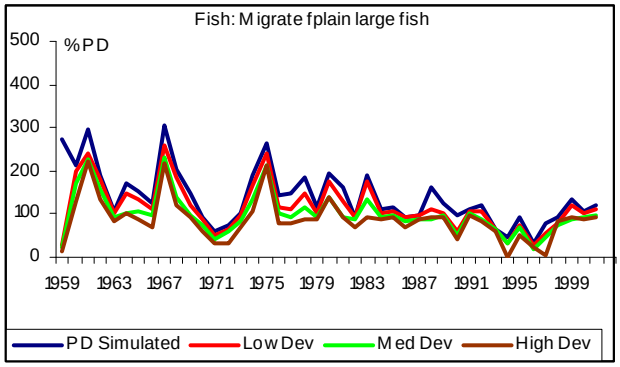
Site 2: Cubango River @ Mucundi



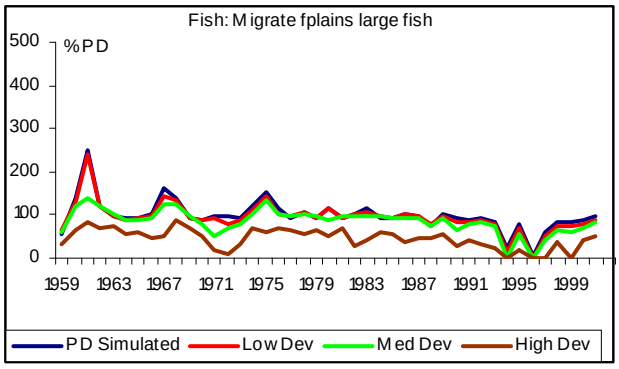
Site 3: Cuito River @ Cuito Cuanavale



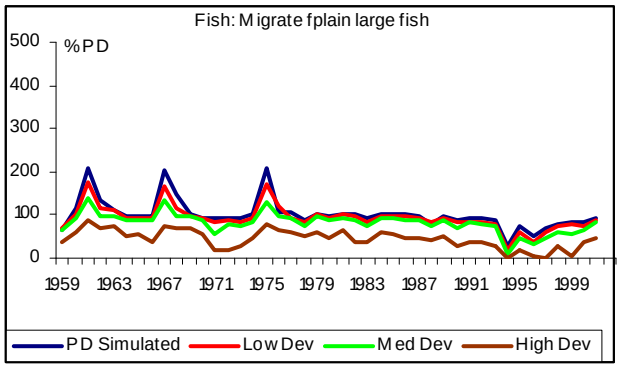
Site 4: Okavango River @ Rundu



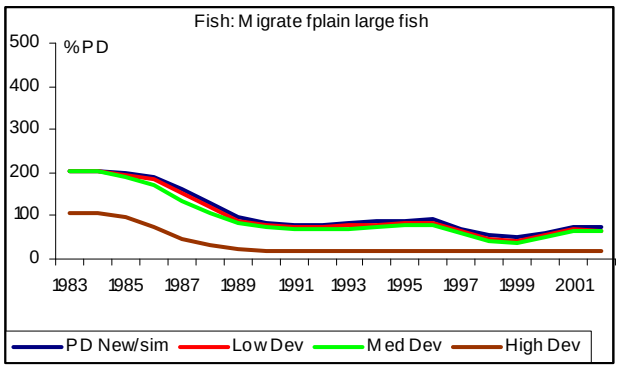
Site 5: Okavango River @ Popa Falls



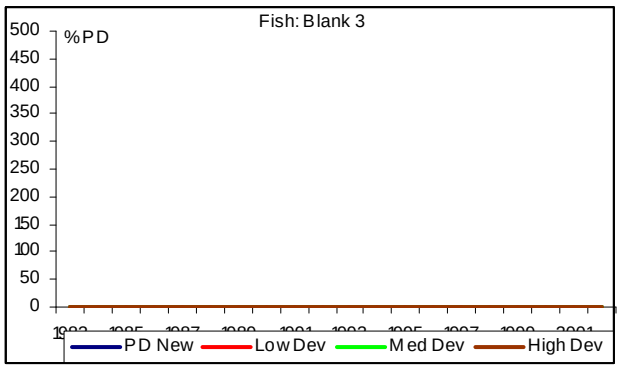
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

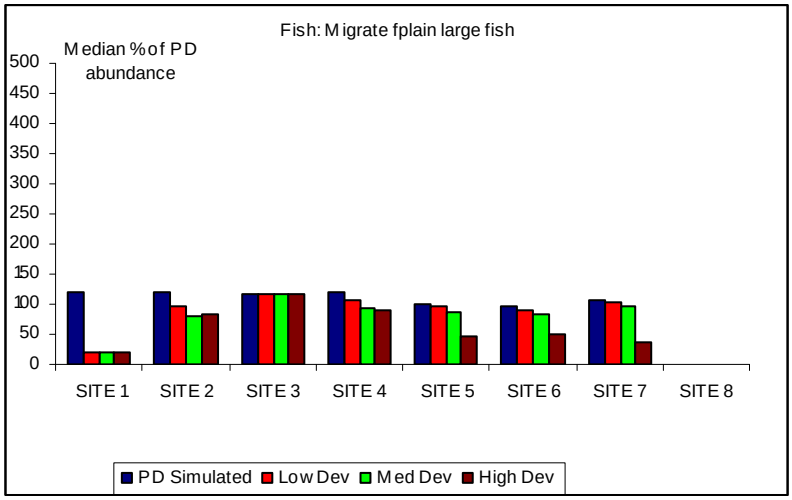


Site 8: Boteti River



Summary change per scenario

Depend on regular flooding of shallow vegetated floodplains and deeper [>200cm] refuges during low flow conditions.



Low Scenario

Any disruption of the normal flooding pattern or sedimentation regime will have a detrimental effect. However, minor changes that may cause variations that fall within the natural variability will not have any major effect on these species.

Moderate Scenario

Any disruption of the normal flooding pattern or sedimentation regime will have a detrimental effect. However, species such as catfish may not be adversely affected by declining habitat quality relative to other species in the group.

High Scenario

Disruption of natural flooding patterns impacts negatively on availability of floodplain habitat for breeding and feeding and migratory movements of this group. The breeding success and survival will be specifically affected. Increased predation by pioneer predators with declining water quality can take place and the highly resilient catfish [Clarias spp] may become the dominant species in the system. Construction of dams will affect sedimentation and replenishment of nutrients and organic material on the floodplains, negatively affecting the foodweb and fish communities.

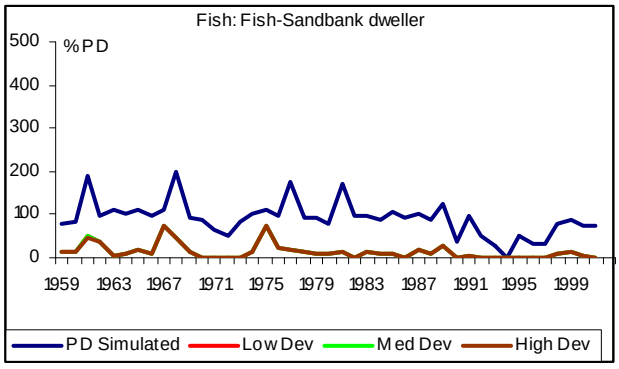
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

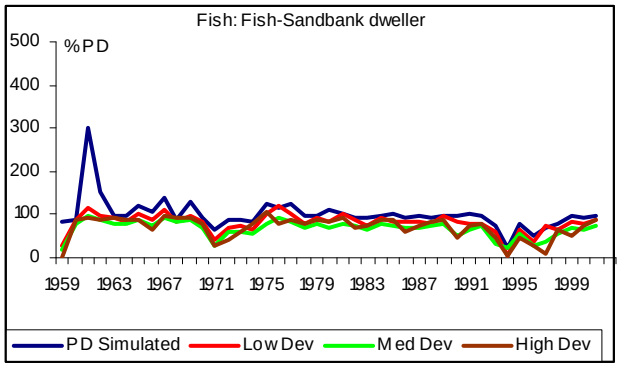
7.5. Fish-Sandbank dweller

(Species living on sandbanks and habitats with sandy bottoms.) - Fish species living mainly on the actively moving sandbanks or a sandy bottom. Example: Sand catlet [*Leptoglanis cf dorae*].

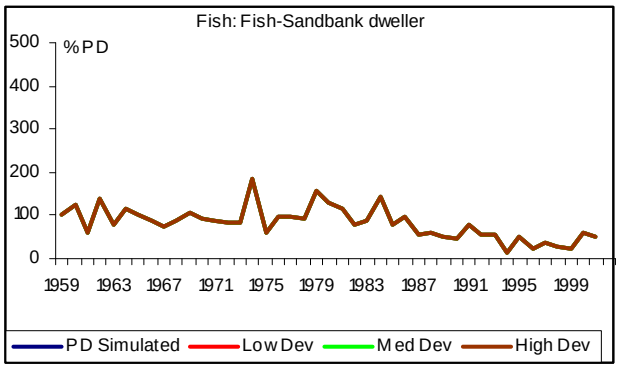
Site 1: Cubango River @ Capico



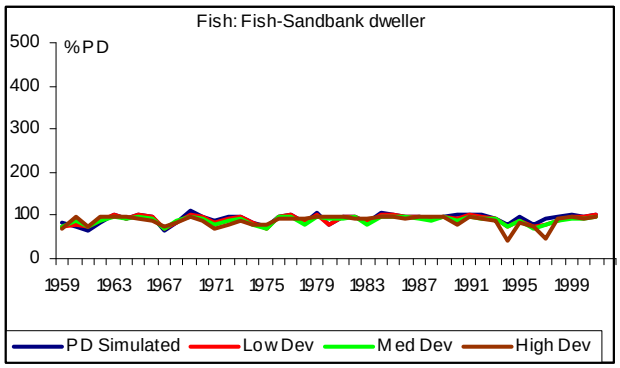
Site 2: Cubango River @ Mucundi



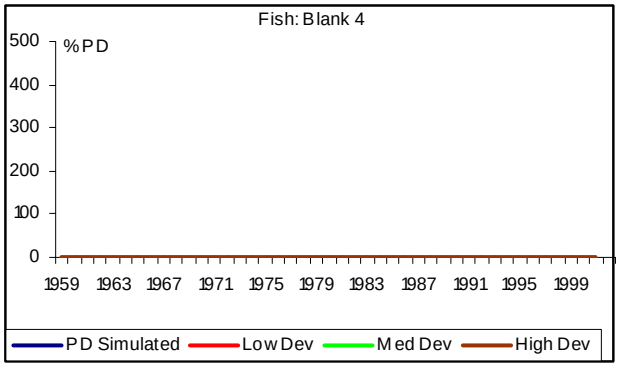
Site 3: Cuito River @ Cuito Cuanavale



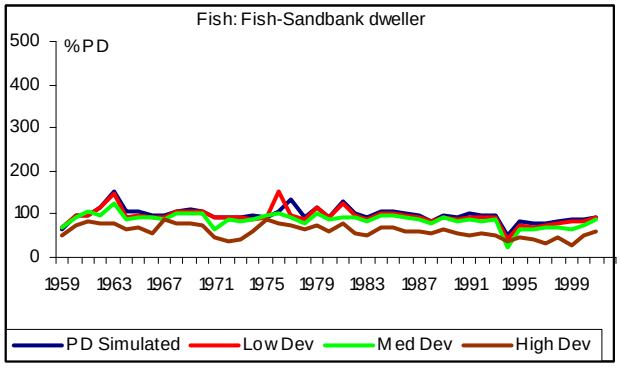
Site 4: Okavango River @ Rundu



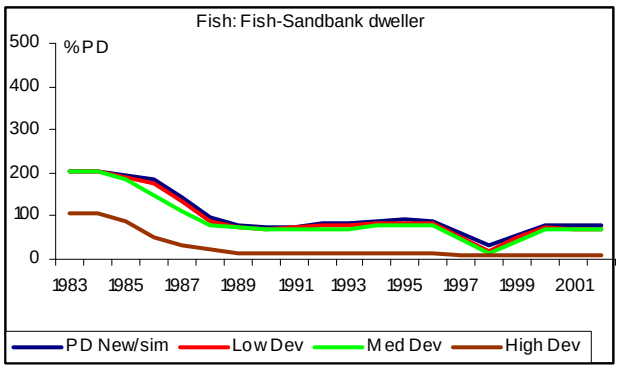
Site 5: Okavango River @ Popa Falls



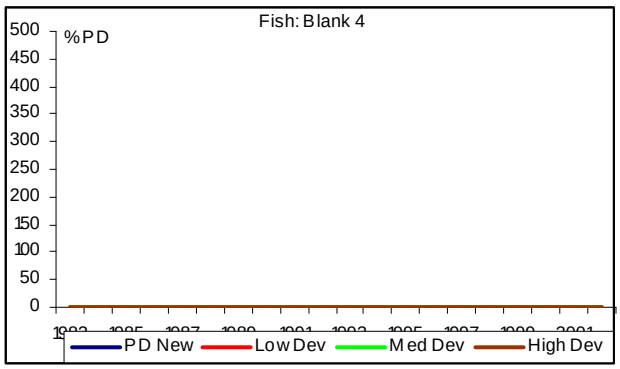
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

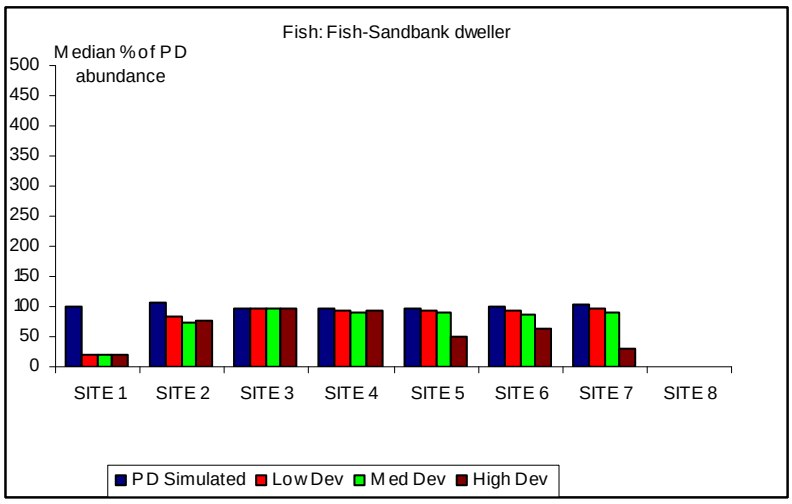


Site 8: Boteti River



Summary change per scenario

Depend on active sandbanks with flowing water and seasonal natural variation of water levels.



Low Scenario

Any disruption of the normal flooding pattern or sedimentation regime will have a detrimental effect on this group, especially if the sediment balance is disturbed by water storage development.

Moderate Scenario

Any disruption of the normal flooding pattern or sedimentation regime will have a detrimental effect on this group, especially if the sediment balance is disturbed by water storage development.

High Scenario

Disruption of natural flow patterns that keep sandbanks active may result in the destruction of this habitat which will be ultimately detrimental to the fish species survival associated with it.

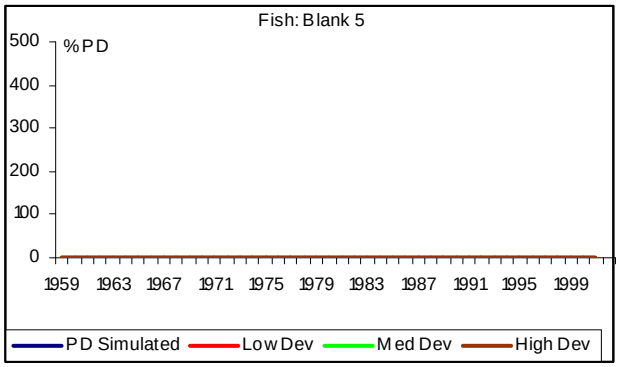
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

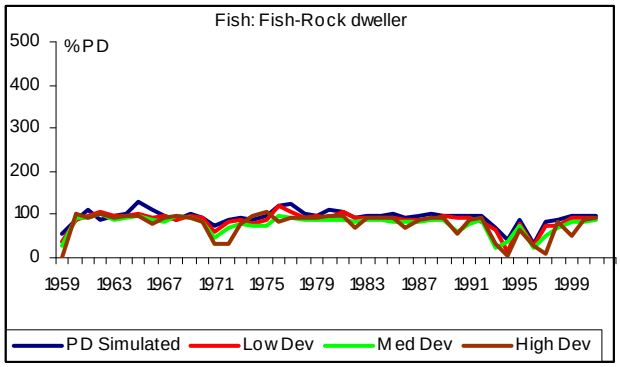
7.6. Fish-Rock dweller

(Rheophillic species of riffles and rapids) - Fish species living amongst rocks and in crevices in flowing water. Example: Southern stargazer [*Amphilius uranoscopus*].

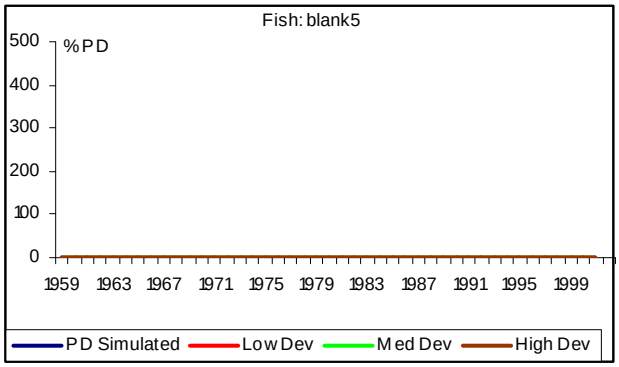
Site 1: Cubango River @ Capico



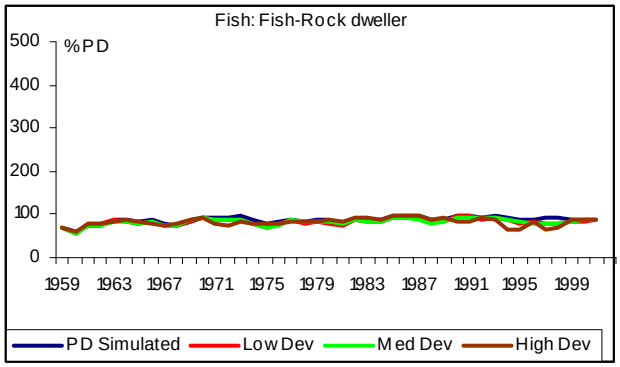
Site 2: Cubango River @ Mucundi



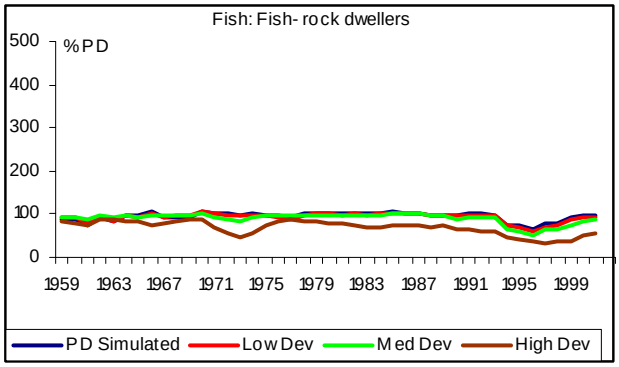
Site 3: Cuito River @ Cuito Cuanavale



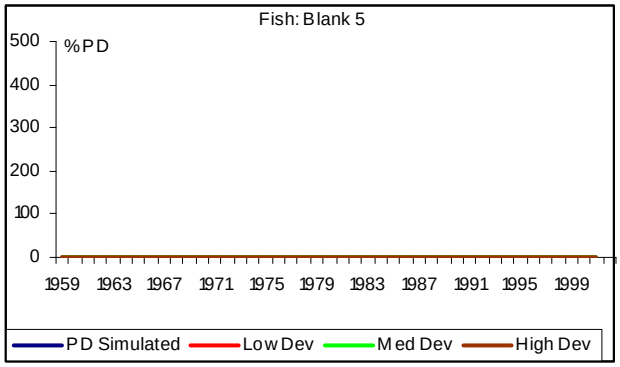
Site 4: Okavango River @ Rundu



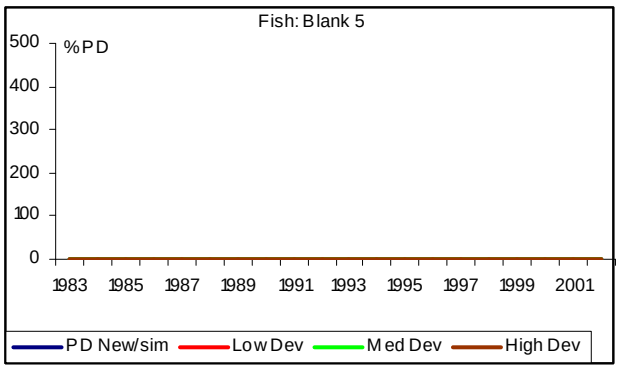
Site 5: Okavango River @ Popa Falls



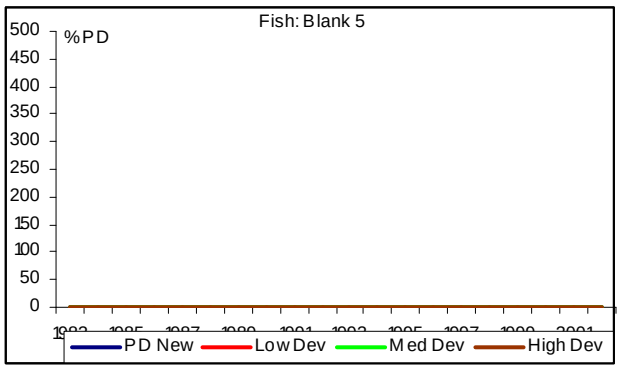
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

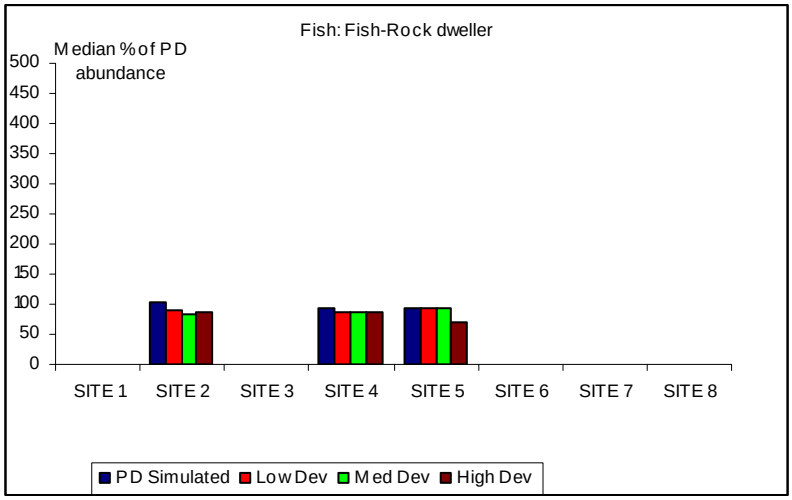


Site 8: Boteti River



Summary change per scenario

Depend on presence of a rocky bottom and flowing water as well as natural variation in water level.



Low Scenario

This indicator group is sensitive to any disruption of the hydrological regime or limited deterioration of water quality expected in the low scenario.

Moderate Scenario

This indicator group is sensitive to any disruption of the hydrological regime or deterioration of water quality expected in the medium scenario.

High Scenario

Decreased flow may expose the rock habitat, which would decrease both the availability of habitat and the survival of fish species in this group. Unnatural flooding patterns would also have a negative effect on availability of food items and fish breeding patterns in this habitat.

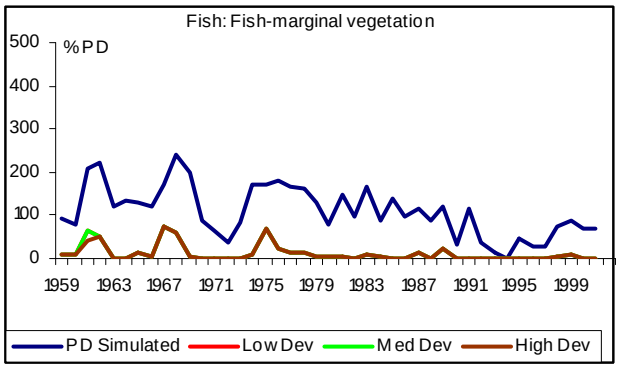
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

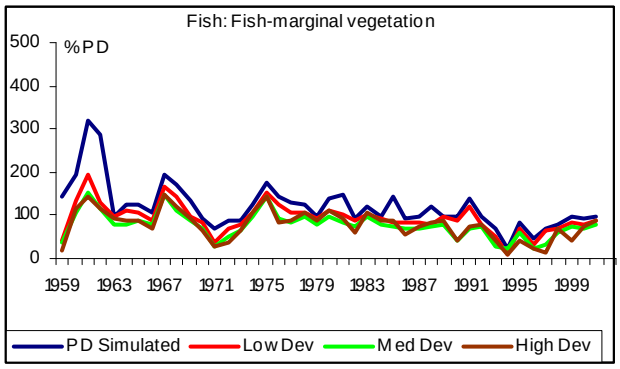
7.7. Fish-marginal vegetation

(Species living amongst marginal vegetation on edge of channels.) - Fish species living mainly amongst vegetation on margin of river and may move into floodplains during flood conditions. Example: Banded tilapia [*Tilapia sparrmanii*].

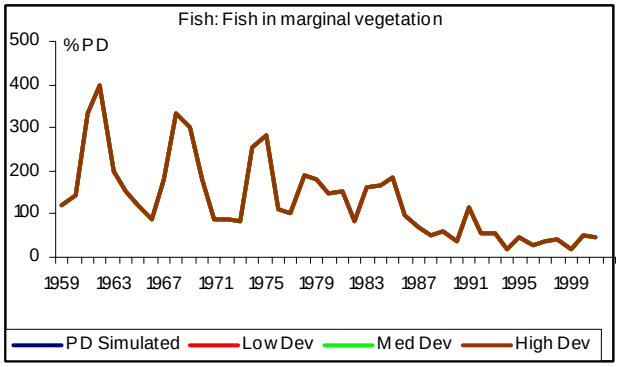
Site 1: Cubango River @ Capico



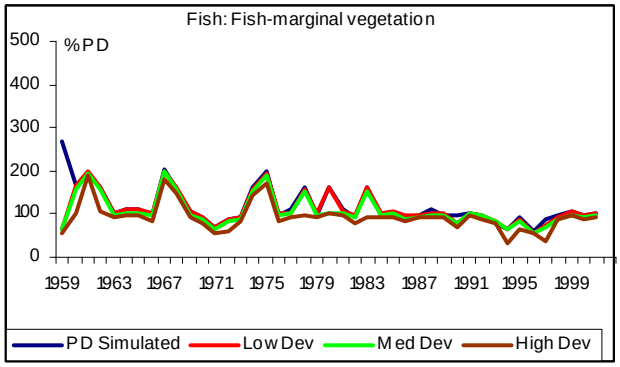
Site 2: Cubango River @ Mucundi



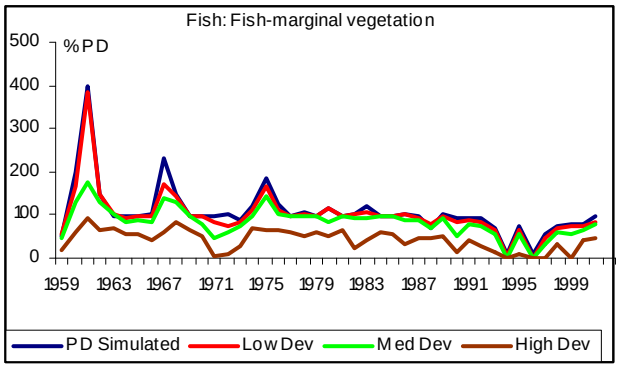
Site 3: Cuito River @ Cuito Cuanavale



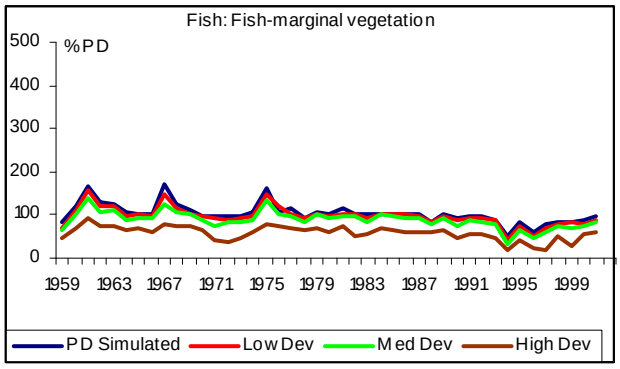
Site 4: Okavango River @ Rundu



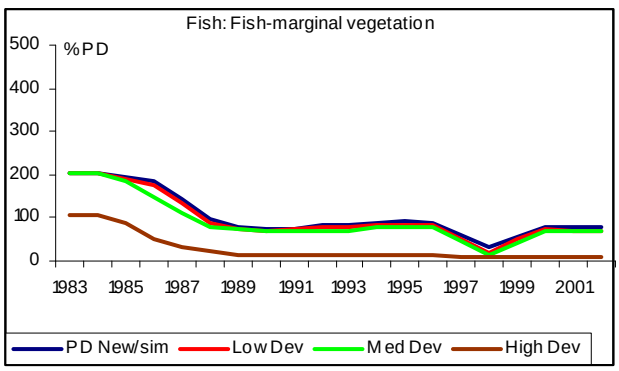
Site 5: Okavango River @ Popa Falls



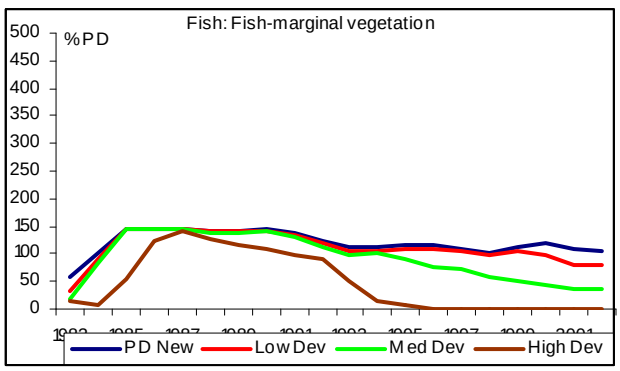
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

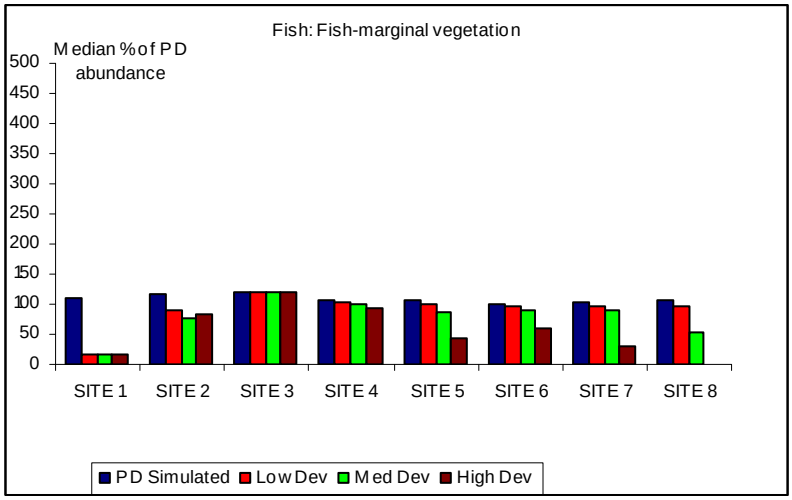


Site 8: Boteti River



Summary change per scenario

Depend on the presence of marginal vegetation, stable soils and naturally varying water levels for establishment of emergent and submerged vegetation.



Low Scenario

Any changes to the flood regime or water quality can affect this group by changing the availability of marginal vegetation.

Moderate Scenario

Any unnatural changes to the flood regime or water quality caused by the medium development in the river basin can affect this group by changing the availability of marginal vegetation. It is expected that medium developments will have a negative impact on fish survival in this group.

High Scenario

Decreased flow in the river channel and aseasonal flooding may affect both emergent and submerged vegetation which would result in loss of habitat and food availability. Fish species in this indicator group may then experience low survival rates (e.g. decreased breeding success, increased predation, etc).

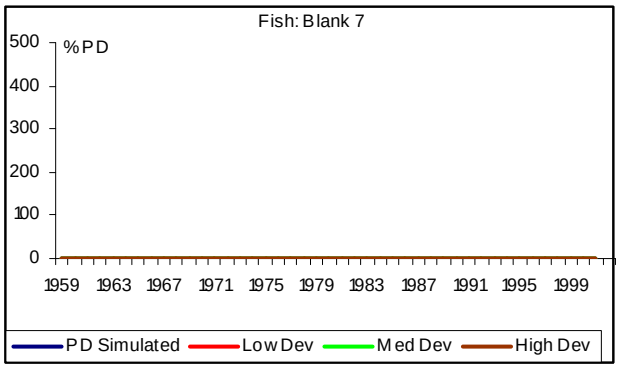
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

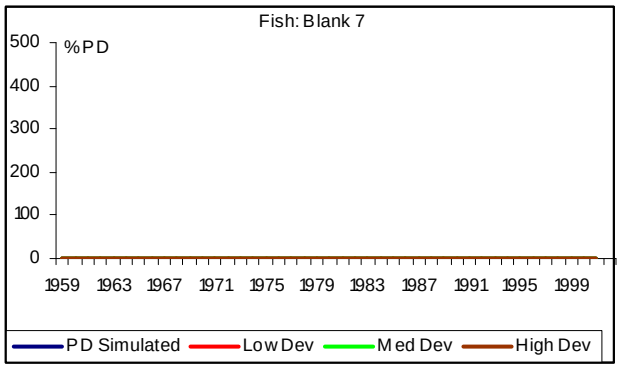
7.8. Fish in backwaters

(Fish species living in vegetated pools and backwaters.) - Fish species living mainly amongst vegetation on margin of river and associated backwaters during low water level conditions. May move into floodplains during flood conditions. Example: Okavango tilapia [*Tilapia ruweti*].

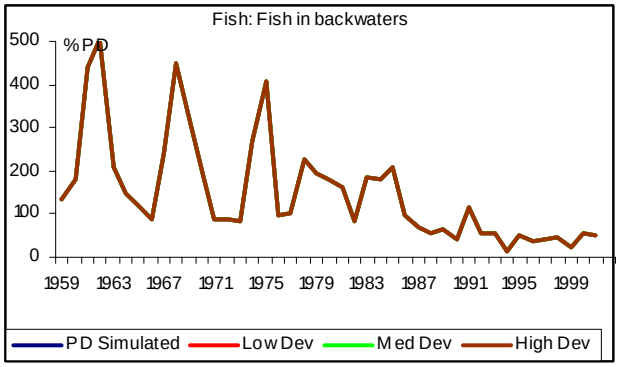
Site 1: Cubango River @ Capico



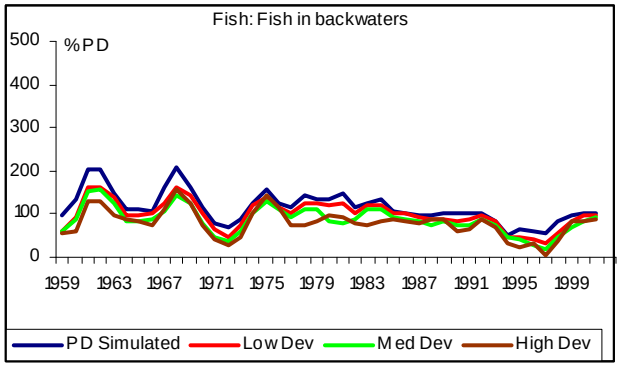
Site 2: Cubango River @ Mucundi



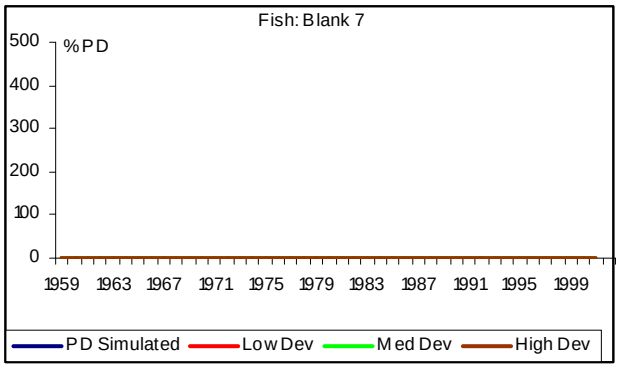
Site 3: Cuito River @ Cuito Cuanavale



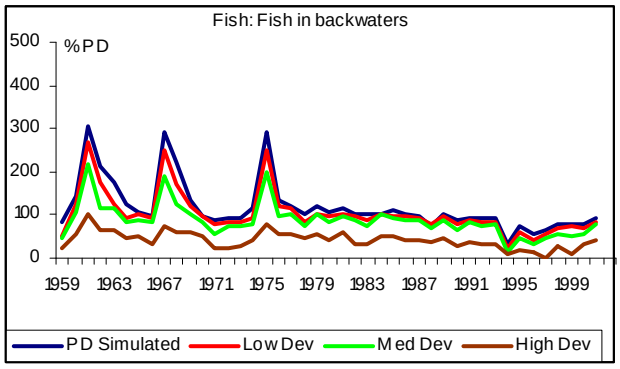
Site 4: Okavango River @ Rundu



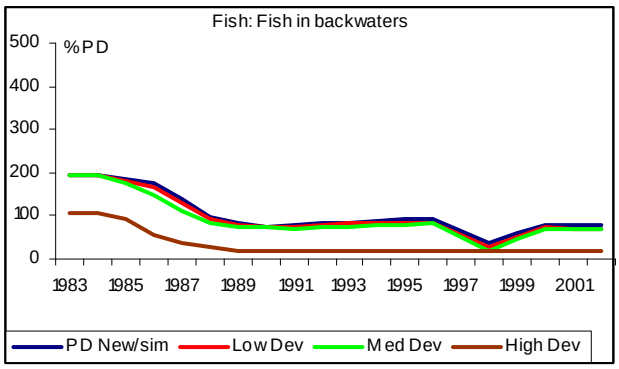
Site 5: Okavango River @ Popa Falls



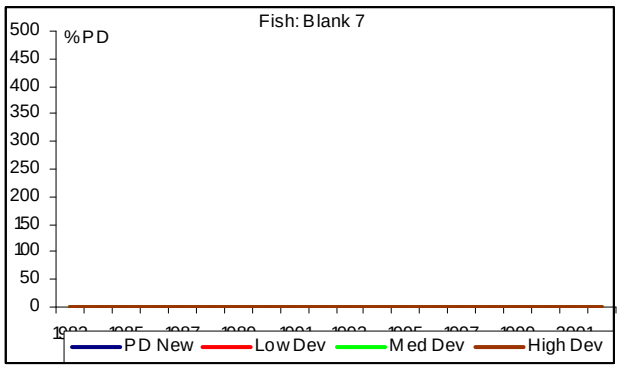
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

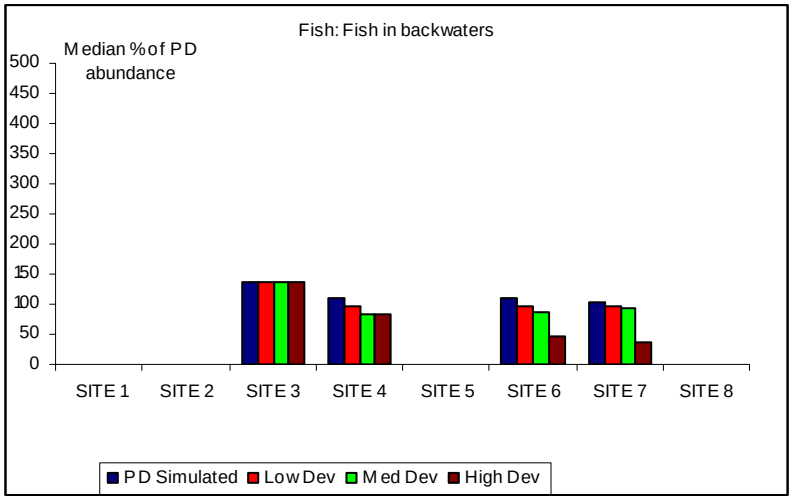


Site 8: Boteti River



Summary change per scenario

Depend on maintenance of oxbows and pools on the margin of the floodplain of the river by normal natural hydrological regime, including standing water conditions during low flow.



Low Scenario

Backwaters may change due to changes in flood cycles and sediment load and water quality. This will impact on fish communities of backwaters.

Moderate Scenario

Backwaters may deteriorate due to changes in flood cycles and sediment load and water quality. This will impact on fish communities of backwaters.

High Scenario

Oxbows and backwaters may be lost due to siltation as result of lack of scouring function of large floods and increased or reduced sedimentation. Reduced water flow will result in habitat loss affecting surival of backwater communities. Unnatural flooding regimes may further reduce fish survival. Proposed dams will affect sedimentation and replenishment of nutrients on the flood plains and backwaters, ultimately causing a decline in fish communities and replacement by pioneer fish species.

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

8. Wildlife

This section provides the time-series for the wildlife indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Semi Aquatics (hippos, crocodiles)
- Frogs, river snakes
- Lower floodplain grazers
- Middle floodplain grazers
- Outer floodplain grazers.

8.1. Photographs

8.1.1 Semi Aquatics (hippos, crocodiles)

Photo: K Roberts

Photo: C Santos

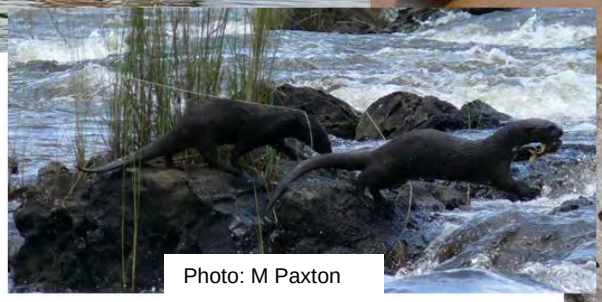


Photo: M Paxton

Photo: K Roberts

8.1.2 Frogs, river snakes

Photos: M Paxton

Photos: K Roberts

8.1.3 Lower floodplain grazers

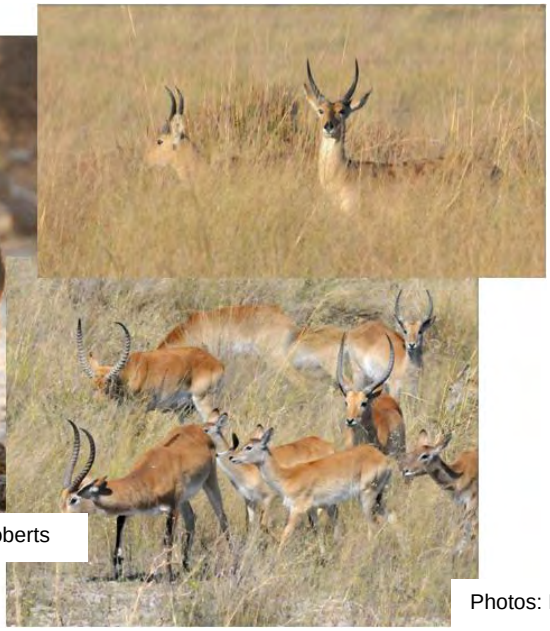
Photos: K Roberts

8.1.4 Middle floodplain grazers

Photos: K Roberts

8.1.5 Outer floodplain grazers

Photo: K Roberts

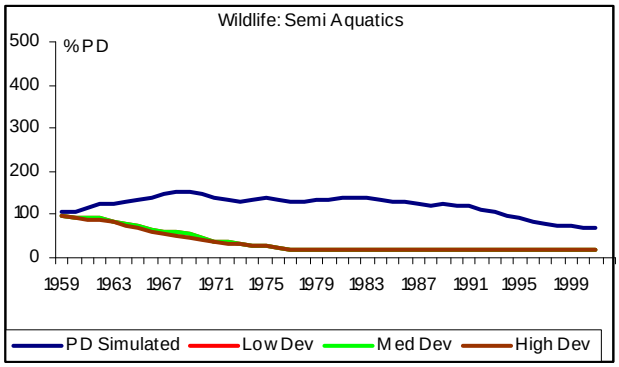


Photos: K Roberts

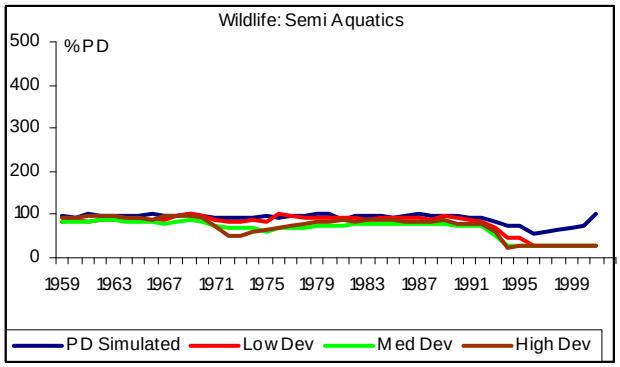
8.2. Semi Aquatics

(Main channel dwellers, but ranging over banks, floodplains and Islands) - Hippopotamus, crocodile, otters, monitors and terrapins.

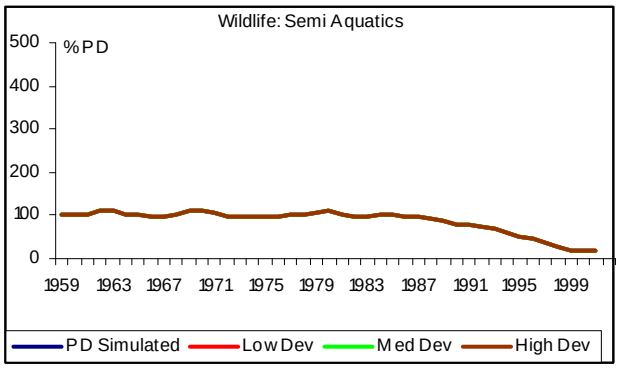
Site 1: Cubango River @ Capico



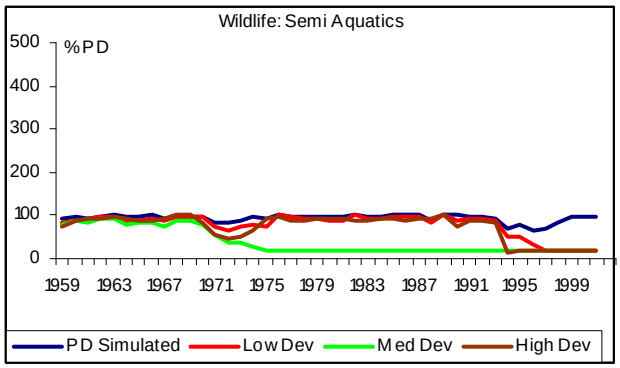
Site 2: Cubango River @ Mucundi



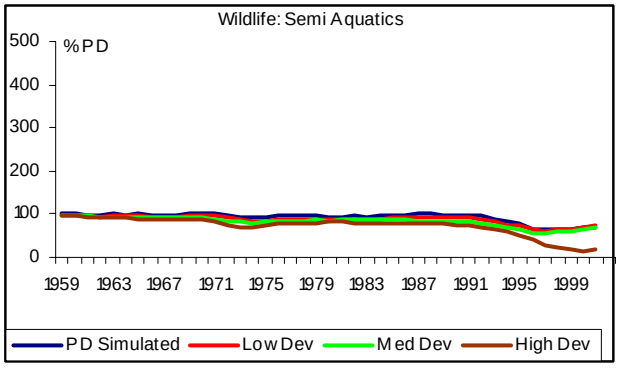
Site 3: Cuito River @ Cuito Cuanavale



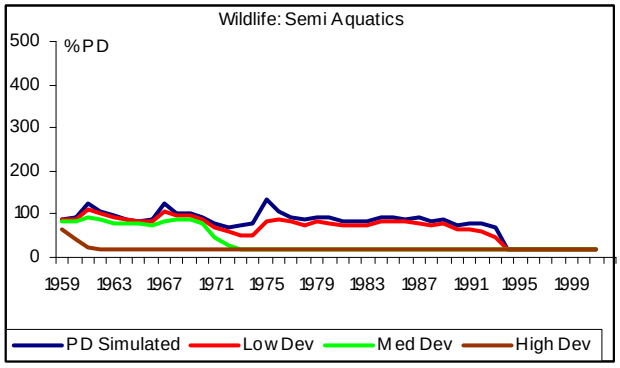
Site 4: Okavango River @ Rundu



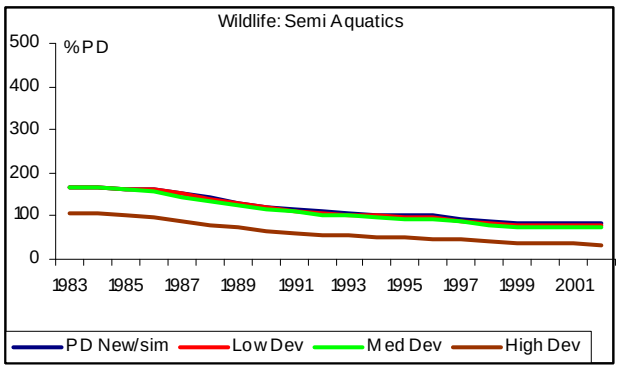
Site 5: Okavango River @ Popa Falls



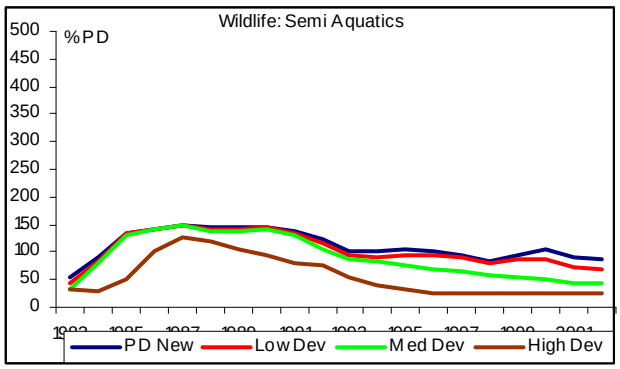
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

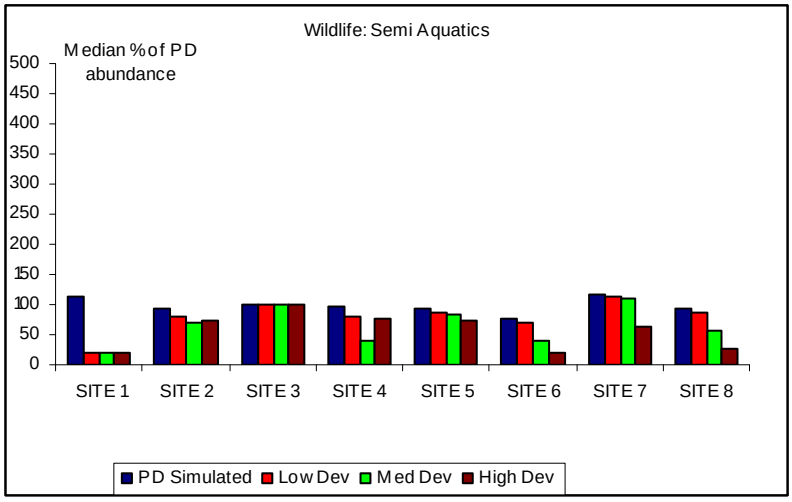


Site 8: Boteti River



Summary change per scenario

Particularly sensitive to dry season water depth for habitat and island integrity.



Low Scenario

Would affect local populations of some species in some areas.

Moderate Scenario

Would reduce populations of some species in unprotected areas.

High Scenario

Would reduce most populations of most species.

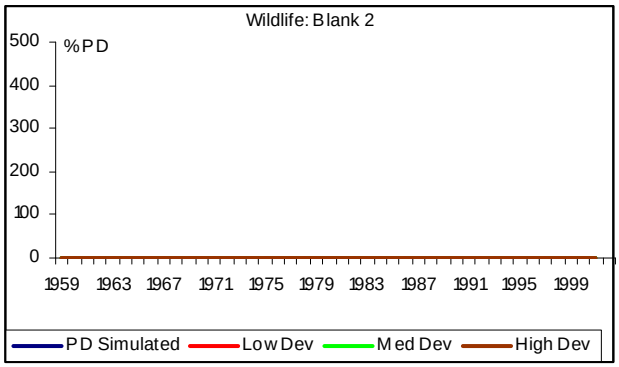
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

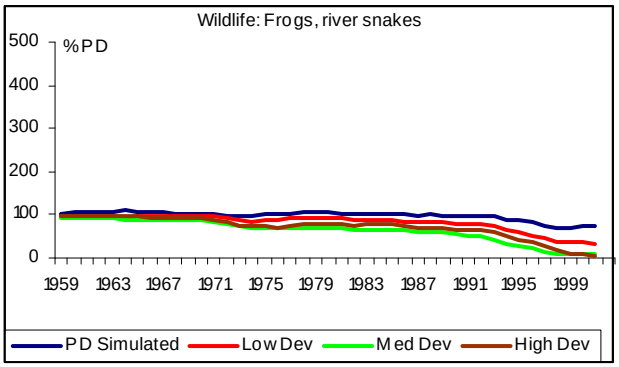
8.3. Frogs, river snakes

(Pools, permanent swamp, lower floodplain areas.) - Snakes, ridged frogs, musk shrews.

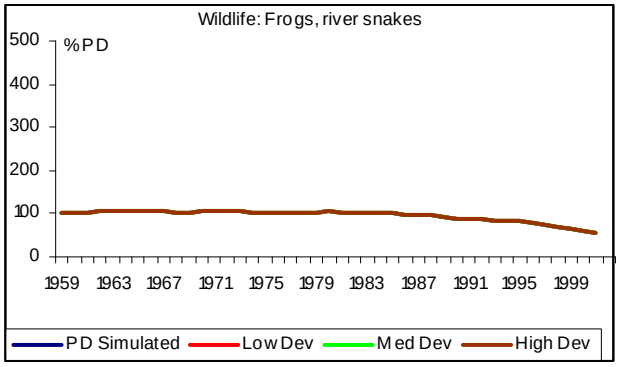
Site 1: Cubango River @ Capico



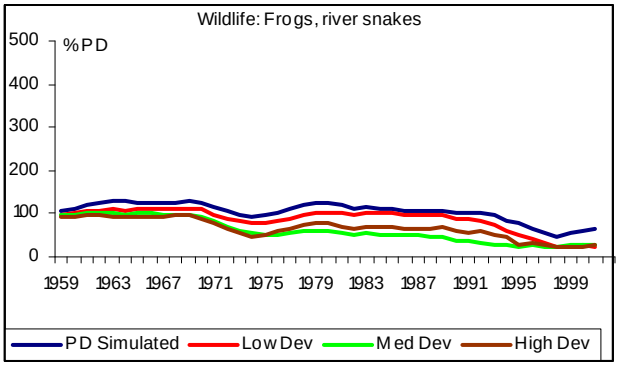
Site 2: Cubango River @ Mucundi



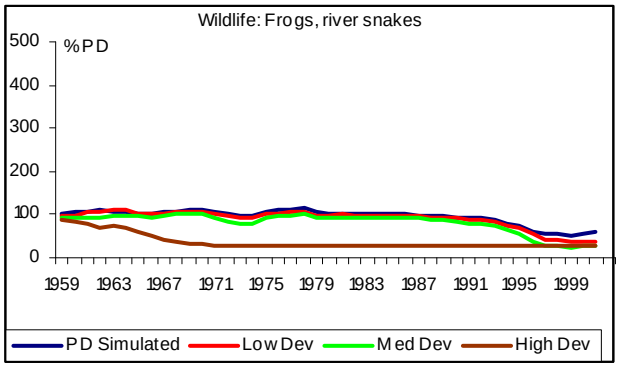
Site 3: Cuito River @ Cuito Cuanavale



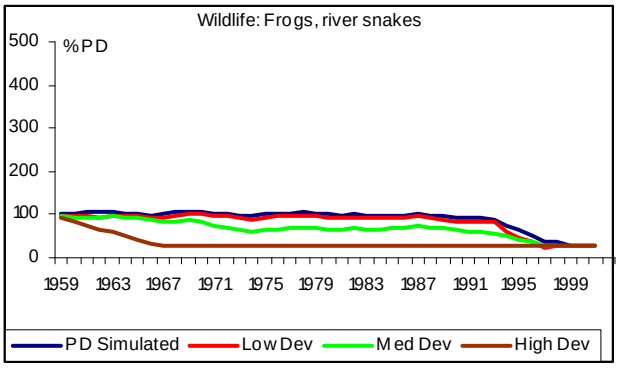
Site 4: Okavango River @ Rundu



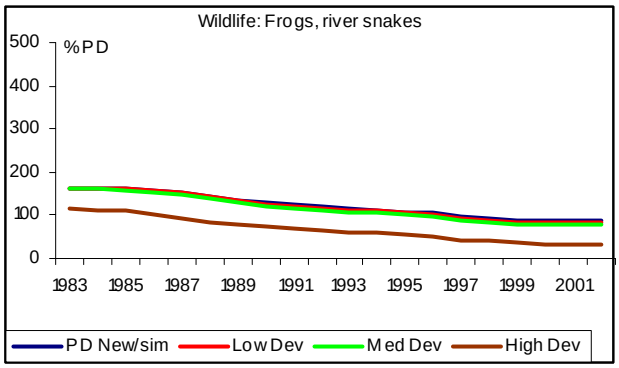
Site 5: Okavango River @ Popa Falls



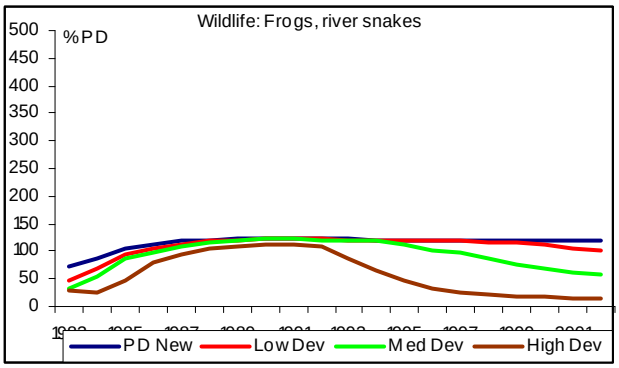
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

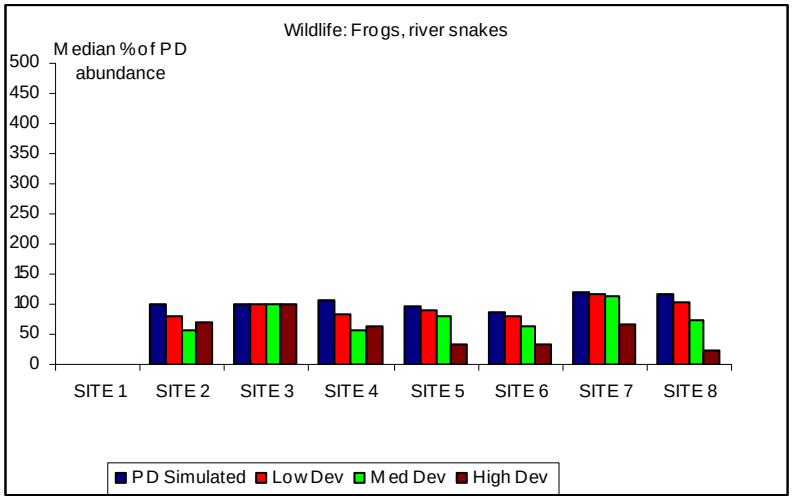


Site 8: Boteti River



Summary change per scenario

Particularly sensitive to dry season water levels and duration to maintain backwaters and marginal vegetation and reduced seasonal floods



Low Scenario

Little change in populations foreseen.

Moderate Scenario

Some population reductions due to local changes in habitat.

High Scenario

Reduced habitat availability would cause reductions of populations in this indicator.

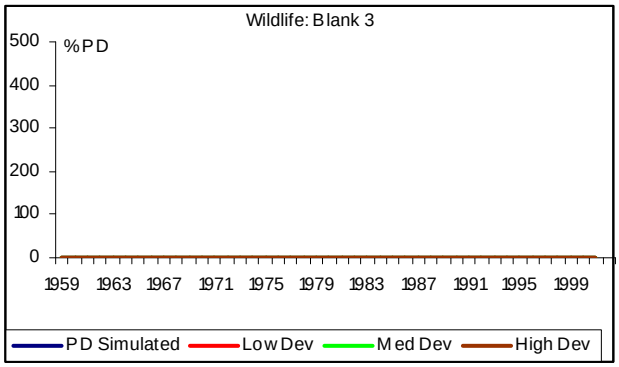
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

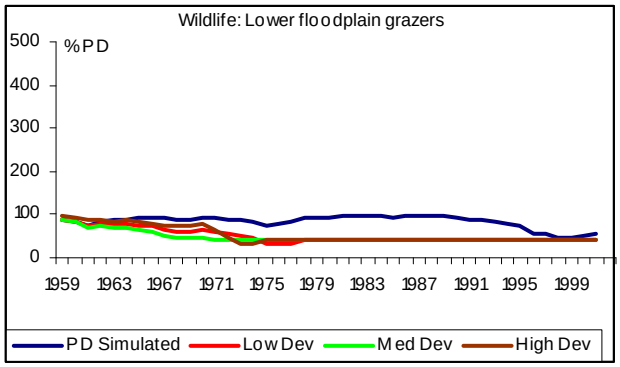
8.4. Lower floodplain grazers

(Permanent swamp, primary and secondary floodplain) - Lechwe, sitatunga, reedbuck, waterbuck.

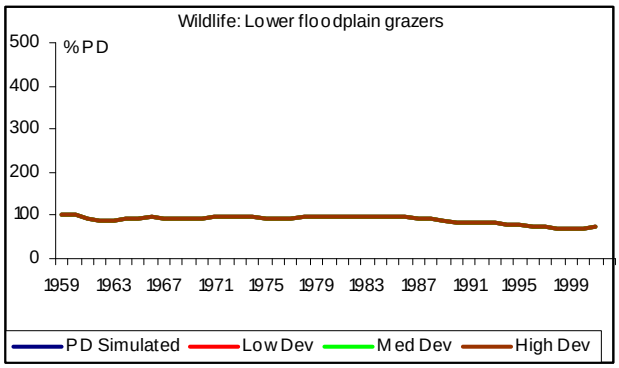
Site 1: Cubango River @ Capico



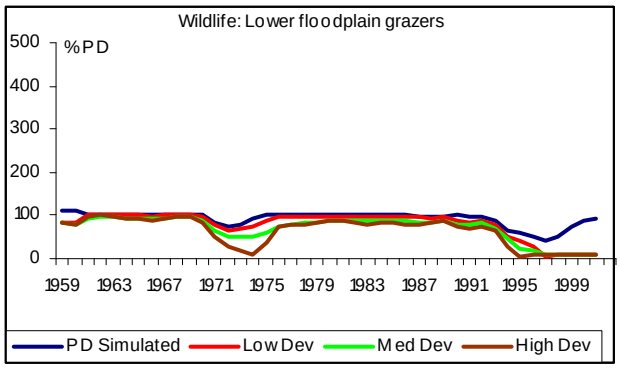
Site 2: Cubango River @ Mucundi



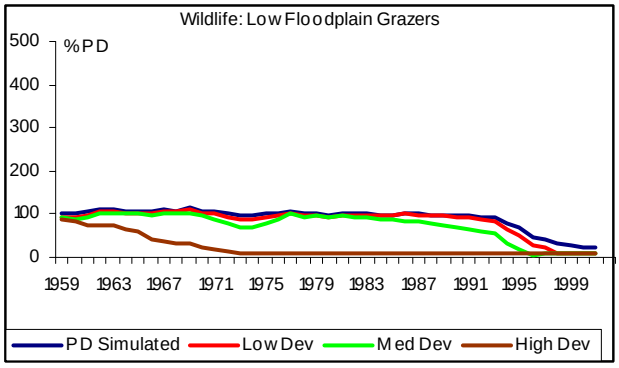
Site 3: Cuito River @ Cuito Cuanavale



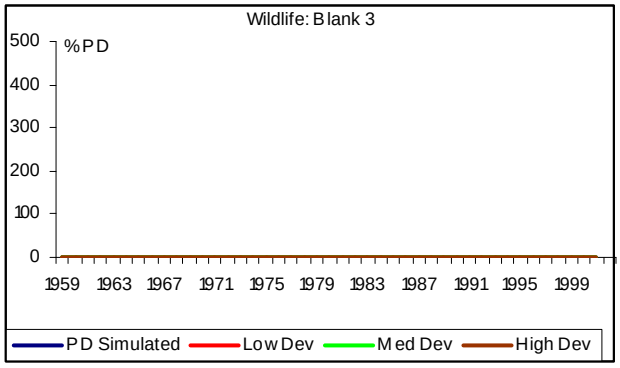
Site 4: Okavango River @ Rundu



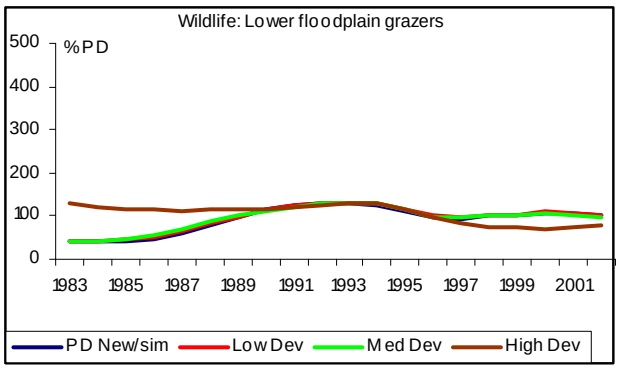
Site 5: Okavango River @ Popa Falls



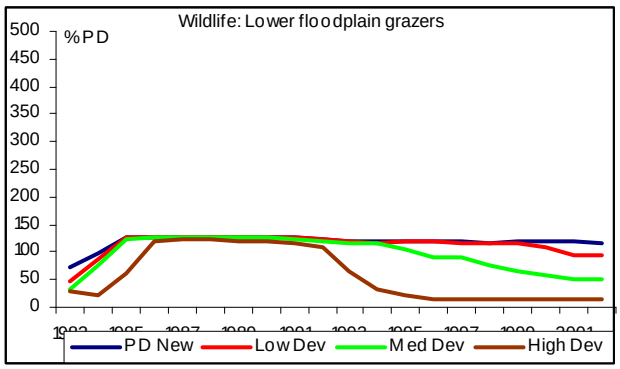
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

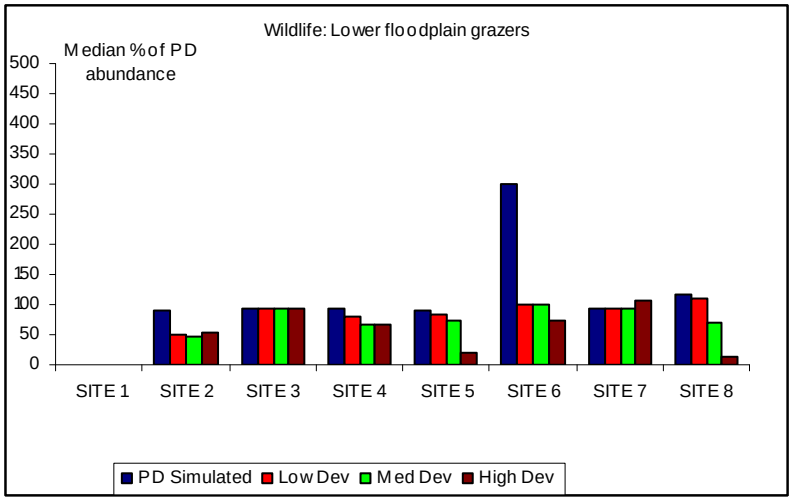


Site 8: Boteti River



Summary change per scenario

Need seasonal floods of 2-6 months duration.



Low Scenario

Provided there is some seasonal flooding little change in populations foreseen.

Moderate Scenario

Some population reductions due to local changes in lower floodplain area.

High Scenario

Would reduce populations of all species.

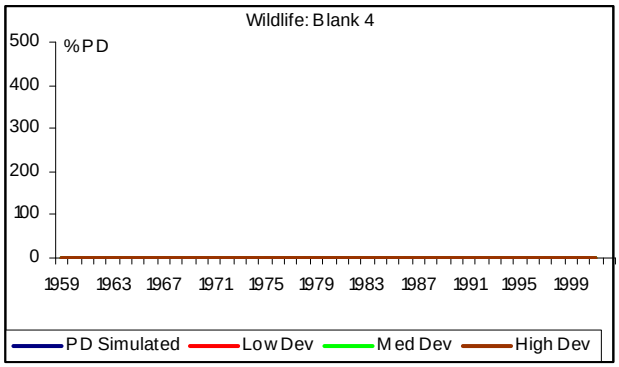
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

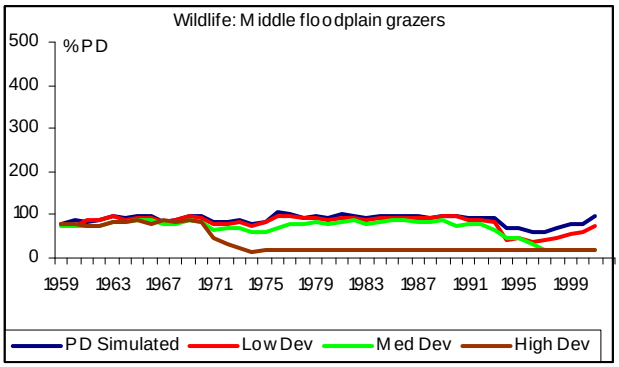
8.5. Middle floodplain grazers

(Secondary and tertiary floodplain) - Wildebeest, zebra, impala, duiker, aarvark, mice.

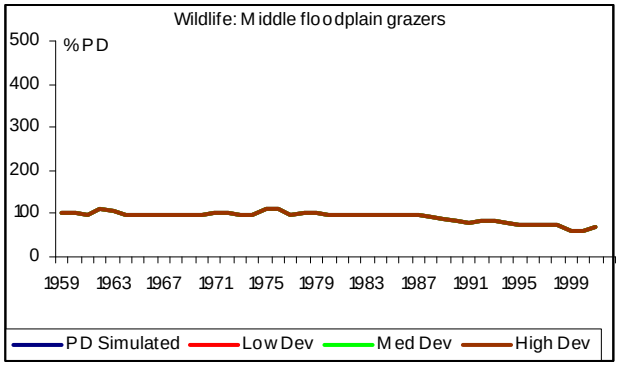
Site 1: Cubango River @ Capico



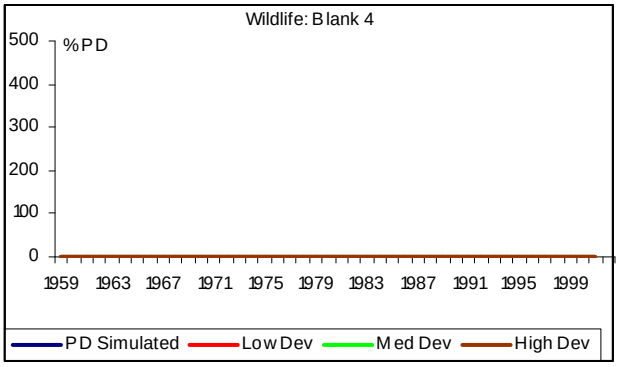
Site 2: Cubango River @ Mucundi



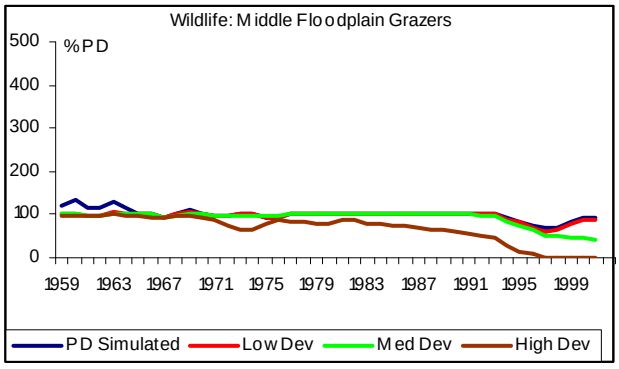
Site 3: Cuito River @ Cuito Cuanavale



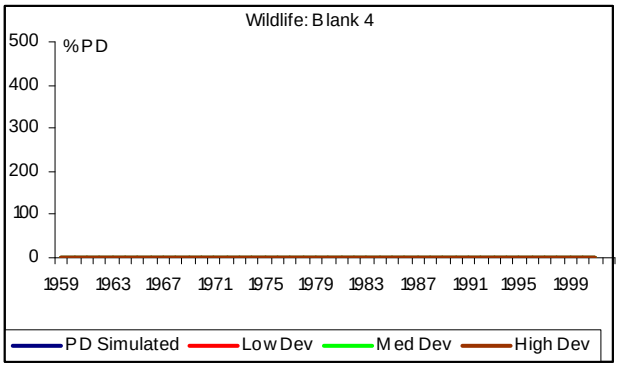
Site 4: Okavango River @ Rundu



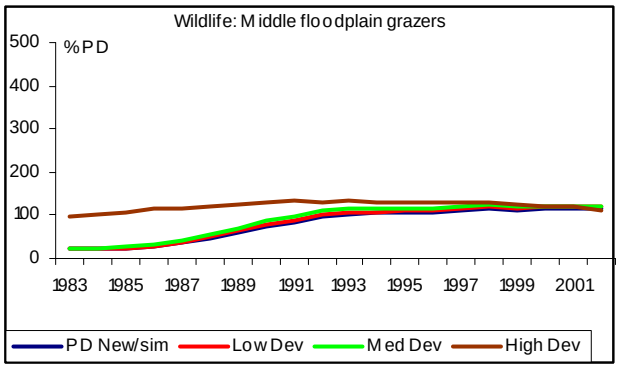
Site 5: Okavango River @ Popa Falls



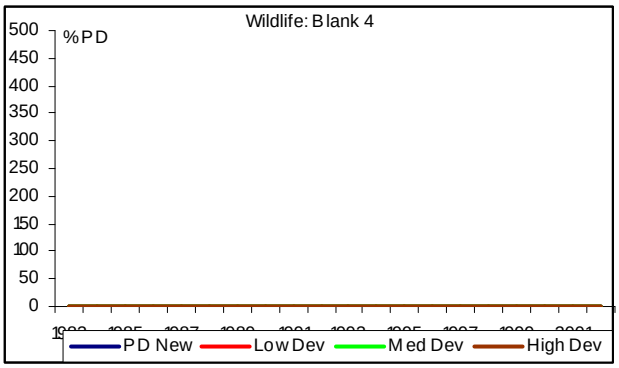
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

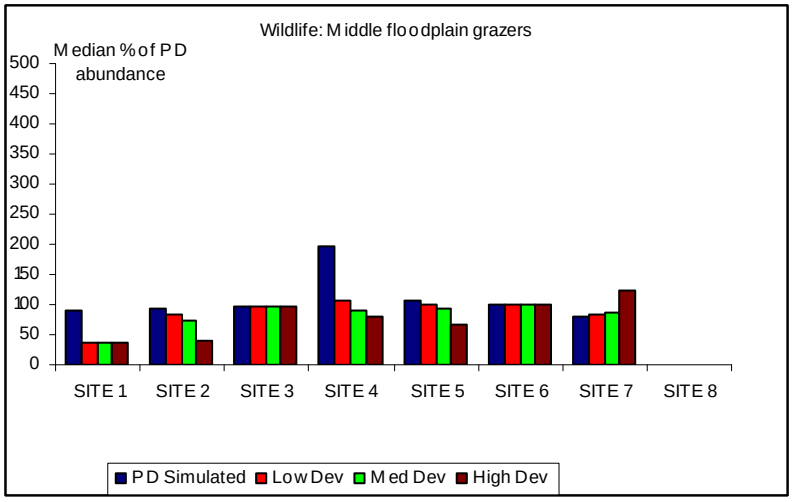


Site 8: Boteti River



Summary change per scenario

Need periodic flooding.



Low Scenario

Little change in populations foreseen.

Moderate Scenario

Little change in populations foreseen in project areas.

High Scenario

Some population reductions due to local changes in habitat and use by other species.

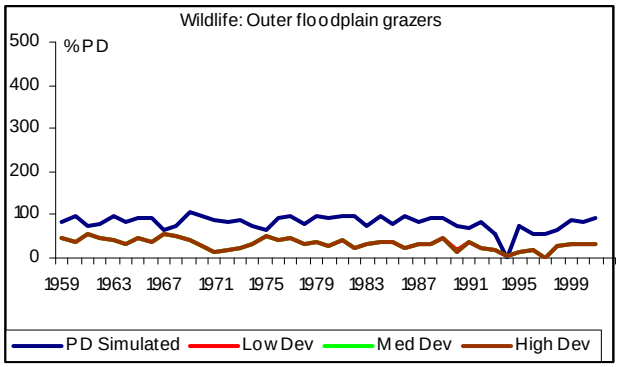
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

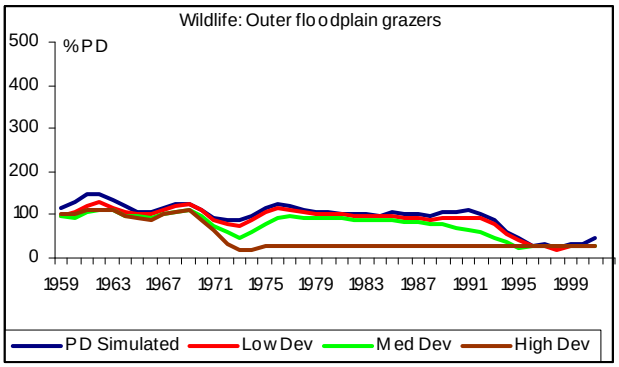
8.6. Outer floodplain grazers

(Primary and secondary floodplain grazers) - Elephant, buffalo, tsesebe, warthog.

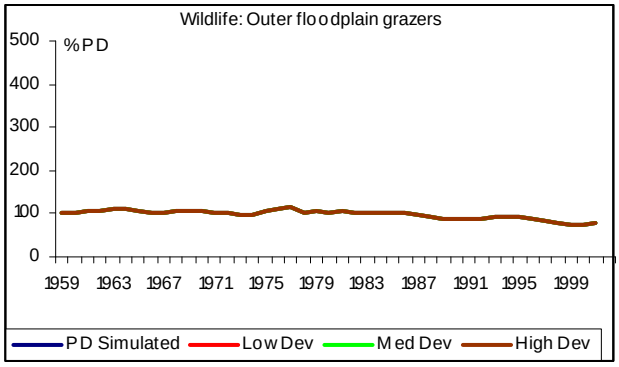
Site 1: Cubango River @ Capico



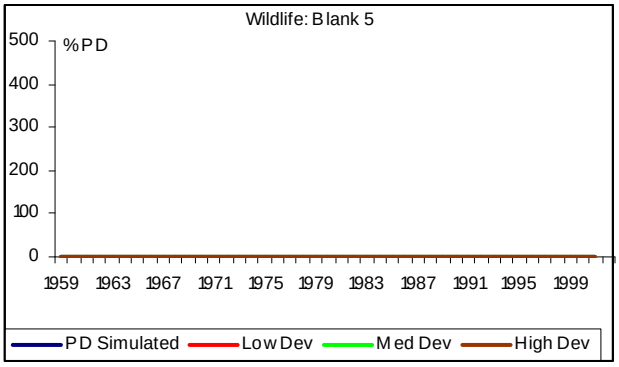
Site 2: Cubango River @ Mucundi



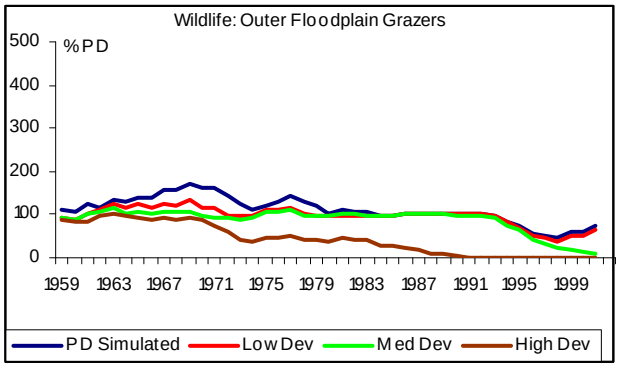
Site 3: Cuito River @ Cuito Cuanavale



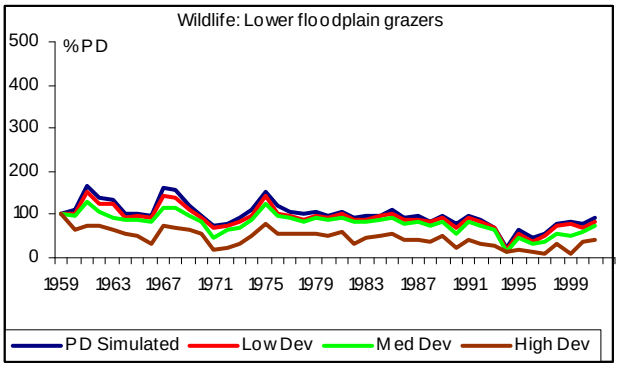
Site 4: Okavango River @ Rundu



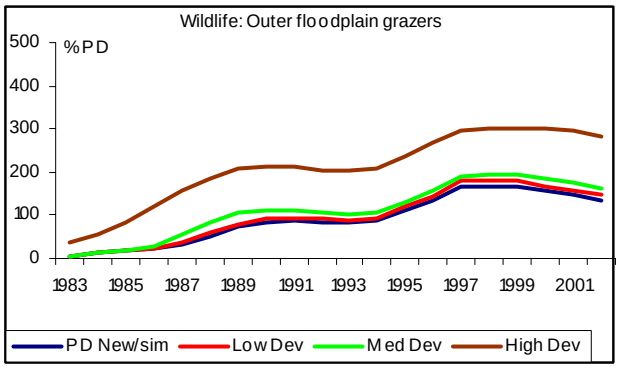
Site 5: Okavango River @ Popa Falls



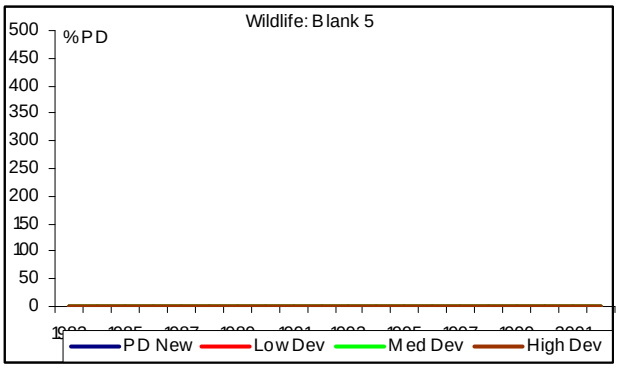
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

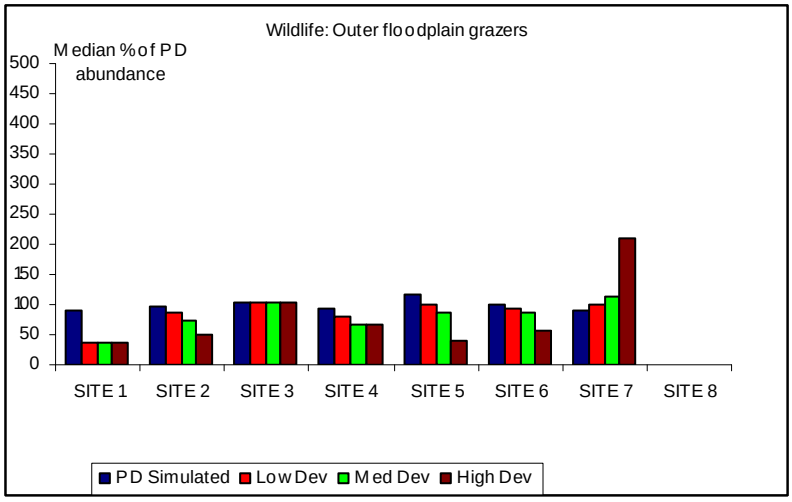


Site 8: Boteti River



Summary change per scenario

Need seasonal floods of 2-6 months duration.



Low Scenario

Provided there is some seasonal flooding little change in populations foreseen.

Moderate Scenario

Some population reductions due to local changes in lower floodplain area.

High Scenario

Would result in a sharp decline in populations associated with rivers but would increase the populations of these species in the Delta.

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

9. Birds

This section provides the time-series for bird indicators under the flow regime resulting from each scenario and an estimated mean percentage change from present day for each indicator. The indicators presented here are:

- Piscivores - open water
- Piscivores - shallow water
- Piscivores and invertebrate feeders
- Specialists - floodplains
- Specialists - water lilies
- Specialists - fruit trees
- Breeders - reedbeds, floodplains
- Breeders - overhanging trees
- Breeders - banks
- Breeders - rocks, sandbars.

9.1. Photographs

9.1.1 Piscivores – open water

Photo: T Moutloatse

Photo: P Hancock

Photo: M Paxton

9.1.2 Piscivores – shallow water

Photos: P Hancock

Photo: M Paxton

9.1.3 Piscivores and invertebrate feeders

Photo: P Hancock

Photo: M Paxton

Photo: P Scheepers

Photo: P Scheepers

Photo: J Bestelink

9.1.4 Specialists – floodplains

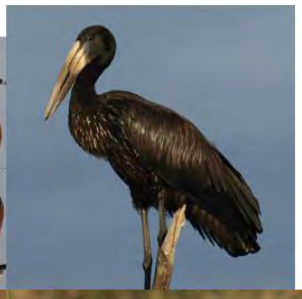


Photo: P Hancock

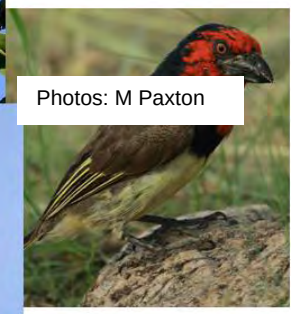
Photos: J Bestelink

Photo: J Macdonald

9.1.5 Specialists – water lilies

Photo: P Hancock

9.1.6 Specialists – fruit trees



Photos: M Paxton

Photo: M Kamakama

9.1.7 Breeders – reedbeds, floodplains

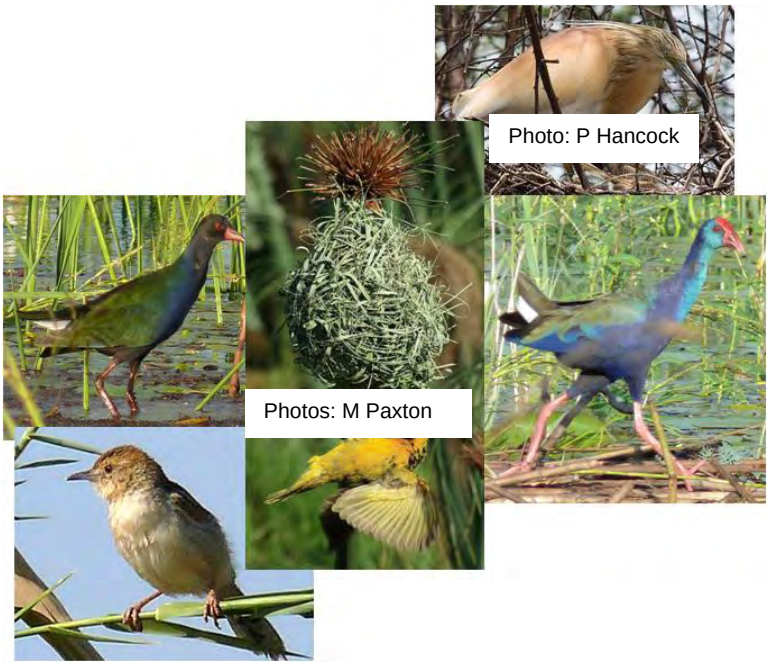


Photo: K Oake

Photo: M Paxton

9.1.8 Breeders – overhanging trees

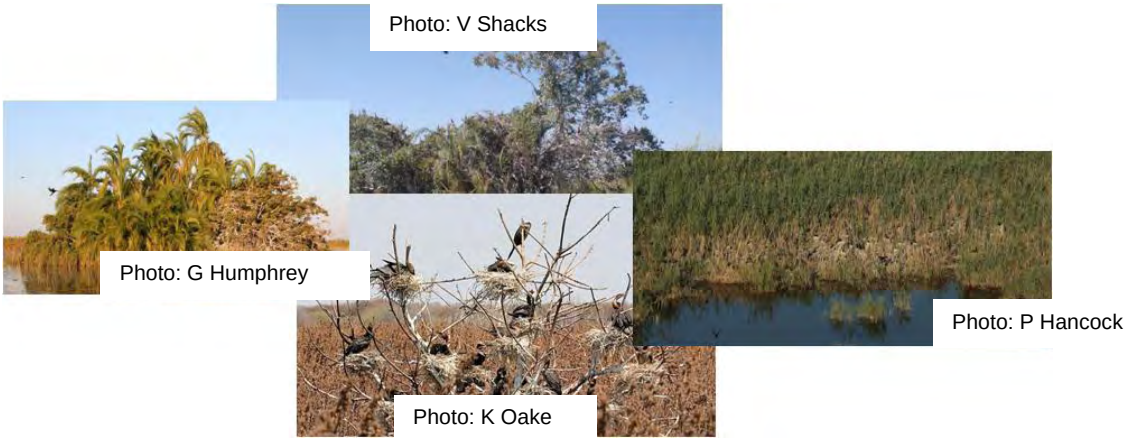
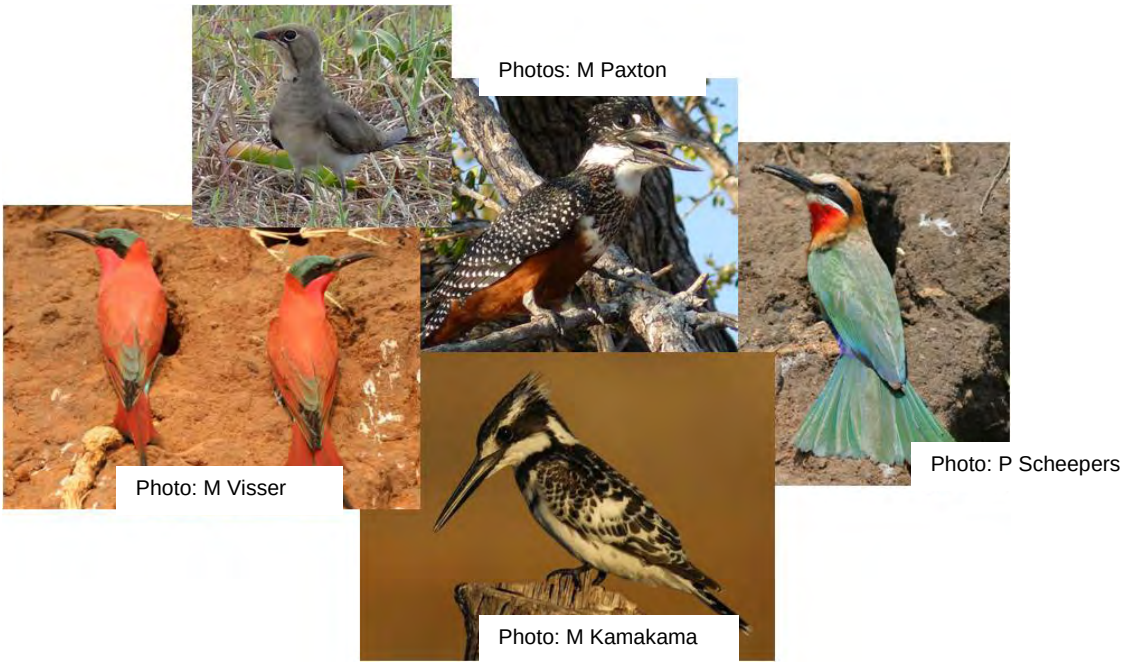


Photo: P Hancock

9.1.9 Breeders – banks



Photos: M Paxton

Photo: M Visser

Photo: P Scheepers

Photo: M Kamakama

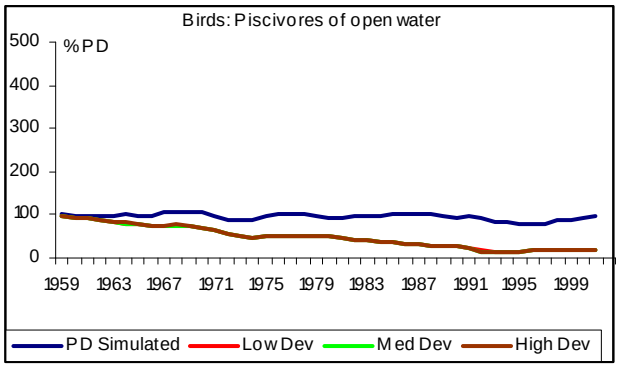
9.1.10 Breeders – rocks, sandbars

Photos: M Paxton

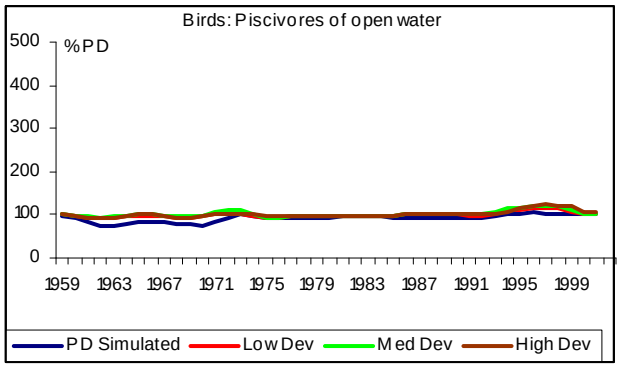
9.2. Piscivores, open water

(Predominantly feed on fish, main river/adjoining pools) - Kingfishers, cormorants, darters.

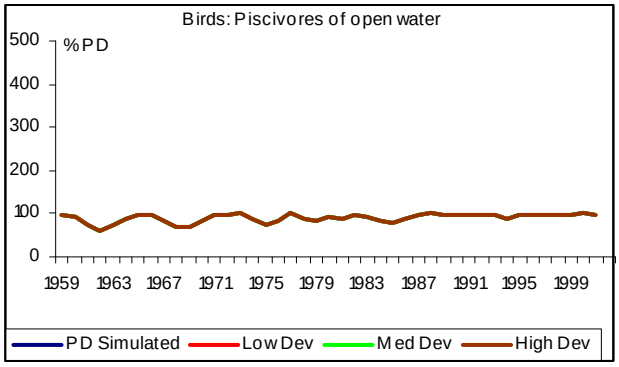
Site 1: Cubango River @ Capico



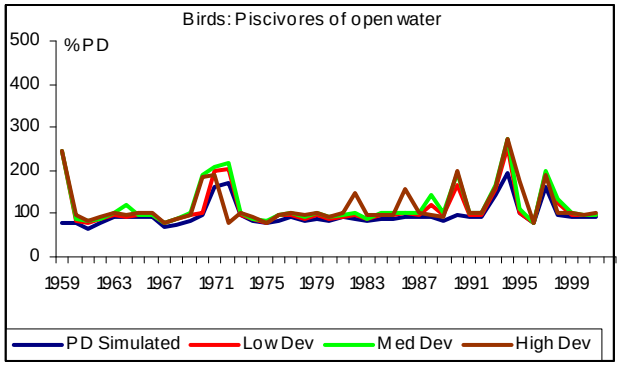
Site 2: Cubango River @ Mucundi



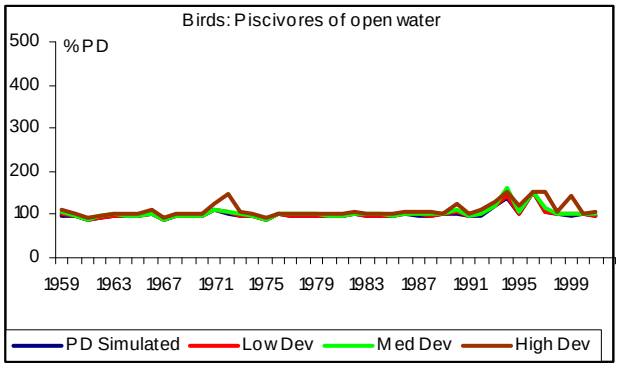
Site 3: Cuito River @ Cuito Cuanavale



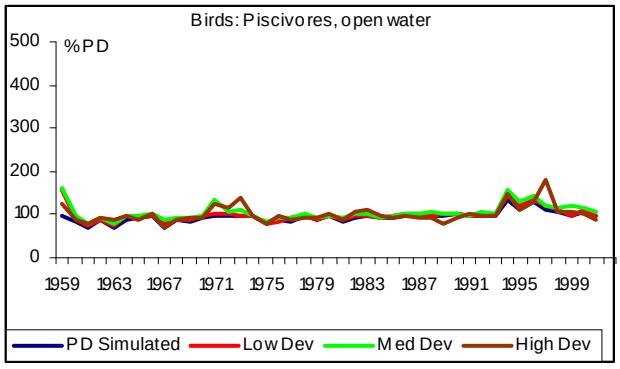
Site 4: Okavango River @ Rundu



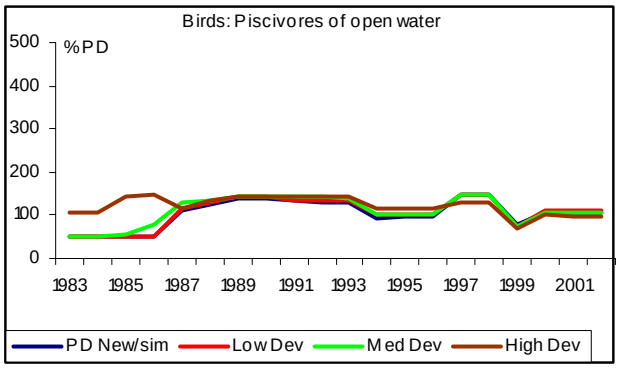
Site 5: Okavango River @ Popa Falls



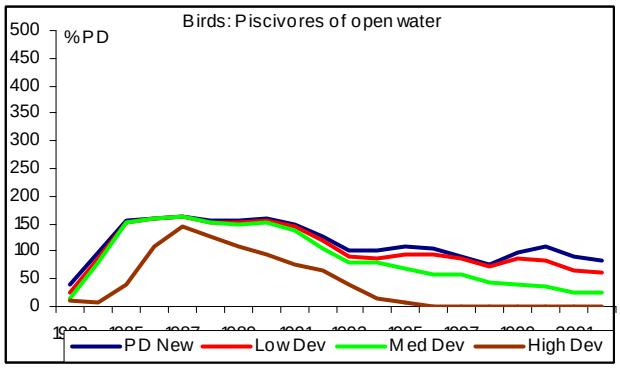
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

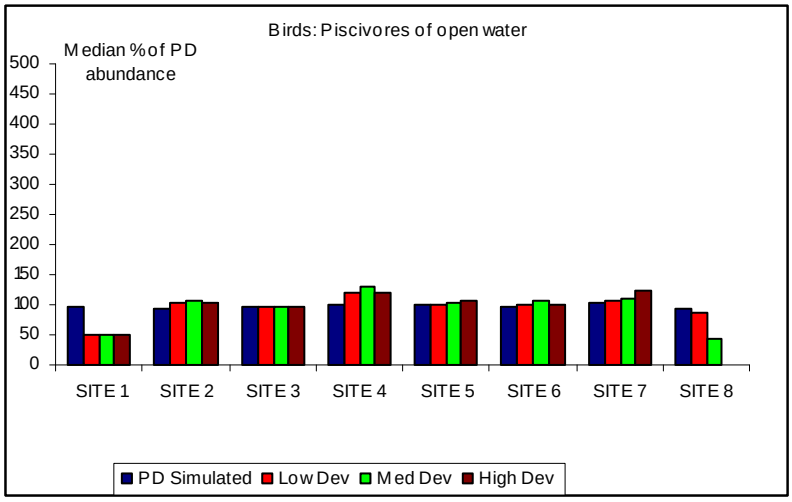


Site 8: Boteti River



Summary change per scenario

These birds generally thrive during low flow levels because their fish prey is more concentrated and vulnerable in the main river and/or isolated pools. However, at prolonged low flows or excessively low flows the prey base will be negatively affected if the floodplains where fish breed are not inundated.



Low Scenario

This situation generally will favour these birds as flows will be slightly reduced; exceptions will be at Site 1, where the lowflow flows are considerably reduced and so there will be very little hunting area available.

Moderate Scenario

This situation generally will favour these birds as flows will be slightly more reduced; an exception will be exceptions will be at Site 1, where the lowflow flows are considerably reduced and so there will be very little hunting area available and on the Boteti because if there is no water here, more areas of suitable habitat will be lost.

High Scenario

This situation will ultimately depress the food supply to very low levels, making conditions unfavourable for these birds. In the Boteti, habitat for these birds is virtually nil under the high scenario.

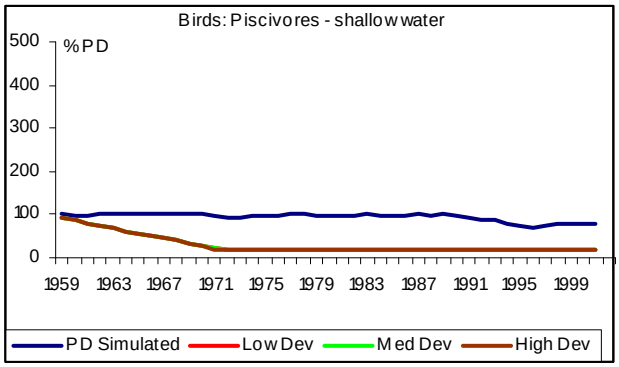
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

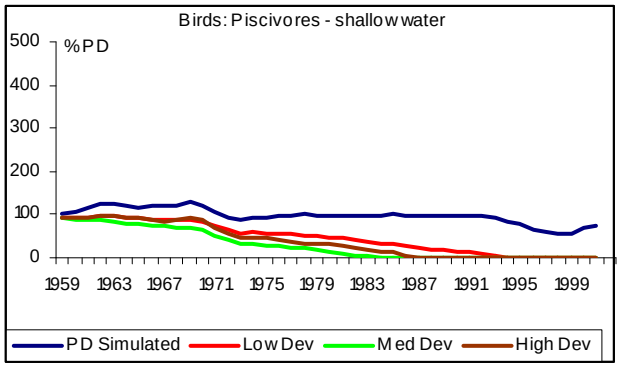
9.3. Piscivores, shallow water

(Hunt from overhanging trees on shallow backwaters by ambush techniques) - Larger herons/egrets

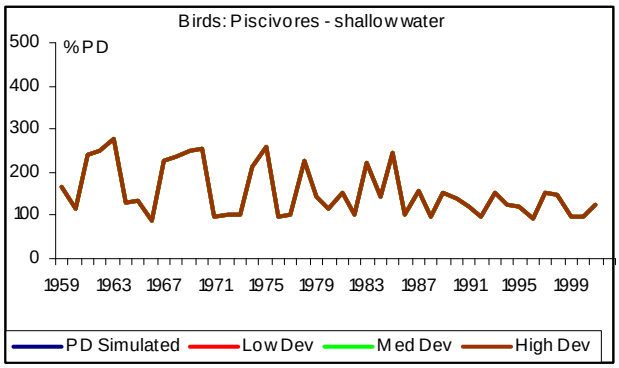
Site 1: Cubango River @ Capico



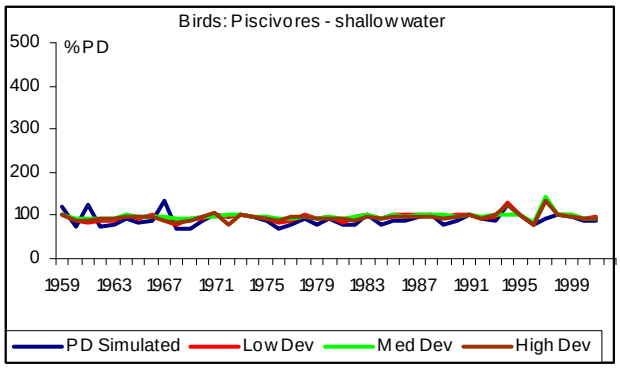
Site 2: Cubango River @ Mucundi



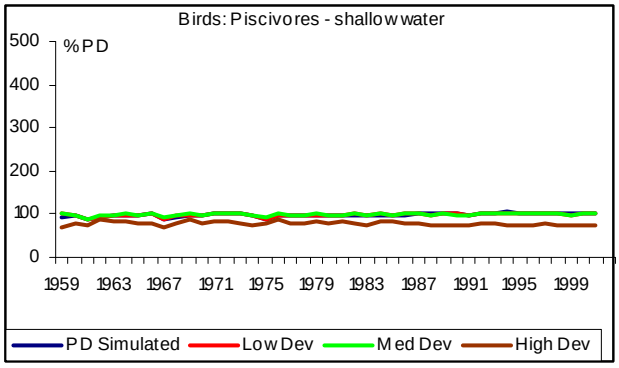
Site 3: Cuito River @ Cuito Cuanavale



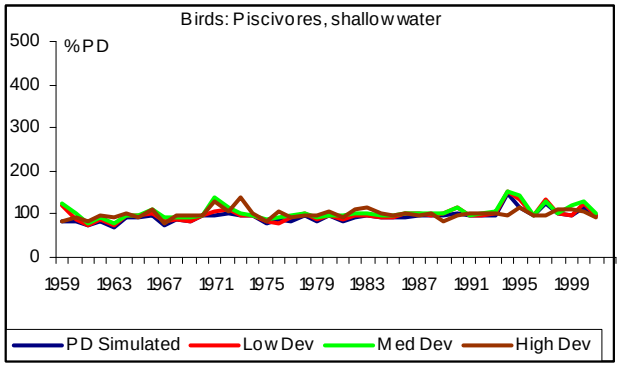
Site 4: Okavango River @ Rundu



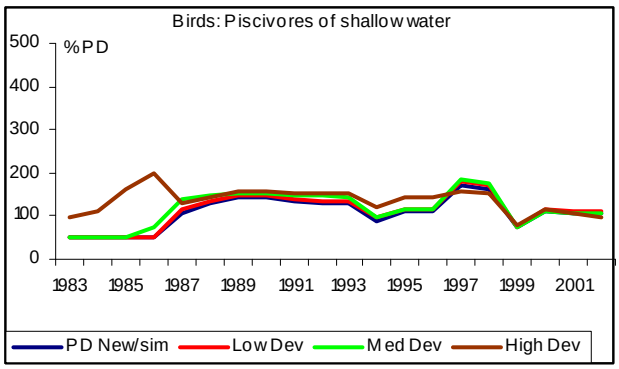
Site 5: Okavango River @ Popa Falls



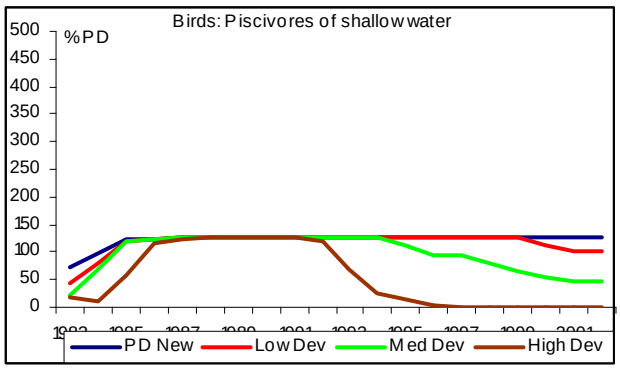
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

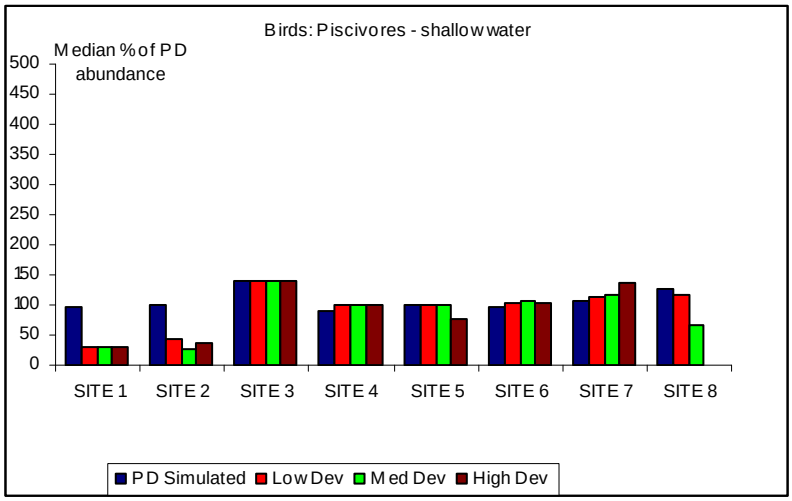


Site 8: Boteti River



Summary change per scenario

The shallower the water in the main channels and on the floodplains, the better for most of these species because prey would be confined into smaller concentrations and hunting opportunities would be improved.



Low Scenario

This situation would slightly favour these birds because of improved hunting opportunities, until such time as prey species are reduced by water levels too low to enable them to breed successfully.

Moderate Scenario

This situation would slightly favour these birds because of improved hunting opportunities, until such time as prey species are reduced by water levels too low to enable them to breed successfully.

High Scenario

This scenario will reduce prey species below sustainable levels, and although water levels would be favourable for these birds, lack of prey species would make this scenario intolerable, causing population declines, and the demise of some species.

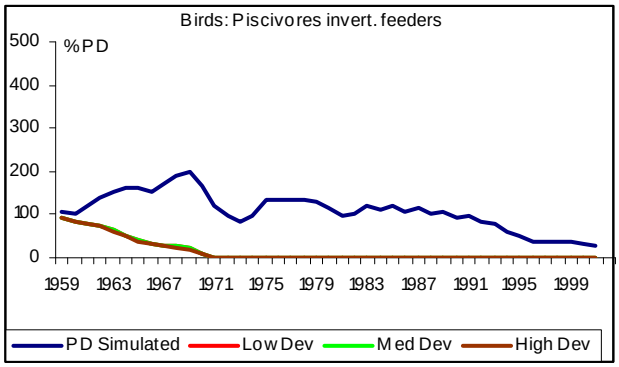
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

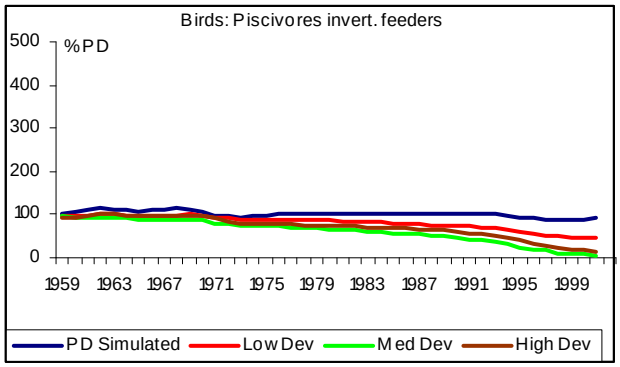
9.4. Piscivores

(Feed on fish-fry at receding water level times after spawning in flood-plains, or fish trapped in drying pools.) - Little Egret, Black Heron, Glossy Ibis, Saddle-billed Stork, Lapwings.

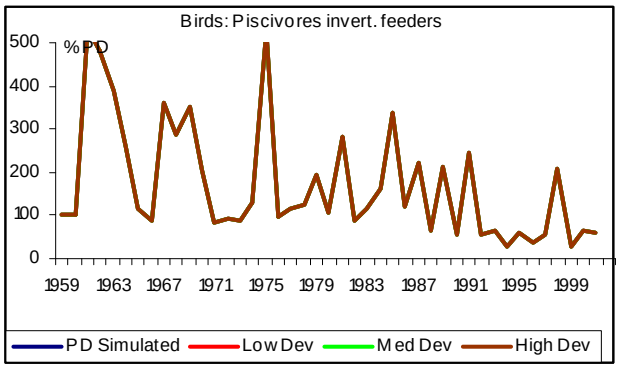
Site 1: Cubango River @ Capico



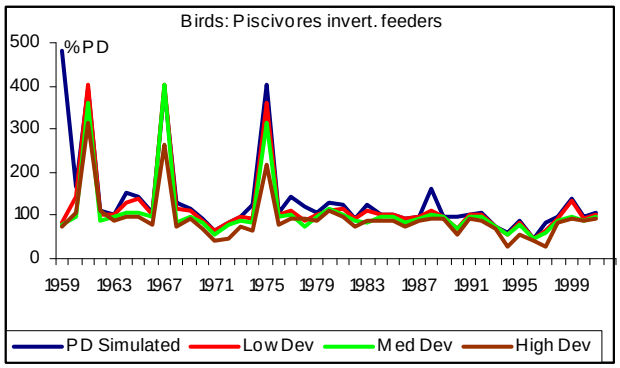
Site 2: Cubango River @ Mucundi



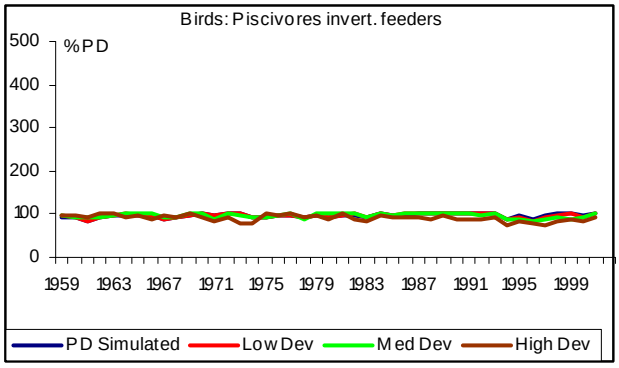
Site 3: Cuito River @ Cuito Cuanavale



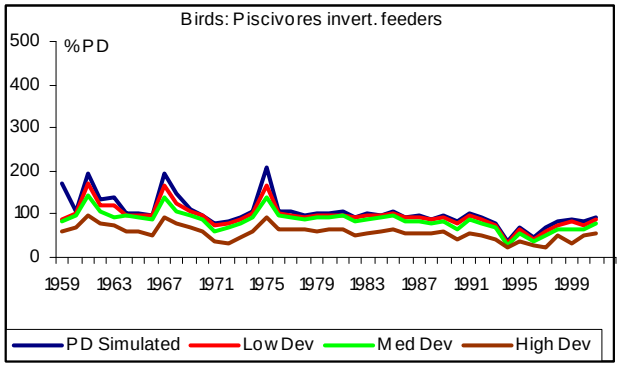
Site 4: Okavango River @ Rundu



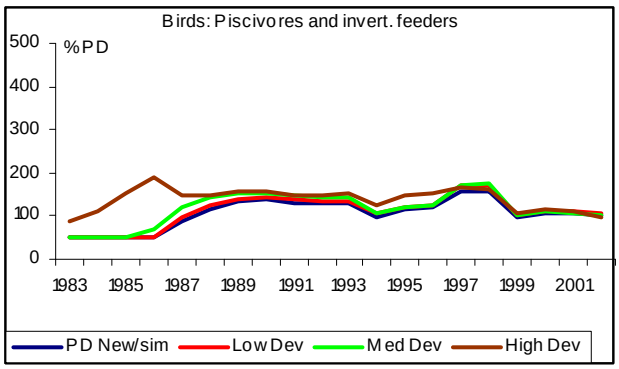
Site 5: Okavango River @ Popa Falls



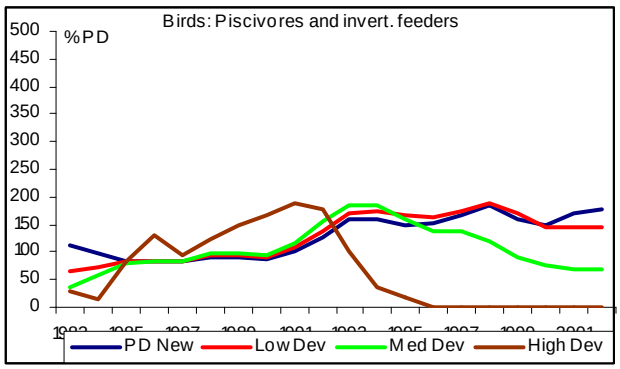
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

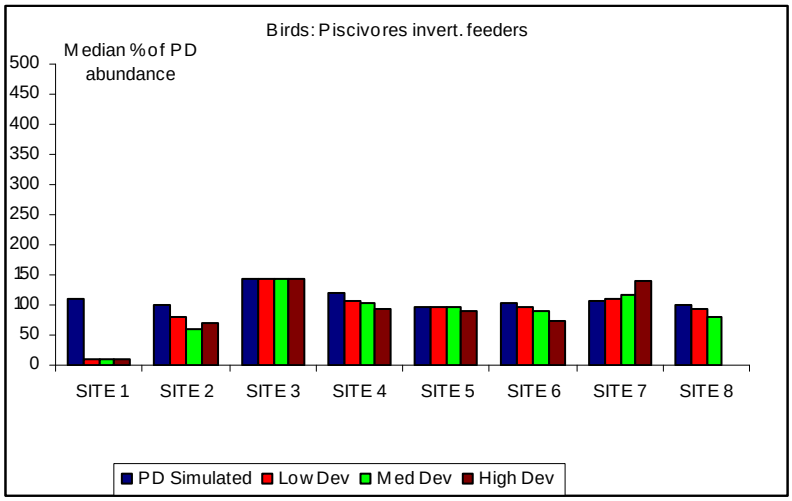


Site 8: Boteti River



Summary change per scenario

Timing and volume of flow are critical for these birds - when the river first overflows its banks onto the floodplains it causes optimal hunting and feeding conditions, and then again when receding waters cause isolated pools, trapping small fish and invertebrates.



Low Scenario

This scenario should not negatively affect the flooding and drying critical to these birds, but may impact negatively on prey species and other food items.

Moderate Scenario

This scenario is slightly advanced over the low scenario, and should not negatively affect the flooding and receding waters critical to these birds but prey and food item availability becomes more critical.

High Scenario

Large water offtakes upstream will affect the critical flooding regime that these birds depend on, and cause population declines and demise.

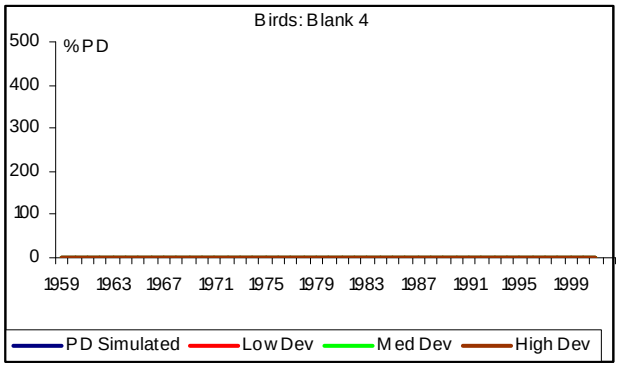
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

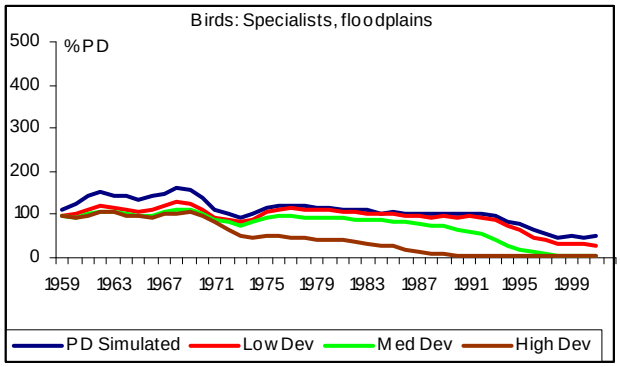
9.5. Specialists, floodplains

(Feed on molluscs, frogs, fish or selective vegetation and organisms occurring on shallow floodplains) - African Openbill, ducks, geese, Wattled Crane.

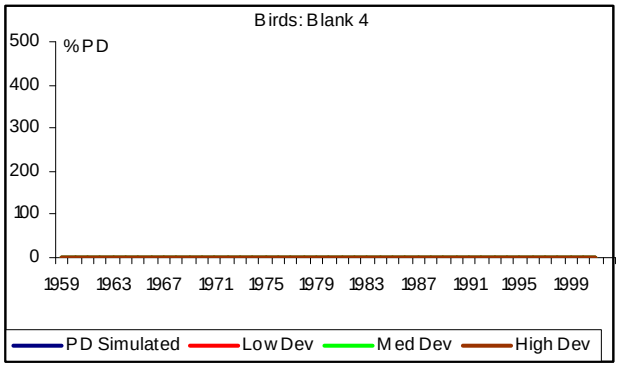
Site 1: Cubango River @ Capico



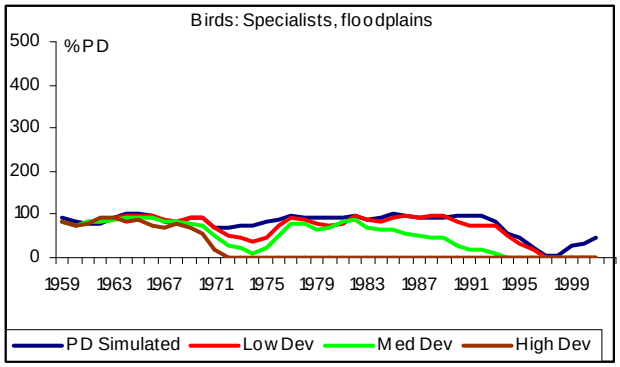
Site 2: Cubango River @ Mucundi



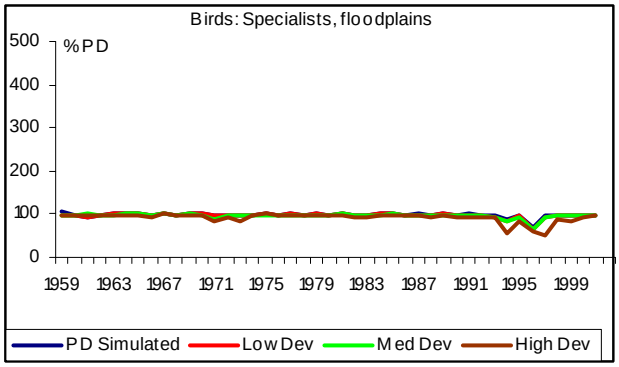
Site 3: Cuito River @ Cuito Cuanavale



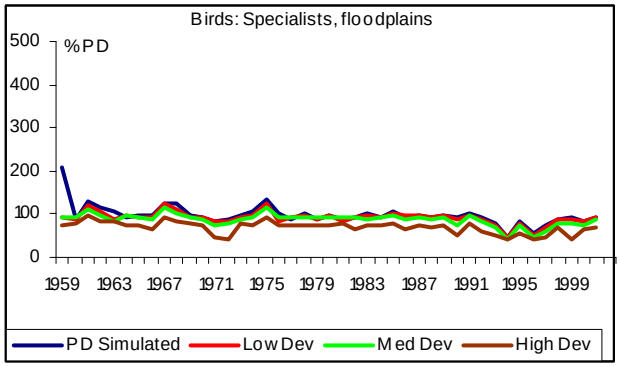
Site 4: Okavango River @ Rundu



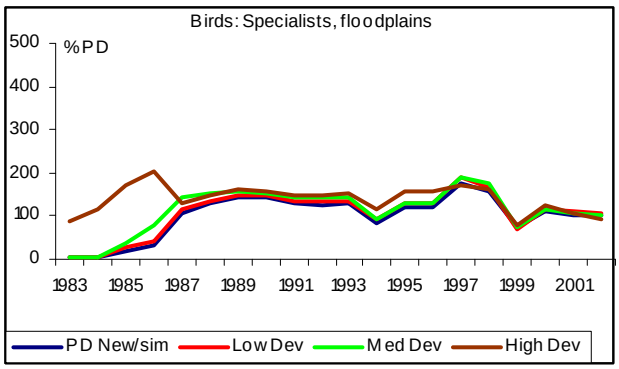
Site 5: Okavango River @ Popa Falls



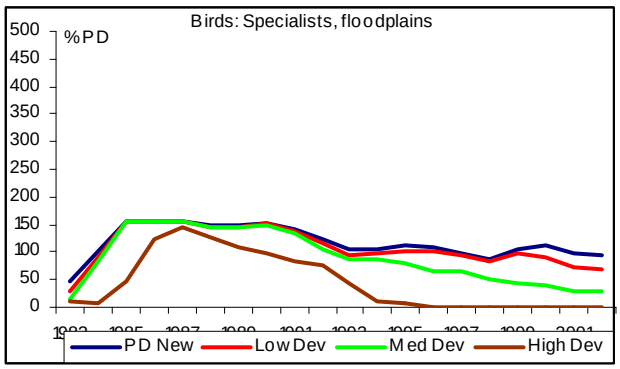
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

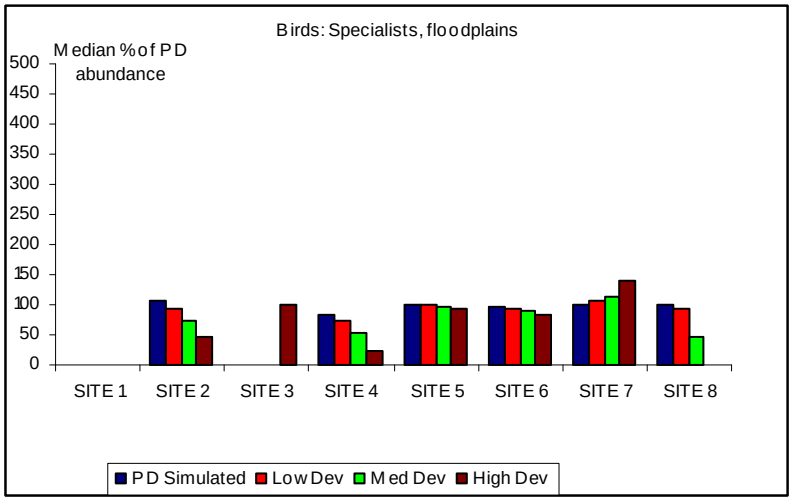


Site 8: Boteti River



Summary change per scenario

These birds utilise floodplain areas when they are newly flooded and food availability is at its optimal level due to new breeding and germination activities, and also when waters are receding and food items are confined and concentrated i.e. inundation and receding of waters is vitally important for this group of indicators.



Low Scenario

Very little significant changes will occur under this scenario.

Moderate Scenario

This scenario will start to influence food item (snails, molluscs, submerged or floating macrophytes) availability because flooding levels are being reduced to the extent that they will negatively affect food item development.

High Scenario

At this stage, there should be a complete unavailability of food items for these specialist feeders due to disrupted flood regimes causing a decline or demise of these species.

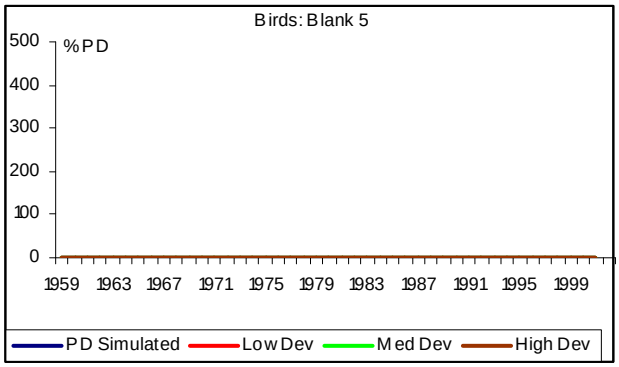
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

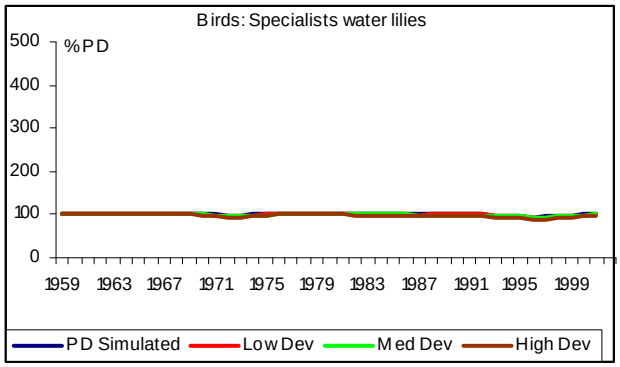
9.6. Specialists, water lilies

(Floodplain pools (rising and receding water levels) and lily-pad covered inlets. Essential for feeding habitat.) - African and Lesser Jacanas.

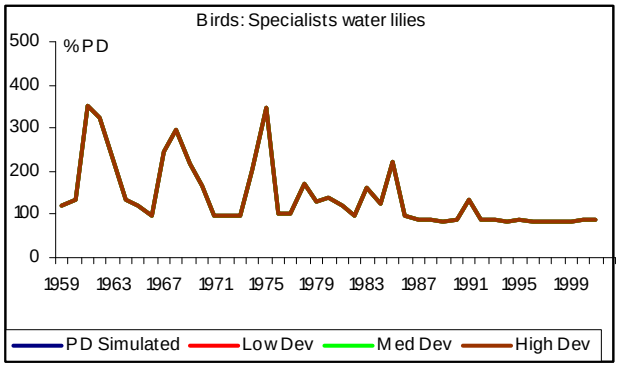
Site 1: Cubango River @ Capico



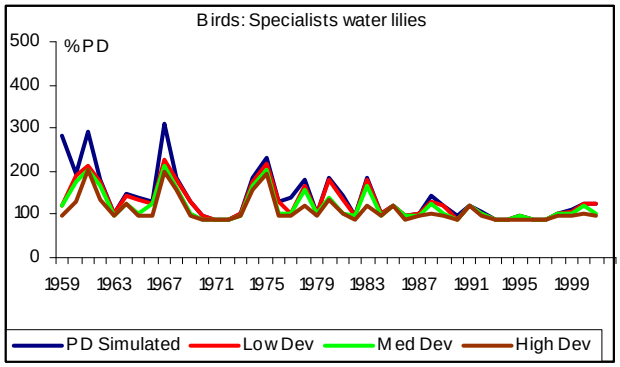
Site 2: Cubango River @ Mucundi



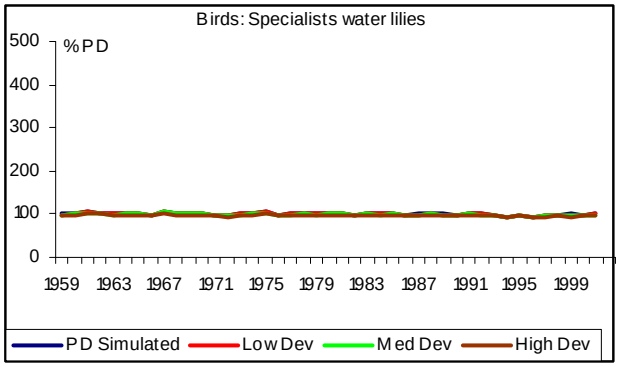
Site 3: Cuito River @ Cuito Cuanavale



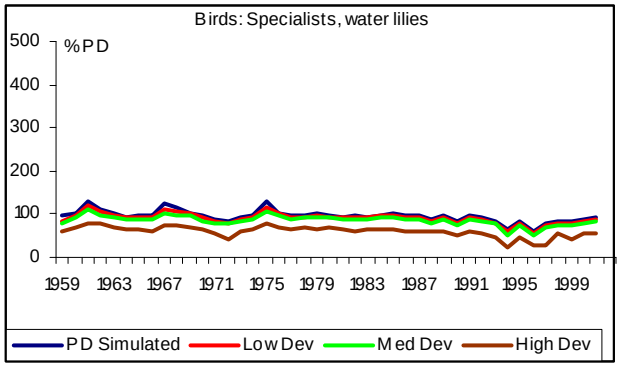
Site 4: Okavango River @ Rundu



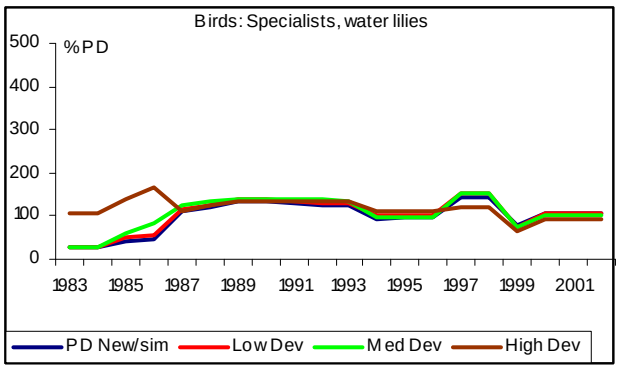
Site 5: Okavango River @ Popa Falls



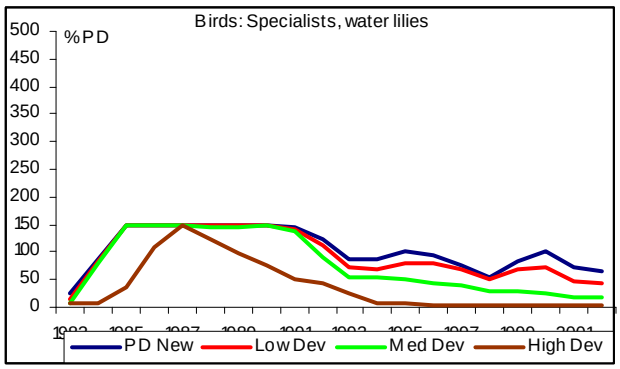
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

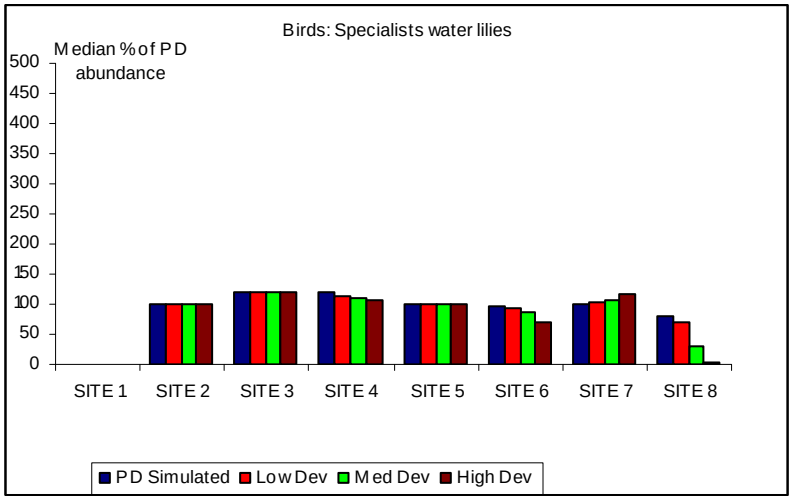


Site 8: Boteti River



Summary change per scenario

Whatever the flood regime, pockets of water lilies generally survive, either in backwaters, lagoons or isolated pools, provide suitable habitat for these birds.



Low Scenario

No significant change will occur under this scenario.

Moderate Scenario

No significant change will occur under this scenario.

High Scenario

We do not foresee that any significant changes will occur under this scenario, given the resilient nature of water lilies.

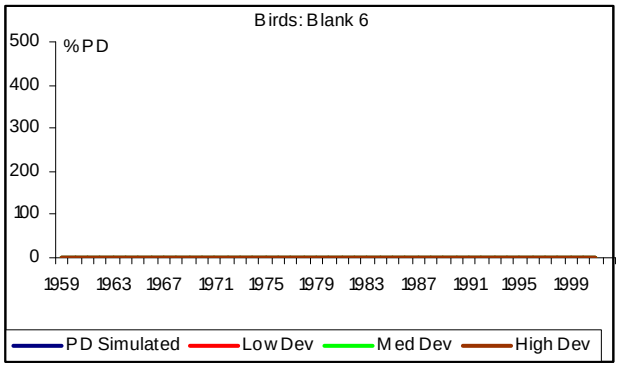
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

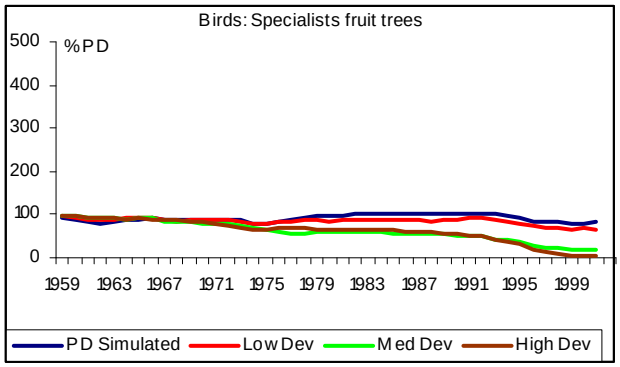
9.7. Specialists, fruit trees

(Specialist frugivores in riparian fruit trees. When riverine fruit trees are in fruit they are an important food source for a large variety of birds.) - Turacos, bulbuls.

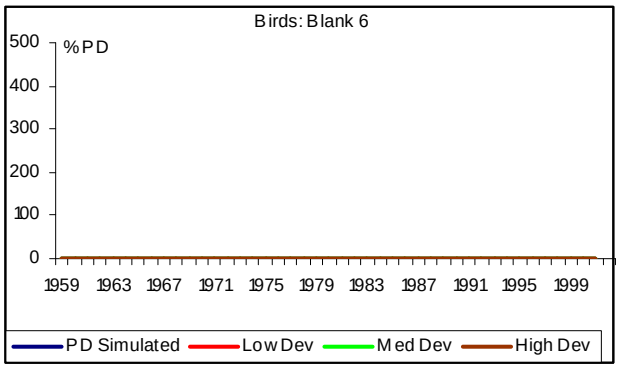
Site 1: Cubango River @ Capico



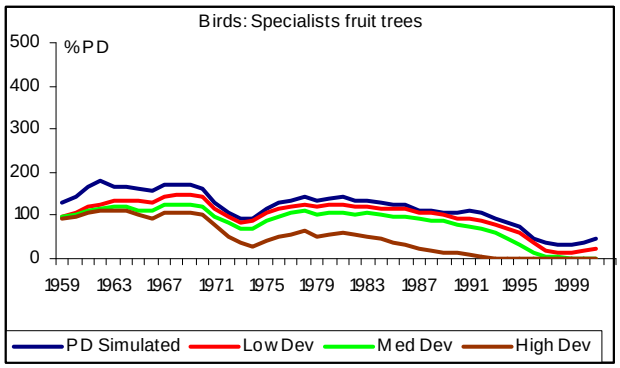
Site 2: Cubango River @ Mucundi



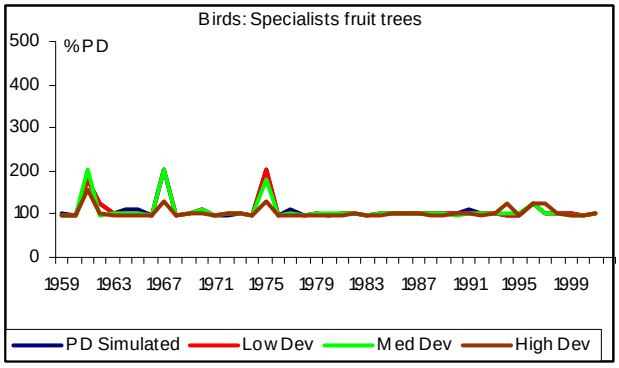
Site 3: Cuito River @ Cuito Cuanavale



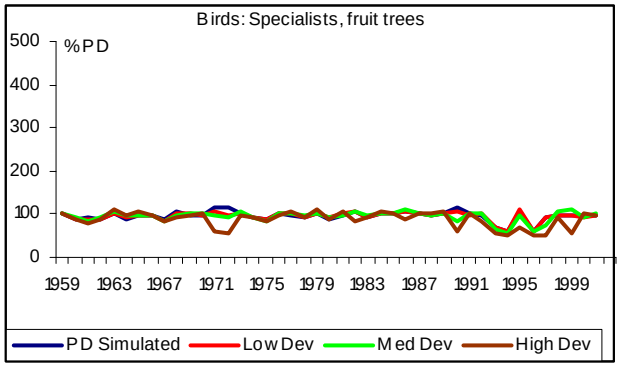
Site 4: Okavango River @ Rundu



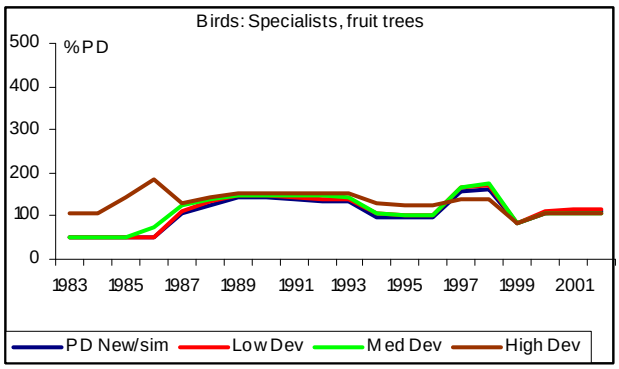
Site 5: Okavango River @ Popa Falls



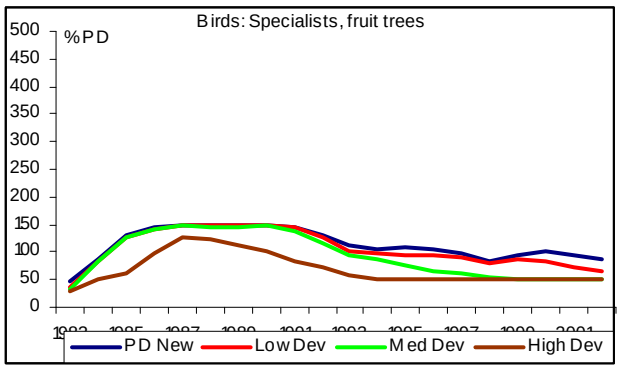
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

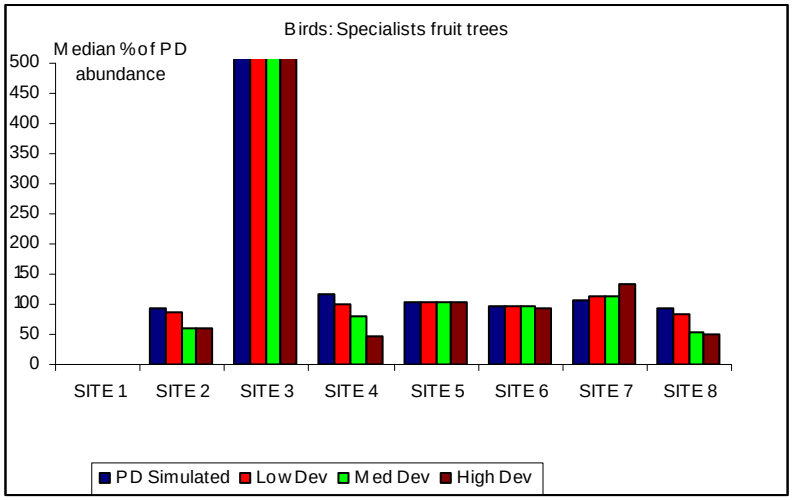


Site 8: Boteti River



Summary change per scenario

These birds will only be indirectly influenced by changes in water flows i.e. they depend on fruit bearing riparian trees that respond to changes in water flows. Because most of these tress are long-lived, there will be a time lag of several years before fruit production will fail when trees start dying from lack of water. The response from the birds should mirror to some extent that for the plants (riparian trees) since if the riparian trees die due to low flows, there will not be a source of food for the birds.



Low Scenario

Given the long lag period and the perennial nature of the fruit trees, this scenario should not significantly affect this indicator.

Moderate Scenario

This scenario may start negatively affecting fruit productivity of fruit-bearing trees, and therefore start influencing these indicator species which may be forced to leave for more suitable habitat.

High Scenario

At this stage, most of the riparian trees, particularly in the lower reaches of the delta, would have died and these indicator species would have left the area.

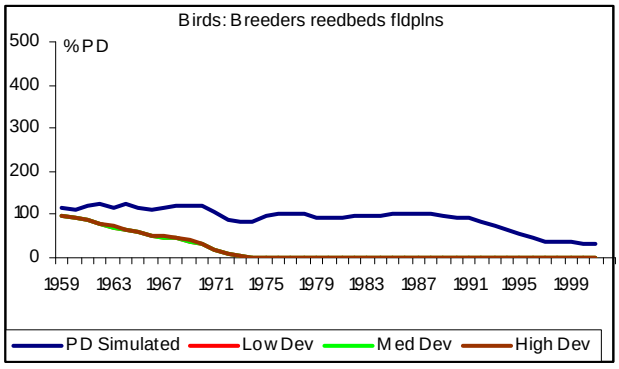
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

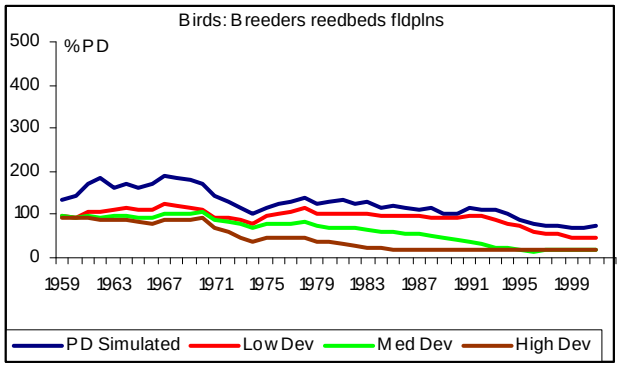
9.8. Breeders, reedbeds and fldplns

(Nesting habitat in reedbeds lining river banks, islands and on floodplains.) - Fan-tailed Widowbird, weavers, bishops, herons and egrets.

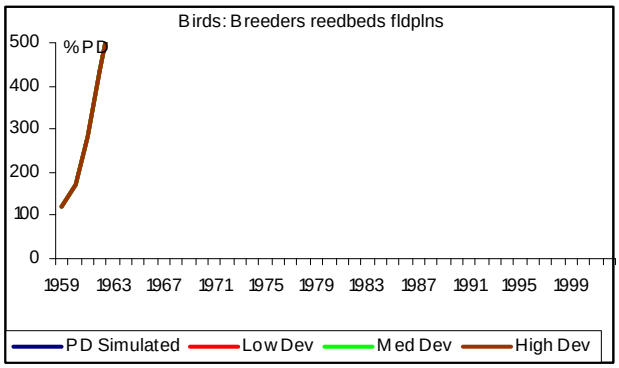
Site 1: Cubango River @ Capico



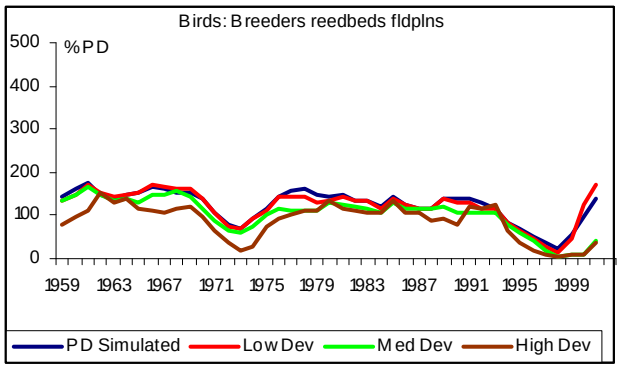
Site 2: Cubango River @ Mucundi



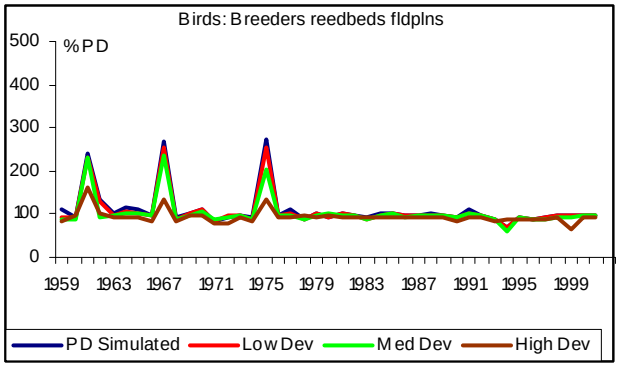
Site 3: Cuito River @ Cuito Cuanavale



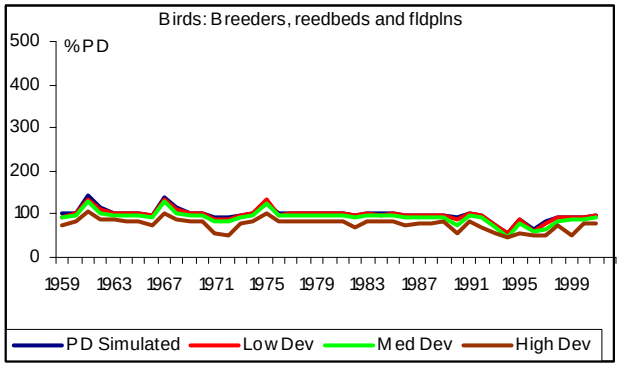
Site 4: Okavango River @ Rundu



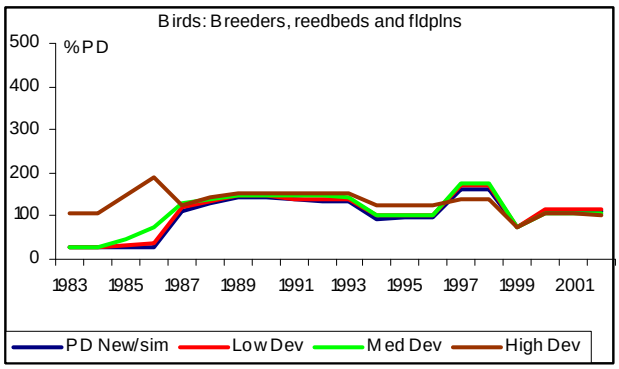
Site 5: Okavango River @ Popa Falls



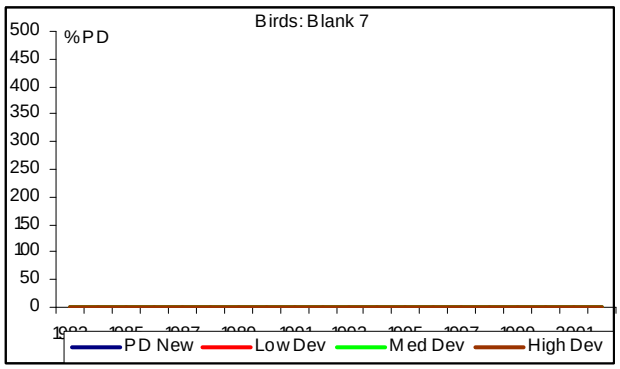
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

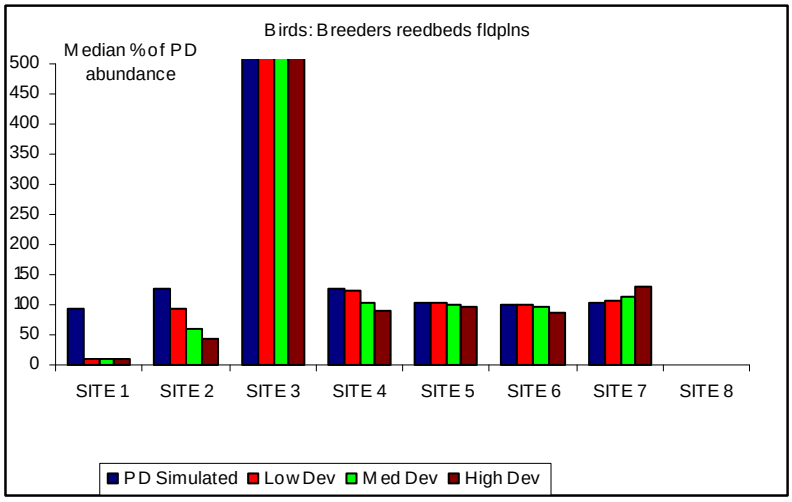


Site 8: Boteti River



Summary change per scenario

These birds must have reedbeds and other vegetation standing in water, in which to build nests as a protective mechanism against predator access to their nests. Therefore, these birds generally wait for high water levels to reach their peak before constructing nests so that the nests are not flooded by rising waters.



Low Scenario

This should not affect the breeding cycle of these birds too drastically.

Moderate Scenario

During this scenario, there should be interference in the water flow, resulting in fluctuating and unreliable high water level, that would disrupt breeding success rate due to nest flooding.

High Scenario

Under this scenario, most of the indicator species will be drastically affected because suitable nesting habitats will be radically reduced due to insufficient water flow and erratically changing water levels during their breeding period.

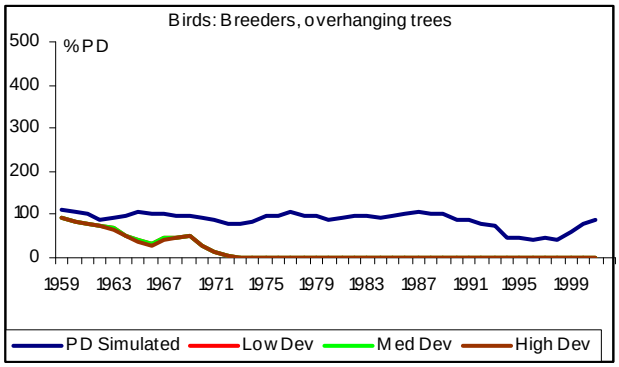
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

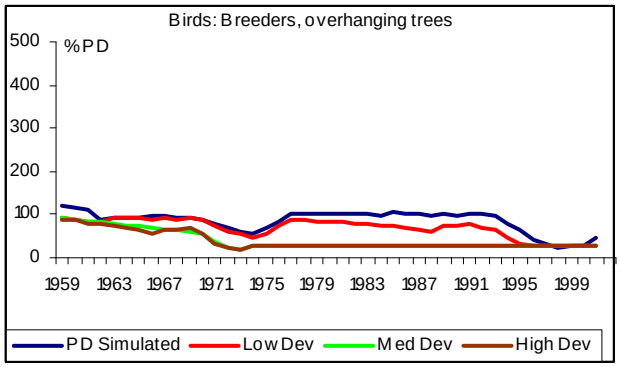
9.9. Breeders, overhanging trees

(Colonial breeders or solitary nesters requiring over-hanging vegetation for nest safety or fledglings vacating the nest) - Herons, cormorants, darters.

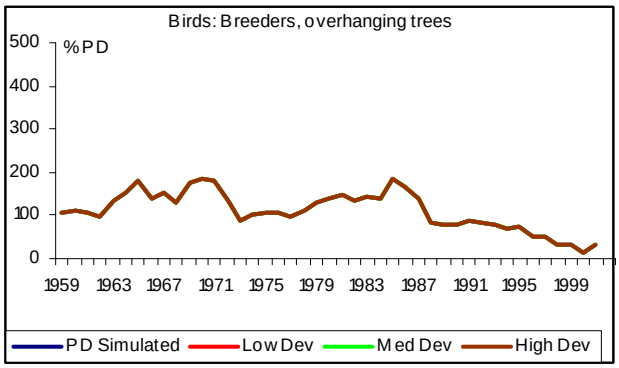
Site 1: Cubango River @ Capico



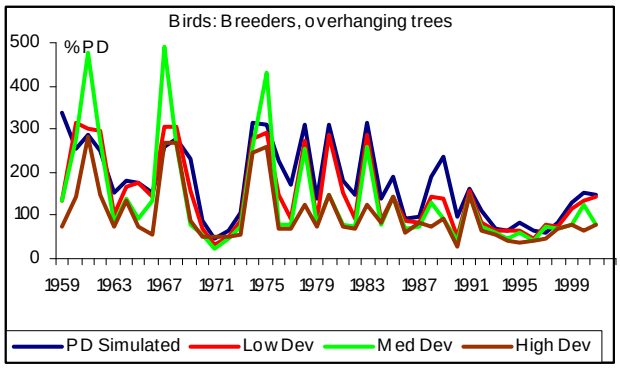
Site 2: Cubango River @ Mucundi



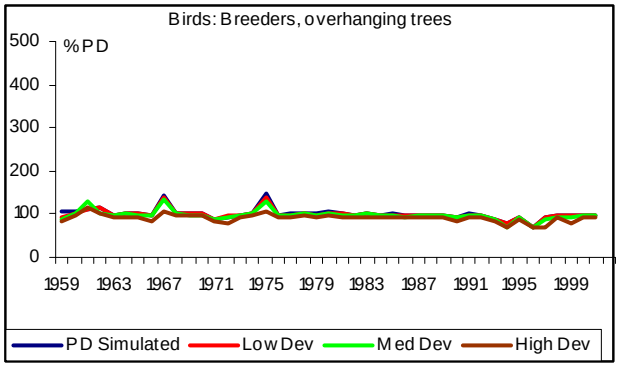
Site 3: Cuito River @ Cuito Cuanavale



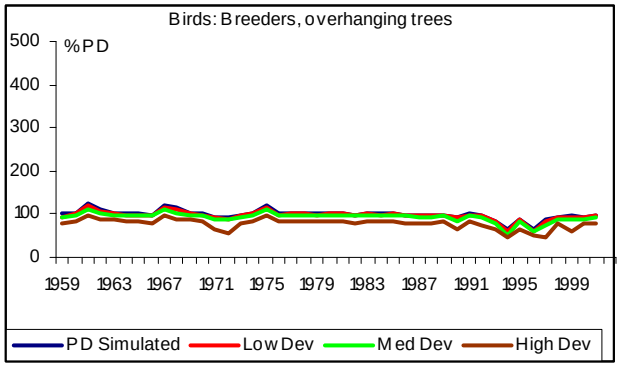
Site 4: Okavango River @ Rundu



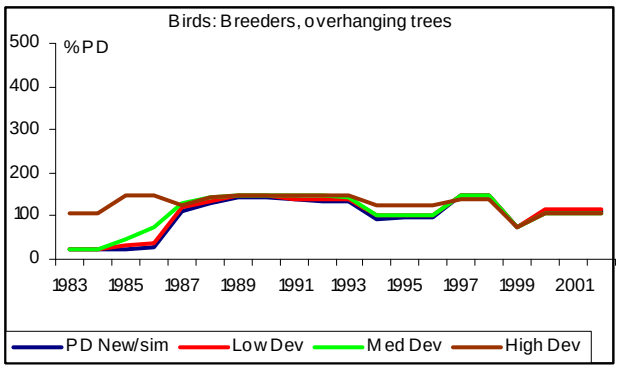
Site 5: Okavango River @ Popa Falls



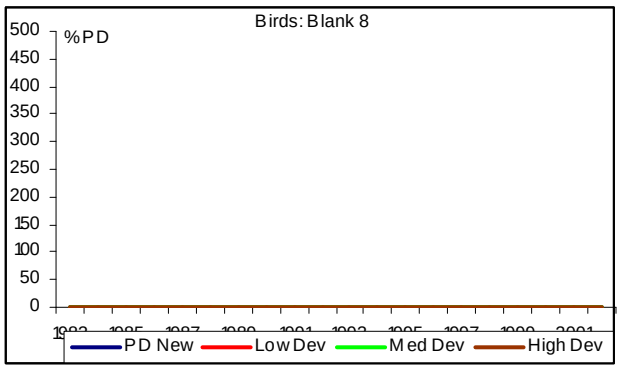
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

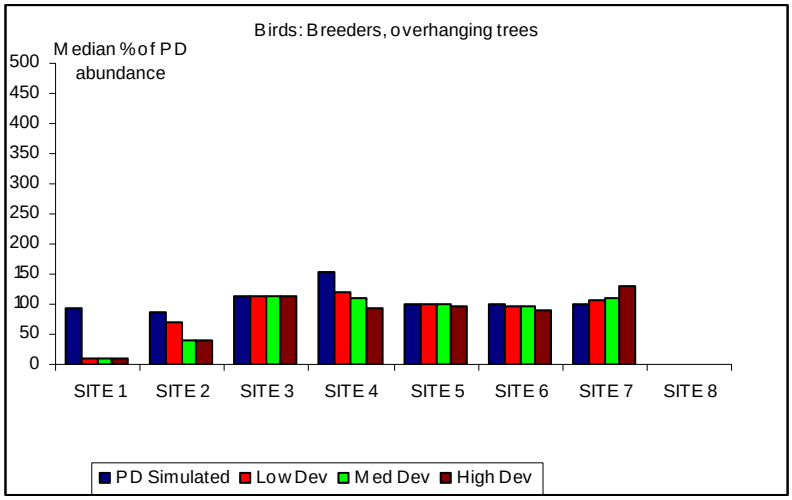


Site 8: Boteti River



Summary change per scenario

Trees overhanging water are critical to the breeding success of these birds for two reasons: protection against predators, and for refuge by chicks when disturbed.



Low Scenario

A lesser flow may not influence the breeding activities of these birds too drastically, because there should still be overhanging trees suitable for breeding, although at this point they should be less available.

Moderate Scenario

A moderate flow reduction may not influence the breeding activities of these birds too much, because there should still be overhanging trees suitable for breeding although at this point they should be less available.

High Scenario

Overhanging trees are will become less suitable or availabledue to interrupted and lessening water flow, and may cause population declines.

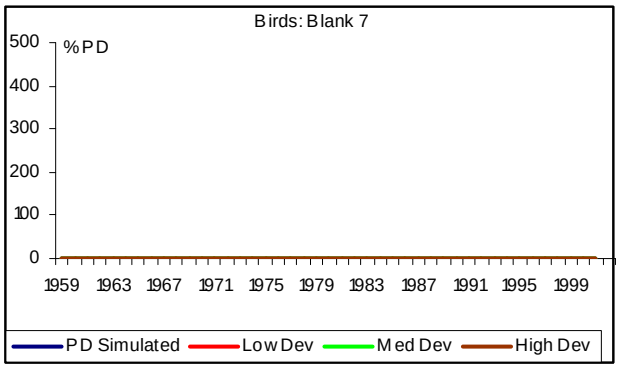
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

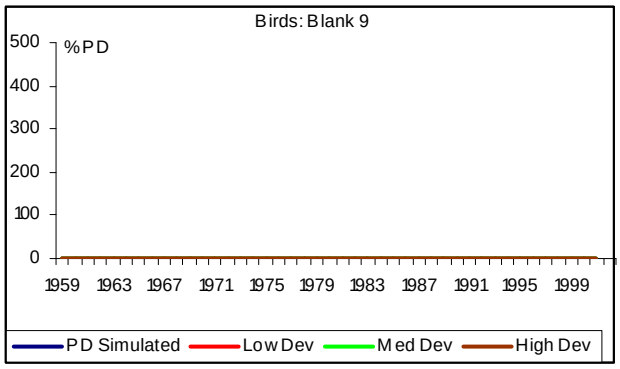
9.10. Breeders, banks

(Require vertical banks for nest holes or the grassy banks for nest sites and fledgling development (Note that kingfishers have been excluded)) - Bee-eaters, Collared Pratincoles, lapwings.

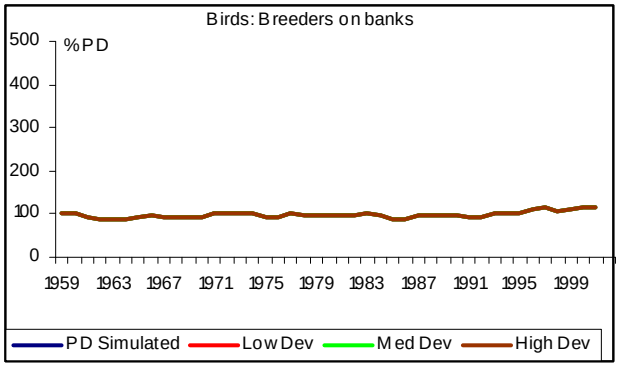
Site 1: Cubango River @ Capico



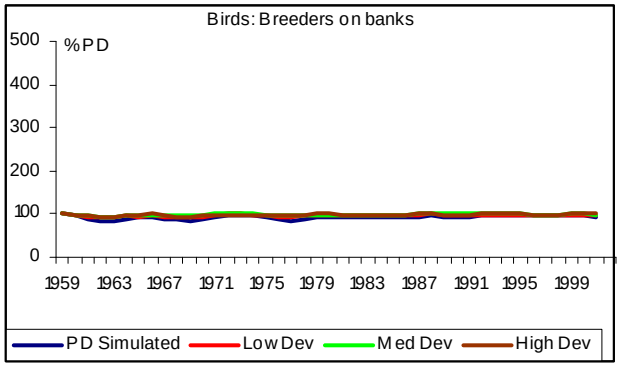
Site 2: Cubango River @ Mucundi



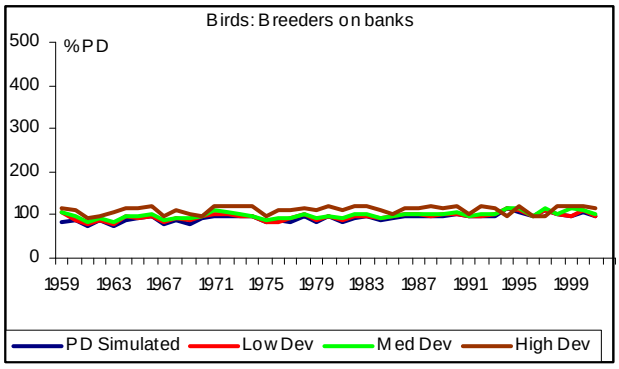
Site 3: Cuito River @ Cuito Cuanavale



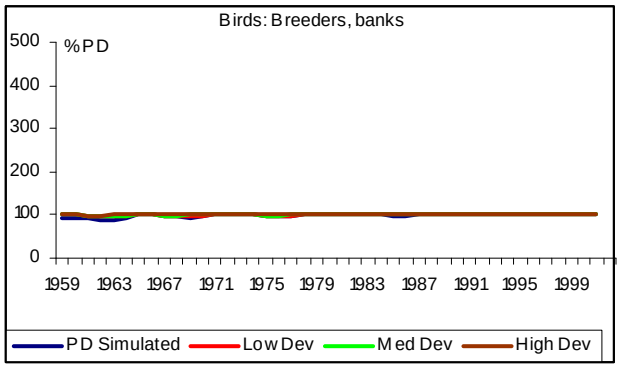
Site 4: Okavango River @ Rundu



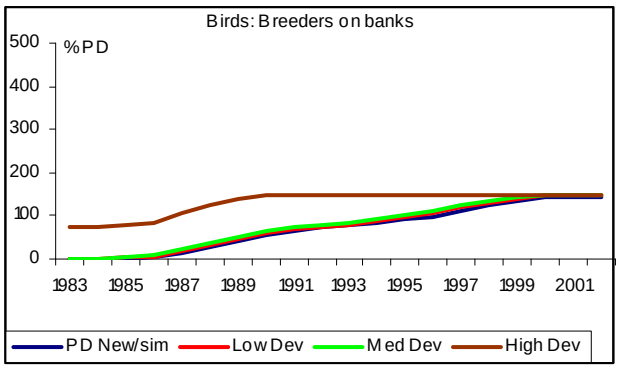
Site 5: Okavango River @ Popa Falls



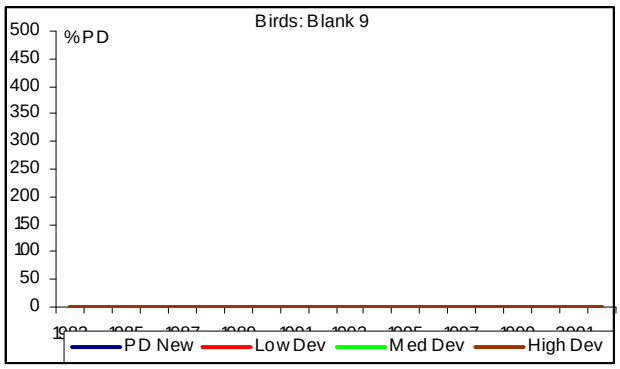
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

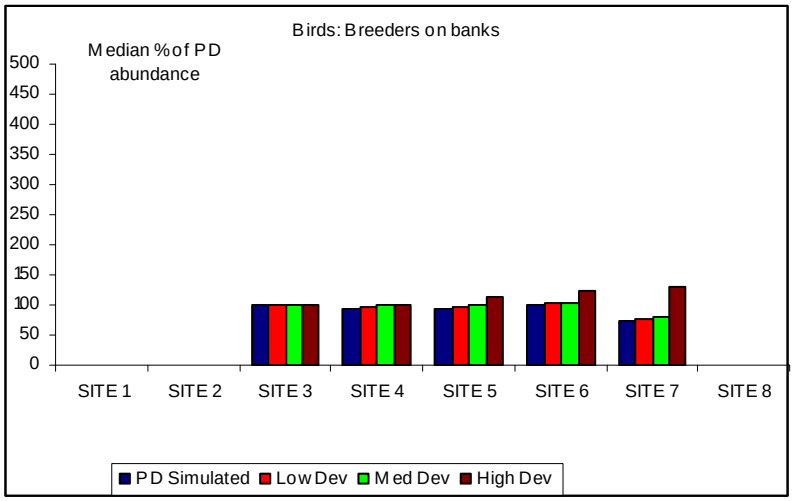


Site 8: Boteti River



Summary change per scenario

These birds are influenced only by the timing of flood recession, which exposes vertical or grassy banks for breeding purposes - they are not necessarily dependent on the river flow for their food supply.



Low Scenario

The low scenario should have no noticeable effect on this indicator group.

Moderate Scenario

If a large amount of water were to be released into the system from a dam, this could unseasonably flood breeding sites for these birds, which would obviously affect them negatively, particularly those using vertical banks.

High Scenario

If a large amount of water were to be released into the system from a dam, this could unseasonably flood breeding sites for these birds, which would obviously affect them negatively, particularly those using vertical banks. Grassy banks on the other hand, will become unsuitable for breeding purposes if floodplain regimes are altered.

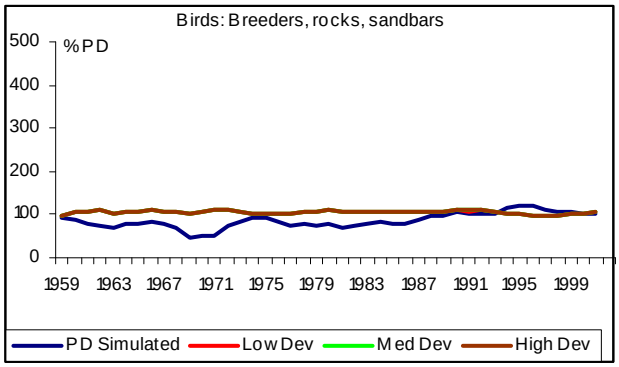
References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

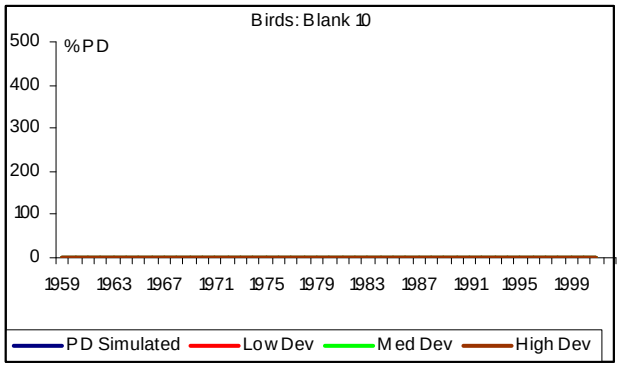
9.11. Breeders, rocks, sandbars

(Totally dependent on emerged rocks, sandbars and islands in the main river for nesting purposes) - Rock Pratincole, African Skimmer, sandpipers, thick-knees.

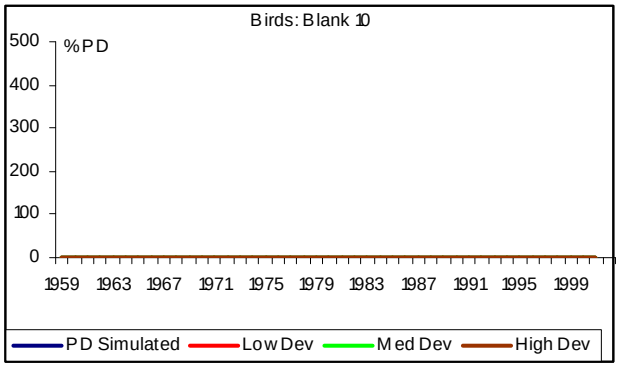
Site 1: Cubango River @ Capico



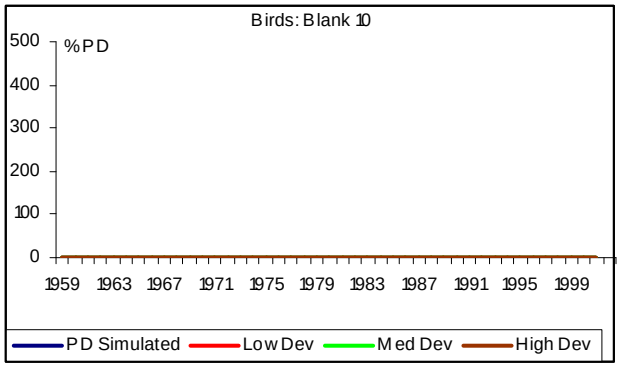
Site 2: Cubango River @ Mucundi



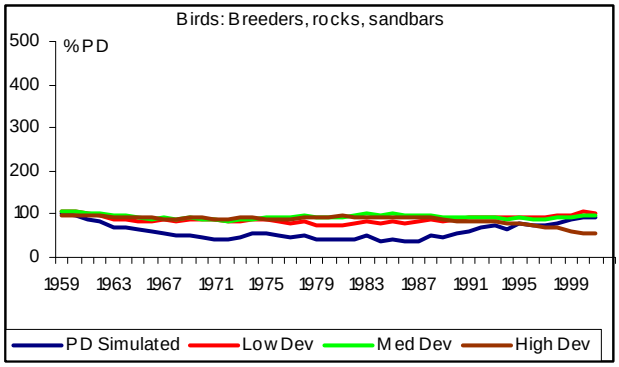
Site 3: Cuito River @ Cuito Cuanavale



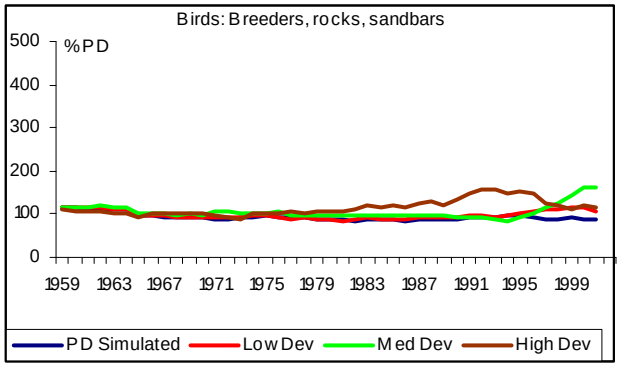
Site 4: Okavango River @ Rundu



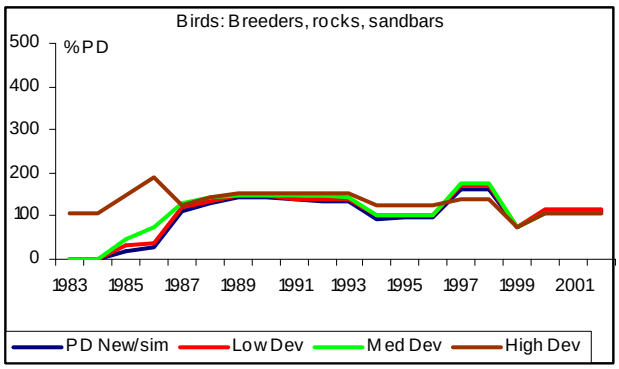
Site 5: Okavango River @ Popa Falls



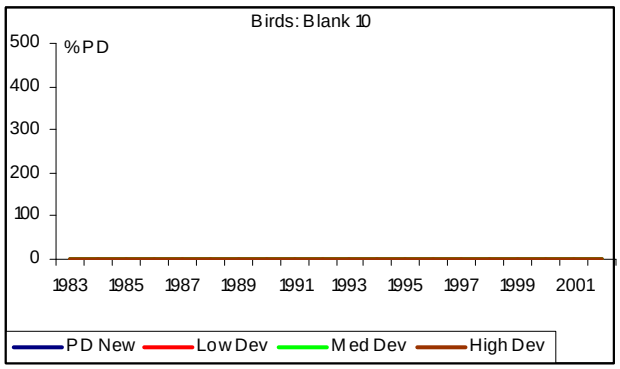
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

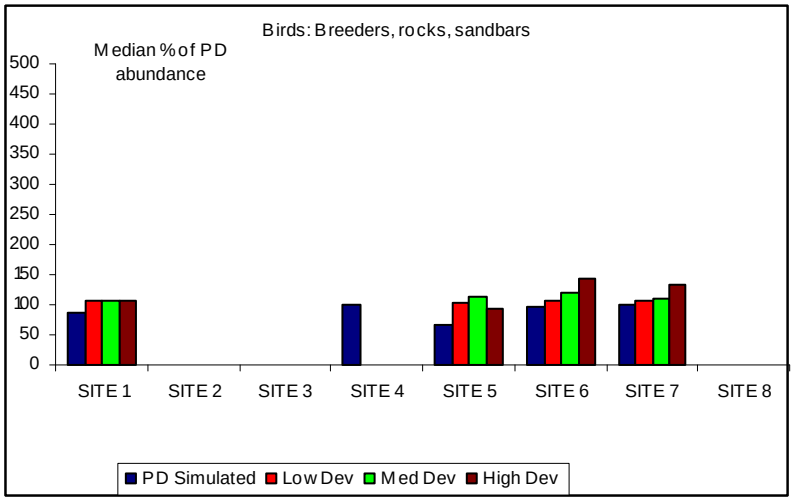


Site 8: Boteti River



Summary change per scenario

Low flow levels generally benefit these birds as this is the time when sandbanks and rocks are exposed for breeding. However, very low flows will result in sandbanks becoming accessible to predators and also negatively affect the food supply of those that eat fish that breed on floodplains.



Low Scenario

These birds should do well under slightly reduced flows, as long as the sandbars remain isolated and inaccessible to predators.

Moderate Scenario

Probably very similar to low scenario, but getting progressively worse for these birds.

High Scenario

Interrupted and lessening water flow will eliminate suitable breeding sites and negatively impact on breeding success by either flooding of nest sites in unseasonal high water situations, or joining sandbars to the mainland during extreme unseasonal low water situations, with increased predator accessibility. Food availability could also be negatively influenced by low water levels for some species.

References

Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10. Socio-economic indicators

This section provides the time-series for the basic catch, harvest, production, socio-economic indicators under the flow regime resulting from each scenario. It also shows the estimated median impact from present day, first by percentage change of a measure of production, then by a change in livelihoods in local currencies, and then by a change in contribution to national income. The indicators presented here are:

- Household income - fish
- Household income - reeds
- Household income - floodplain grass
- Household income - floodplain gardens (molapo farming)
- Household income and wealth - livestock
- Household income - tourism
- Potable water/water quality
- Indirect use
- Non-use

Livelihood and economic contribution values are in local currencies, where in 2008, US$1.00 = 75.20 Angolan Kwanza (Kz) = 8.16 Namibia Dollars (N$) = 7.16 Botswana Pula (P).

10.1. Photographs

10.1.1 Household income - fish

10.1.2 Household income - reeds

10.1.3 Household income - floodplain grass

10.1.4 Household income - floodplain gardens (molapo farming)

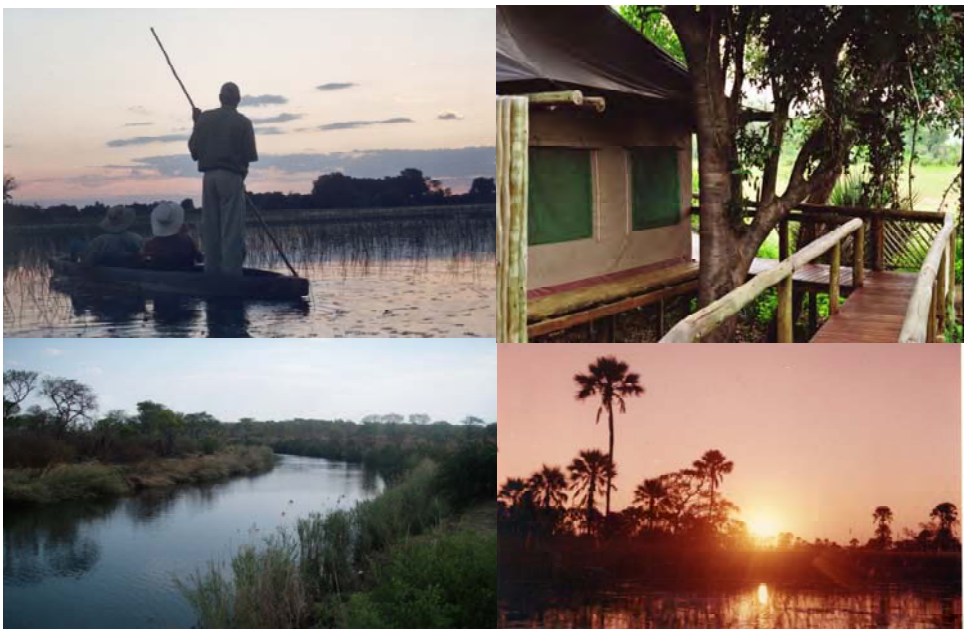
Floodplain crops

10.1.5 Household income and wealth - livestock

Floodplain grazing

10.1.6 Household income - tourism

Tourism



10.1.7 Wellbeing/welfare from intangibles

Overall wellbeing

10.1.8 Indirect use

Indirect use values

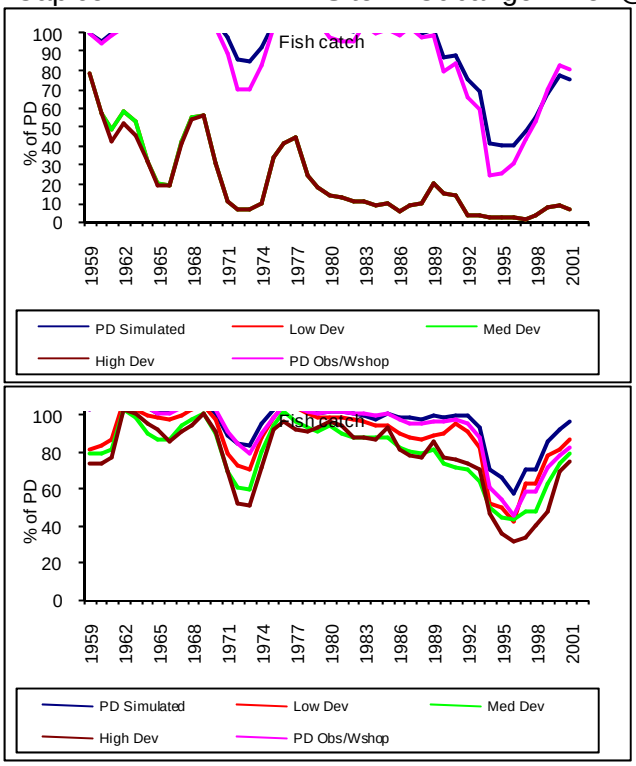
10.1.9 Non-use

Non-use values

10.2. Household income - fish

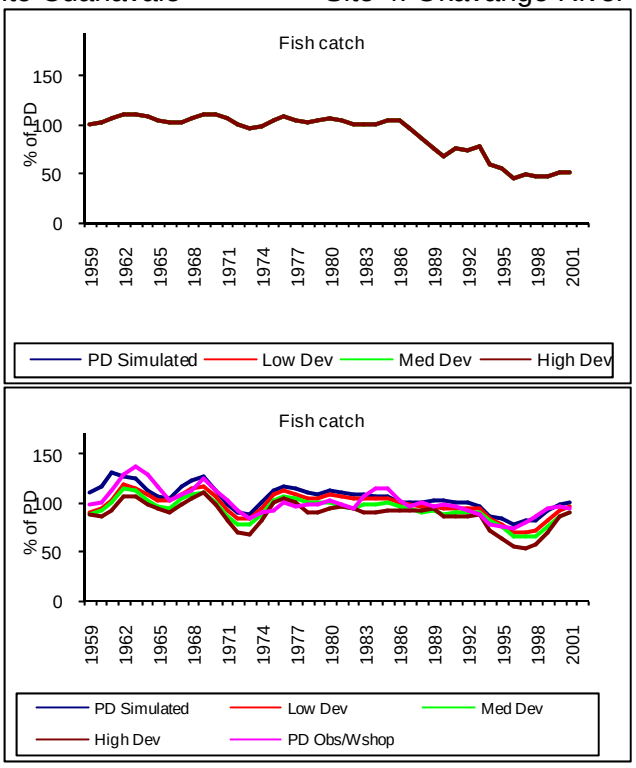
Site 1: Cubango River @ Capico

Site 2: Cubango River @ Mucundi



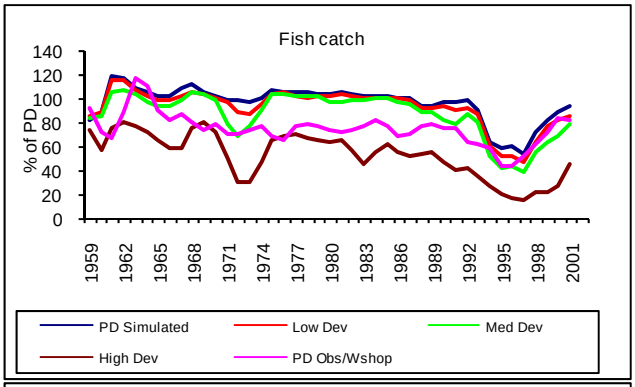
Site 3: Cuito River @ Cuito Cuanavale

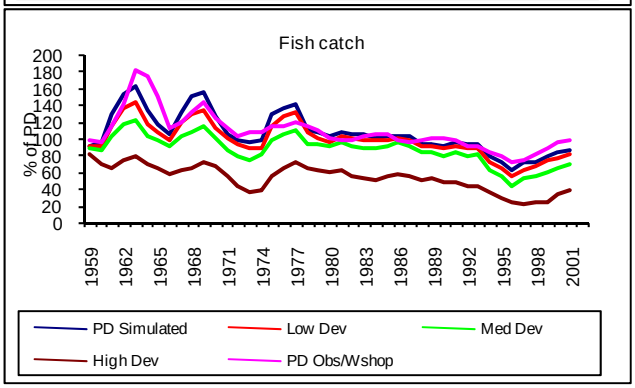
Site 4: Okavango River @ Rundu



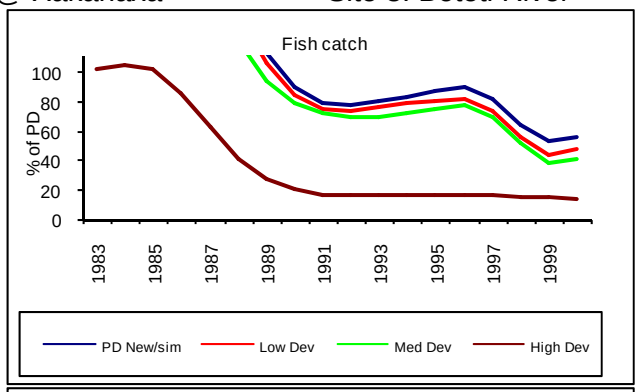
Site 5: Okavango River @ Popa Falls

Site 6: Okavango River @ Pan Handle

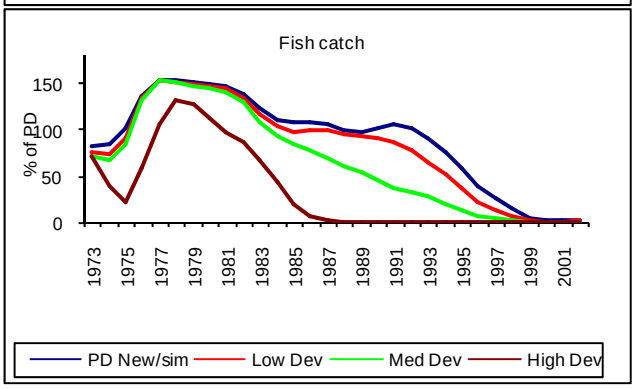




Site 7: Okavango River @ Xakanaxa

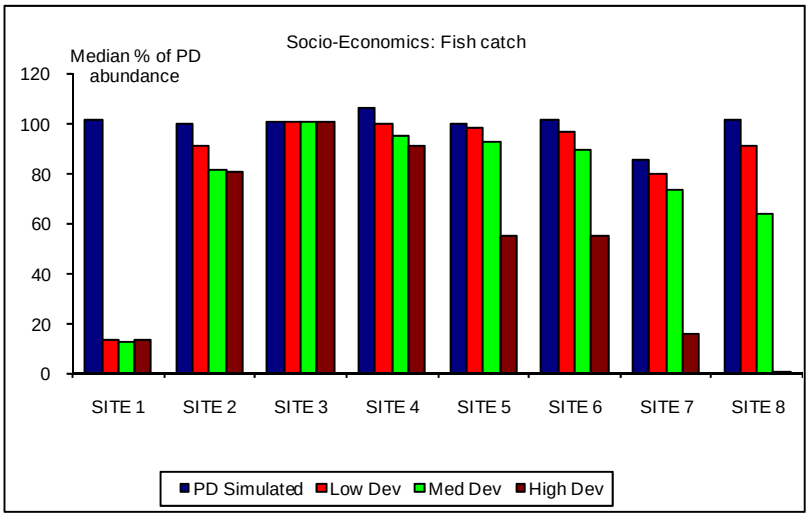


Site 8: Boteti River



Fish catch - summary change per scenario

The catch tends to peak during floods in areas with floodplains. In areas without floodplains catches are more stable. At prolonged low flows or excessively low flows fish abundance will be negatively affected if the floodplains where fish breed are not inundated. Generally the scenarios will progressively reduce catch. In the lower basin the high scenario will severely reduce fish catch.



Low Scenario
This situation generally will reduce catch from PD levels as there is essentially a reduction in overall fish populations; the biggest drop will be in the channel fishery in site 1, where low flow water levels are considerably reduced.

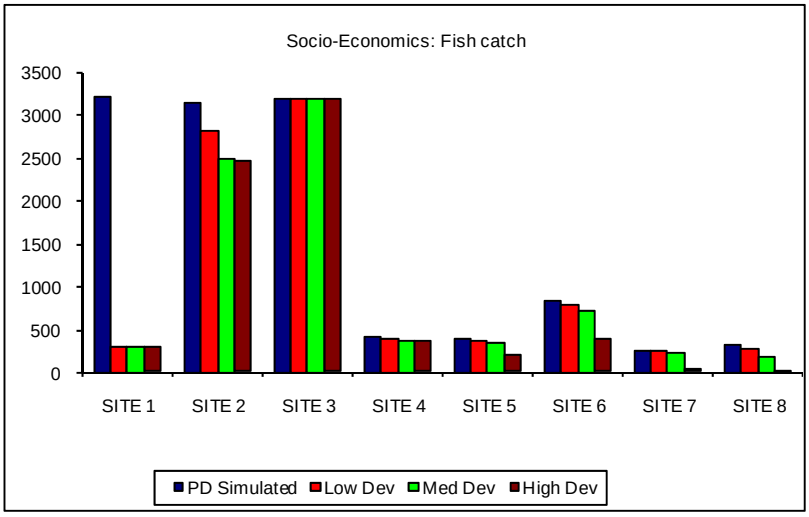
Moderate Scenario
This situation generally will reduce the fish catch further as flows will be slightly more reduced; the biggest drop will be in the channel fishery in site 1, where low flow water levels are considerably reduced.

High Scenario
This situation will generally reduce fish catches further which as a result of reduced flow generally which will ultimately depress fish stocks; this will be very marked in the lower parts of the basin from sites 5 to site 7, where floodplain flooding will be significantly reduced. At site 8 the fishery will be effectively eliminated.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Fish livelihoods - summary change per scenario

The net incomes for fishers or livelihoods tend along with catches to peak during floods in areas with floodplains. In the areas without net incomes are more stable. The relatively simple small scale enterprise is not particularly sensitive to catch reduction and so the patter is similar to that for catch.



Low Scenario
This situation generally will reduce net fishing incomes or fish livelihoods from PD levels as there is essentially a reduction in overall fish populations; the biggest drop will be in the channel fishery in site 1, where low flow water levels are considerably reduced.

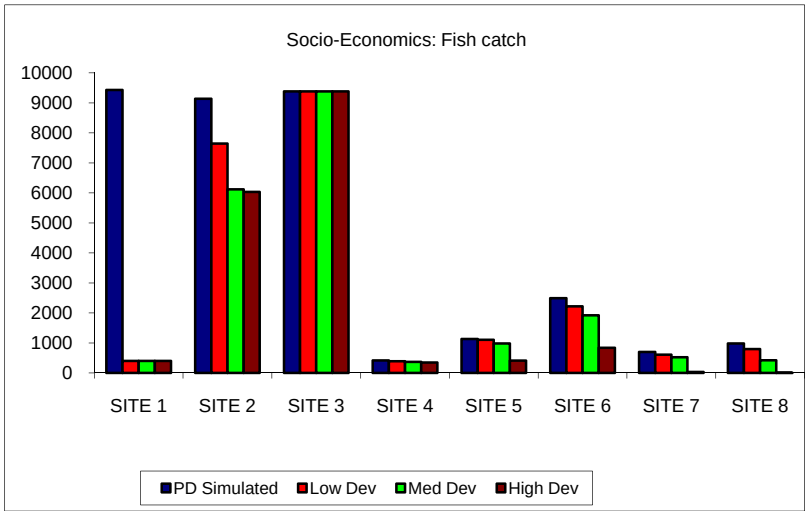
Moderate Scenario
This situation generally will reduce the net fishing incomes or fish livelihoods further as flows will be slightly more reduced; the biggest drop will be in the channel fishery in site 1, where low flow water levels are considerably reduced.

High Scenario
This situation will generally reduce net fishing incomes or fish livelihoods further which as a result of reduced flow generally which will ultimately depress fish stocks; this will be very marked in the lower parts of the basin from sites 5 to site 7, where floodplain flooding will be significantly reduced. At site 8 the fishery will be effectively eliminated.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Fish national income contribution - summary change per scenario

The contribution to national income (economic contribution) of household fishing tends, along with catch and net income, to peak during floods in areas with floodplains. In areas without floodplains economic contribution is more stable. Generally the scenarios will progressively reduce economic contribution. In the lower basin the high scenario will severely reduce fish economic contribution.



Low Scenario
This situation generally will reduce fish economic contribution from PD levels as there is essentially a reduction in overall fish populations; the biggest drop will be in the channel fishery in site 1, where low flow water levels are considerably reduced.

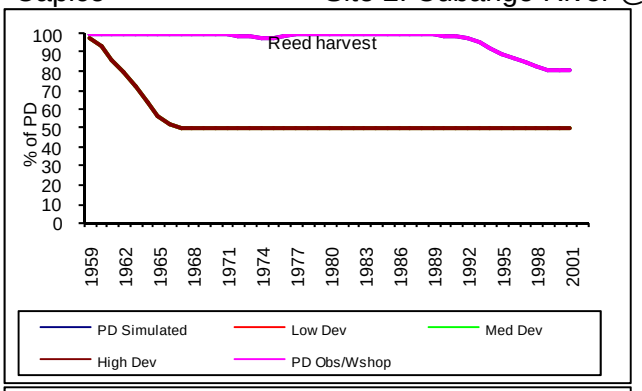
Moderate Scenario
This situation generally will reduce the fish economic contribution further as flows will be slightly more reduced; the biggest drop will be in the channel fishery in site1, where low flow water levels are considerably reduced.

High Scenario
This situation will generally reduce fish economic contribution further which as a result of reduced flow generally which will ultimately depress fish stocks; this will be very marked in the lower parts of the basin at sites 5 and 6, where floodplain flooding will be significantly reduced. At sites 7 and 8 the economic value of fishery will be effectively eliminated.

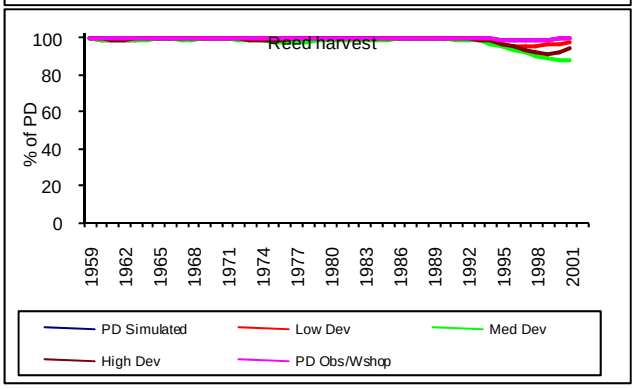
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.3. Household income - reeds

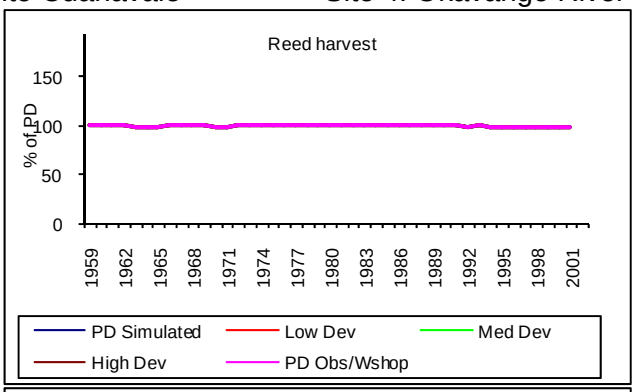
Site 1: Cubango River @ Capico



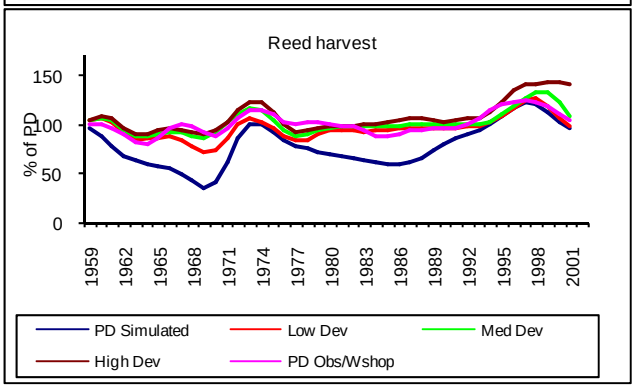
Site 2: Cubango River @ Mucundi



Site 3: Cuito River @ Cuito Cuanavale

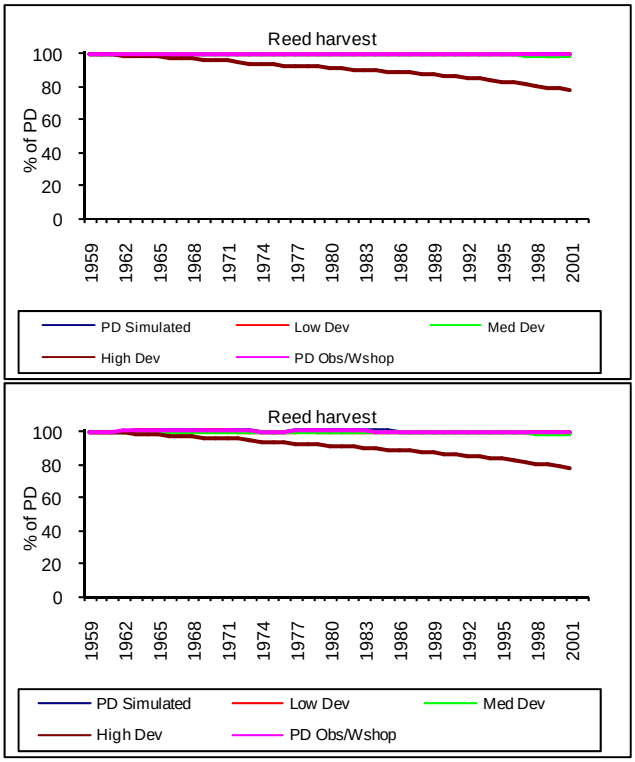


Site 4: Okavango River @ Rundu

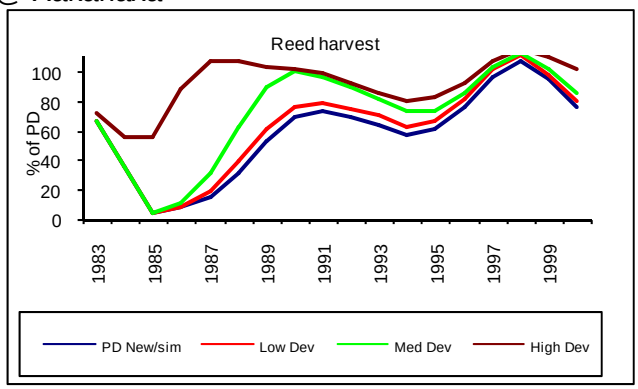


Site 5: Okavango River @ Popa Falls

Site 6: Okavango River @ Pan Handle

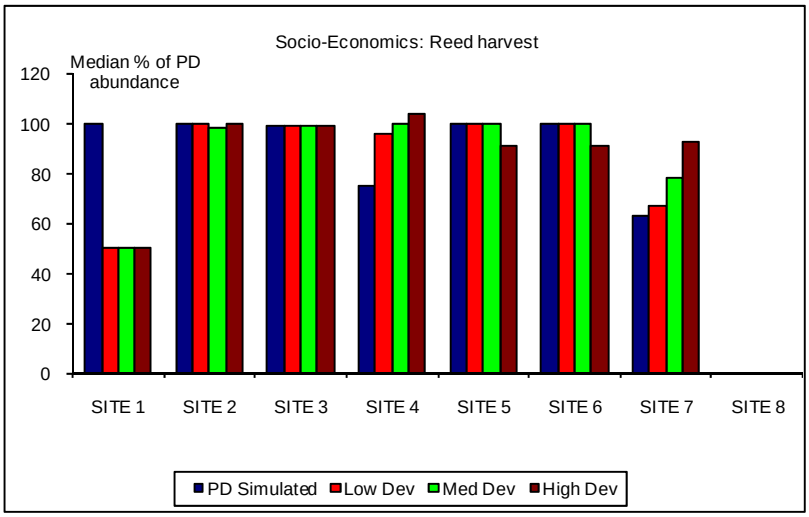


Site 7: Okavango River @ Xakanaxa



Reed harvest - summary change per scenario

Reeds occur in two indicator vegetation sites; upper wetbank, and lower floodplain, and are harvested at both. Harvest response is complex and tends to reflect change in the extent of these stands. Also making it complex is a limit in terms of capacity to harvest and market demand to the response to changes in extent of reeds. Thus the response is muted, and it depends on how well used the PD stocks are. There is no longer significant reed use at site 8.



Low Scenario
This situation would reduce reed harvest by about half at site 1, and it would increase harvest by up to 20% in sites 4 and 7. This is due to the expected increase in upper wetbank and lower floodplain at these sites. Elsewhere no change in reed harvest is expected.

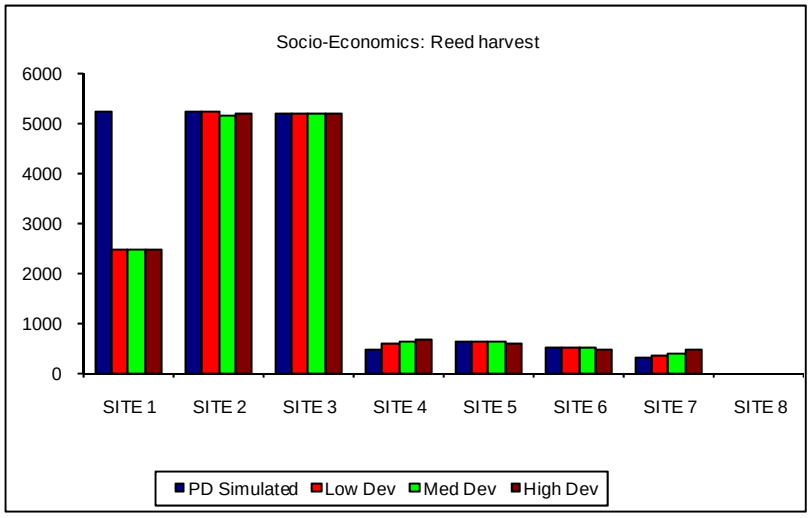
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the increase in harvest in sites 4 and 7 would be more significant, again, due to the expected increase in upper wetbank and lower floodplain at these sites.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the increase in harvest in sites 4 and 7 would be more significant, again, due to the expected increase in upper wetbank and lower floodplain at these sites. In sites 5 and 6, there would be small reductions in reed harvest as a result of reduced reed habitat.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Reed livelihood - summary change per scenario

The net income or livelihood from household reed harvest is expected to remain relatively stable in all sites where reeds are harvested except in site 1, where an already well used resource will decline notably. Elsewhere there will be small increases in household reed livelihoods at sites 4 and 7. Small decreases may be experienced with the high water use scenario at sites 5 and 6.



Low Scenario
This situation would reduce livelihood from household reed harvest by about half at site 1, and it would increase livelihoods slightly in sites 4 and 7. This is due to the expected increase in upper wetbank and lower floodplain at these sites. Elsewhere no change in reed livelihoods is expected.

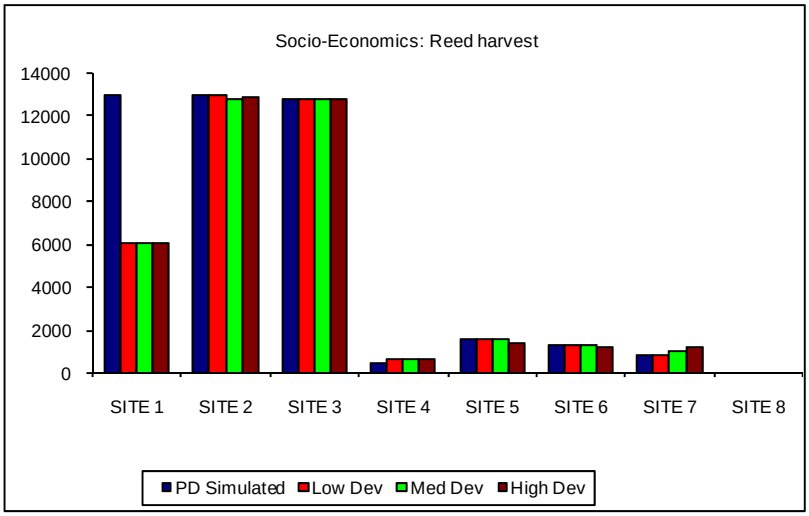
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the slight increase in livelihood from household reed harvest in sites 4 and 7 would be more significant, again, due to the expected increase in upper wetbank and lower floodplain at these sites.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the slight increase in livelihood from household reed harvest in sites 4 and 7 would be more significant, again, due to the expected increase in upper wetbank and lower floodplain at these sites. In sites 5 and 6, there would be small reductions in reed livelihoods as a result of reduced reed habitat.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Reed contribution to national income - summary change per scenario

The pattern for the contribution of household reed harvest to national income is very similar to that for livelihoods. The contribution is expected to remain relatively stable in all sites where reeds are harvested except in site 1, where an already well used resource will decline notably. Elsewhere there will be small increases in reed economic contribution at sites 4 and 7. Small decreases may be experienced with the high water use scenario at sites 5 and 6.



Low Scenario
This situation would reduce reed economic contribution by about half at site 1, and it would increase it slightly in sites 4 and 7. This is due to the expected increase in upper wetbank and lower floodplain at these sites. Elsewhere no change in reed harvest value is expected.

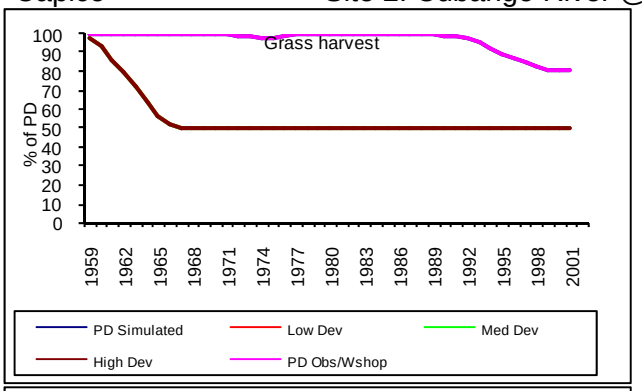
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the slight increase in reed economic contribution in sites 4 and 7 would be more significant, again, due to the expected increase in upper wetbank and lower floodplain at these sites.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the slight increase in reed economic contribution in sites 4 and 7 would be more significant, again, due to the expected increase in upper wetbank and lower floodplain at these sites. In sites 5 and 6, there would be small reductions in reed economic contribution as a result of reduced reed habitat.

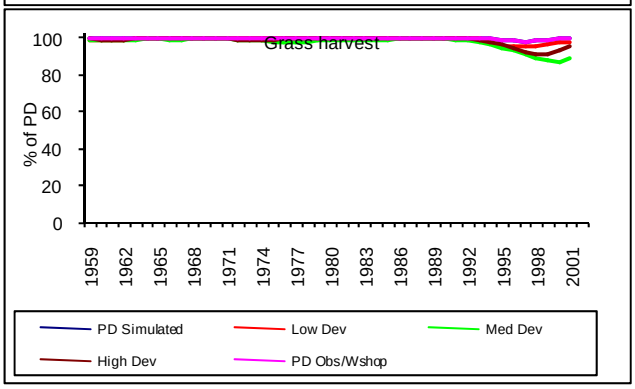
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.4. Household income - floodplain grass

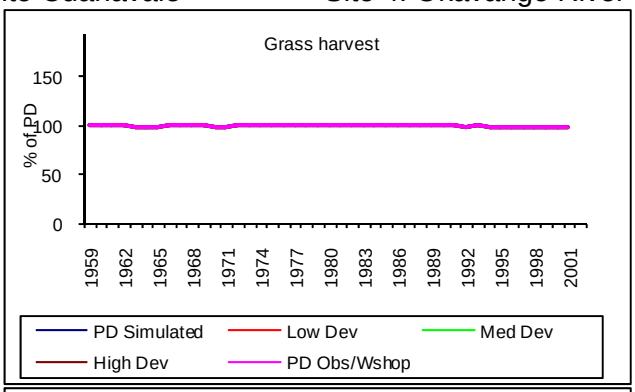
Site 1: Cubango River @ Capico



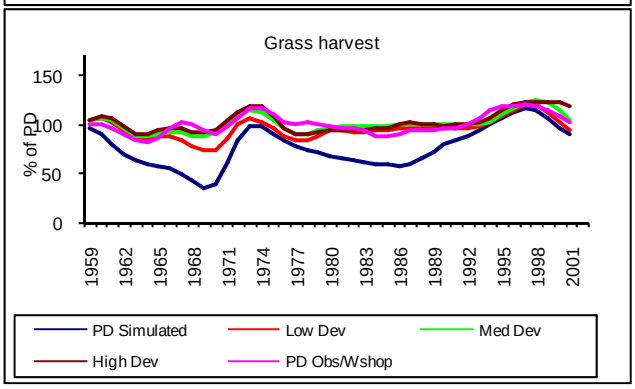
Site 2: Cubango River @ Mucundi



Site 3: Cuito River @ Cuito Cuanavale

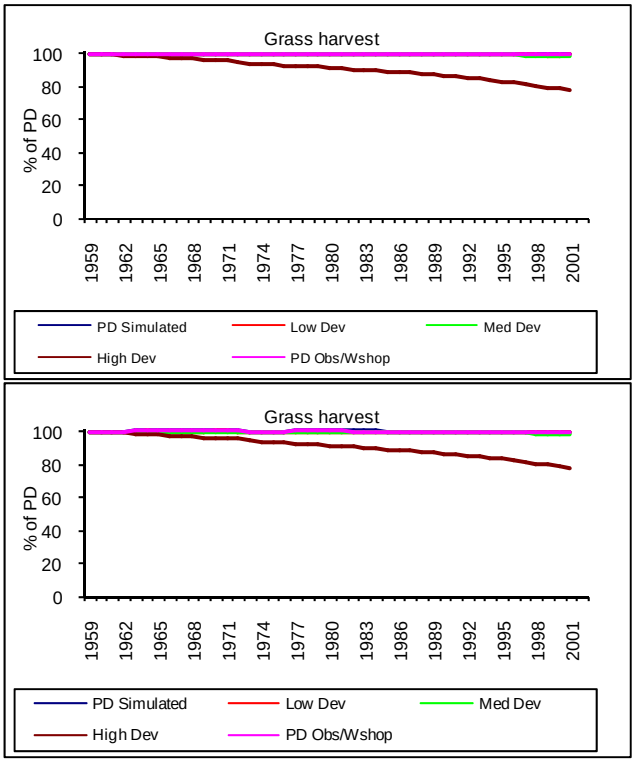


Site 4: Okavango River @ Rundu

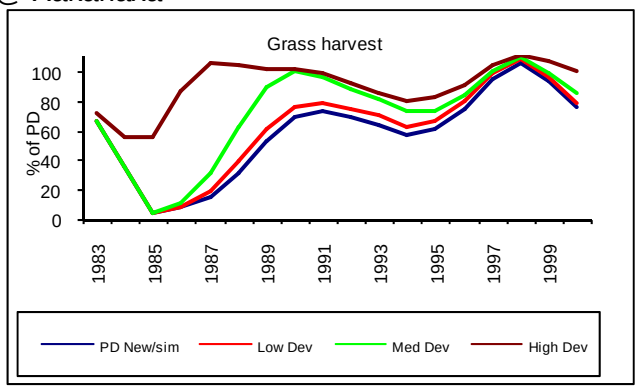


Site 5: Okavango River @ Popa Falls

Site 6: Okavango River @ Pan Handle

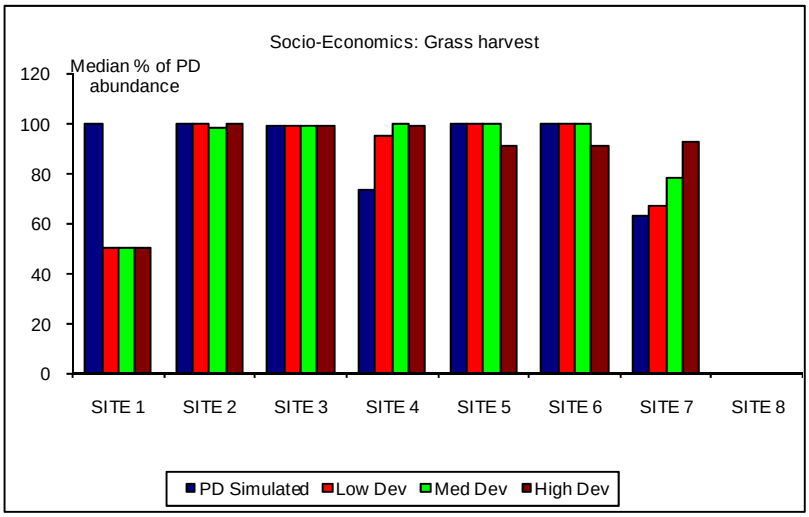


Site 7: Okavango River @ Xakanaxa



Floodplain grass harvest - summary change per scenario

Floodplain grass occurs in two indicator vegetation sites; middle and upper floodplain, and it is harvested at both. Harvest response is complex and tends to reflect change in the extent of these stands. Also making it complex is a limit in terms of capacity to harvest and market demand to the response to changes in extent of floodplain grass. Thus the response is muted, and it depends on how well used the PD stocks are. There is no longer significant floodplain grass use at site 8.



Low Scenario
This situation would reduce floodplain grass harvest by about half at site 1, and it would increase harvest by up to 20% in sites 4 and 7. This is due to the expected increase in middle and upper floodplain at these sites. Elsewhere no change in floodplain grass harvest is expected.

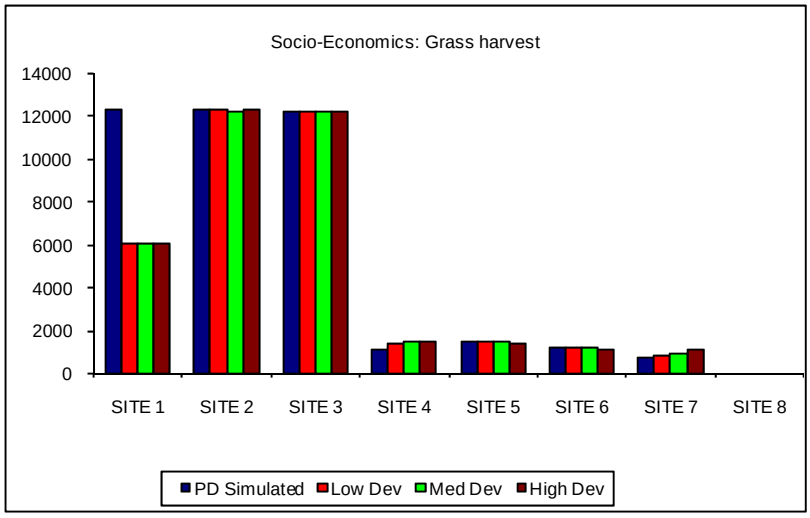
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the increase in harvest in sites 4 and 7 would be more significant, again, due to the expected increase in middle and upper floodplain at these sites.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the increase in harvest in sites 4 and 7 would be more significant, again, due to the expected increase in middle and upper floodplain at these sites. In sites 5 and 6, there would be small reductions in floodplain grass harvest as a result of reduced floodplain grass habitat.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Floodplain grass livelihood - summary change per scenario

The net income or livelihood from household floodplain grass harvest is expected to remain relatively stable in all sites where floodplain grass are harvested except in site 1, where an already well used resource will decline notably. Elsewhere there will be small increases in household floodplain grass livelihoods at sites 4 and 7. Small decreases may be experienced with the high water use scenario at sites 5 and 6.



Low Scenario
This situation would reduce livelihood from household floodplain grass harvest by about half at site 1, and it would increase livelihoods slightly in sites 4 and 7. This is due to the expected increase in middle and upper floodplain at these sites. Elsewhere no change in floodplain grass livelihoods is expected.

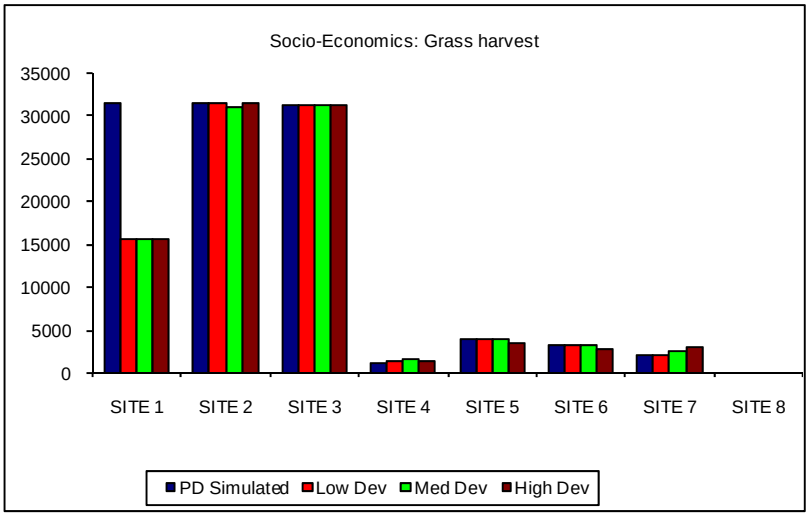
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the slight increase in livelihood from household floodplain grass harvest in sites 4 and 7 would be more significant, again, due to the expected increase in middle and upper floodplain at these sites.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the slight increase in livelihood from household floodplain grass harvest in sites 4 and 7 would be more significant, again, due to the expected increase in middle and upper floodplain at these sites. In sites 5 and 6, there would be small reductions in floodplain grass livelihoods as a result of reduced floodplain grass habitat.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Floodplain grass contribution to national income - summary change per scenario

The pattern for the contribution of household floodplain grass harvest to national income is very similar to that for livelihoods. The contribution is expected to remain relatively stable in all sites where floodplain grasses are harvested except in site 1, where an already well used resource will decline notably. Elsewhere there will be small increases in floodplain grass economic contribution at sites 4 and 7. Small decreases may be experienced with the high water use scenario at sites 5 and 6.



Low Scenario
This situation would reduce floodplain grass economic contribution by about half at site 1, and it would increase it slightly in sites 4 and 7. This is due to the expected increase in middle and upper floodplain at these sites. Elsewhere no change in floodplain grass harvest value is expected.

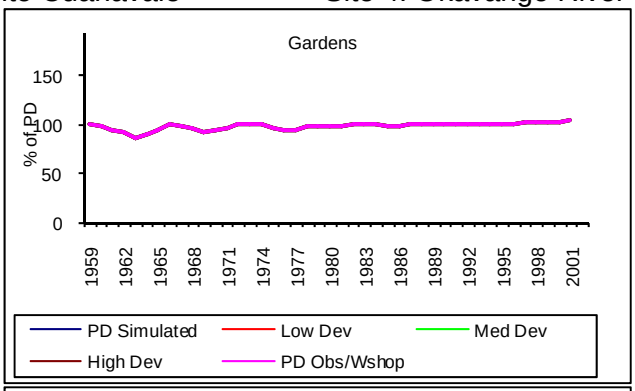
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the slight increase in floodplain grass economic contribution in sites 4 and 7 would be more significant.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the slight increase in floodplain grass economic contribution in sites 4 and 7 would be more significant. In sites 5 and 6, there would be small reductions in floodplain grass economic contribution as a result of reduced floodplain grass habitat.

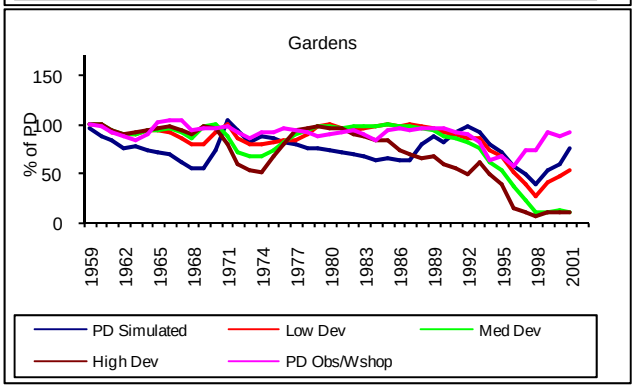
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.5. Household income - floodplain gardens (e.g. molapo farming)

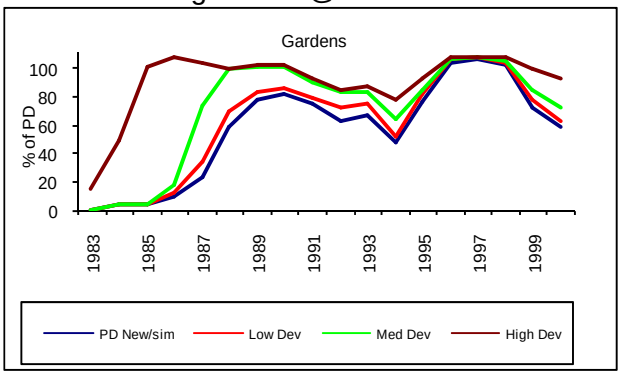
Site 3: Cuito River @ Cuito Cuanavale



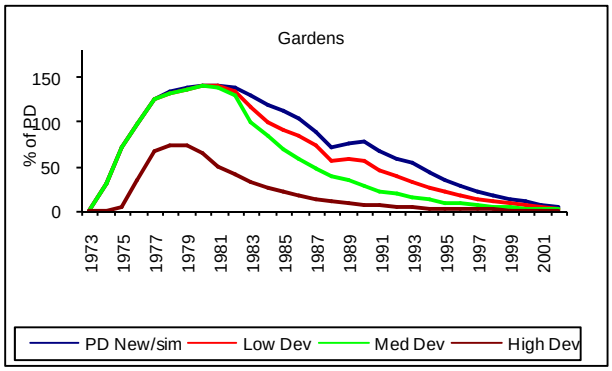
Site 4: Okavango River @ Rundu



Site 7: Okavango River @ Xakanaxa

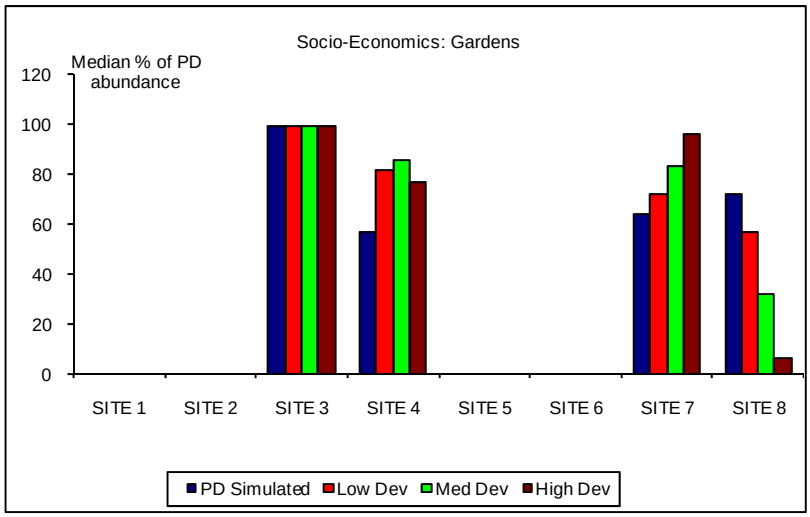


Site 8: Boteti River



Floodplain garden production - summary change per scenario

Floodplain gardens are produced in two indicator vegetation types; lower and middle floodplain and only at sites 3, 4, 7 and 8. Harvest response is complex and tends to reflect change in the extent of these habitats. Also making it complex is a limit in terms of capacity to increase production in response to changes in extent of habitat. Thus the response tends to be muted.



Low Scenario
This situation would increase floodplain garden production by between 5% and 20% at sites 4 and 7. This is due to expected increase in lower and middle floodplain at these sites. At site 8 decreasing flooding would reduce the floodplain gardens by about 10%.

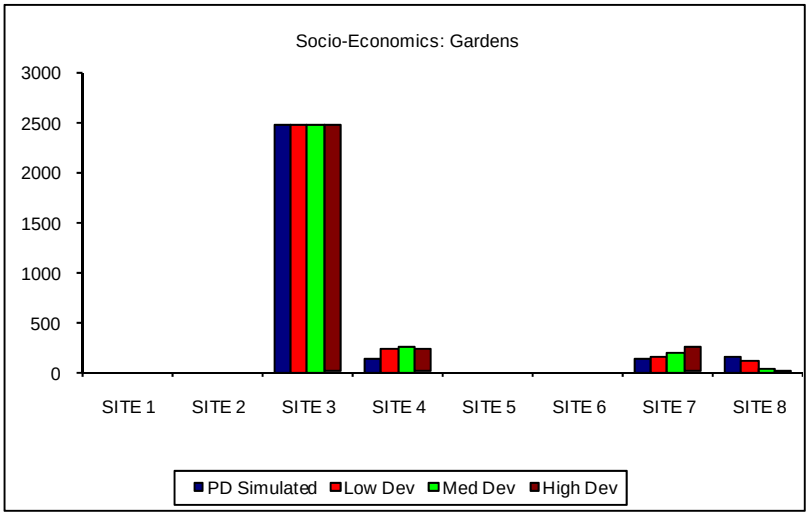
Moderate Scenario
This situation would result in a similar response to that for the low scenario, except that the increase in garden production in sites 4 and 7 would be more significant, again, due to an expected increase in lower and middle floodplain at these sites. There would also be a bigger drop in garden production at site 8.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the increase in gardens in site 4 would be less, and that for site 7 would be significantly more, again, due to the expected increase in lower and middle floodplain at these sites. In site 8, garden production would be almost eliminated

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Floodplain garden livelihood - summary change per scenario

The net income or livelihood from household floodplain gardens is expected to remain relatively stable in all sites, but will follow the same patterns noted for garden production. Thus there will be small increases in household floodplain garden livelihoods at sites 4 and 7. Decreases will be experienced at site 8.



Low Scenario
This situation would cause livelihood from household floodplain garden production to follow the same pattern as that for production, above. Thus it would increase livelihoods slightly in sites 4 and 7, and reduce them in site 8.

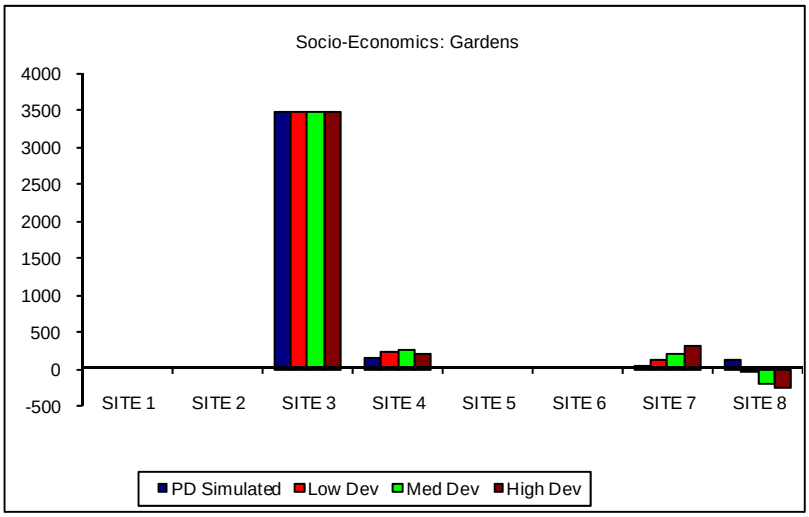
Moderate Scenario
This situation would result in a similar response to that for the low scenario, the slight increase in livelihood from household floodplain gardens in sites 4 and 7 would be more significant, and the reduction at site 8 would be greater.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the slight increase in livelihood from household floodplain gardens in sites 4 and 7 would be more significant. At site 4 livelihoods would decrease slightly below those for the moderate scenario. In site 8, there would be almost no livelihoods from floodplain gardens.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Floodplain garden contribution to national income - summary change per scenario

The pattern for the contribution of household floodplain gardens to national income is very similar to that for livelihoods. It is expected to remain relatively stable in all sites, but will follow the same patterns noted for garden production. Thus there will be small increases in household floodplain garden livelihoods at sites 4 and 7. Decreases will be experienced at sites 8. The medium and high scenarios will actually result in economic losses in the short term.



Low Scenario
This situation would cause economic contribution from household floodplain garden production to follow the same pattern as that for production, above. It would increase livelihoods slightly in sites 4 and 7, and reduce them to zero in site 8.

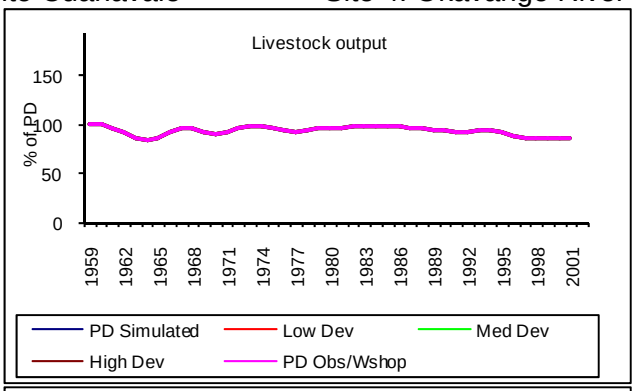
Moderate Scenario
This situation would result in a similar response to that for the low scenario, the slight increase in livelihood from household floodplain gardens in sites 4 and 7 would be more significant, and the reduction at site 8 would be greater, with a short term economic loss.

High Scenario
This scenario would also result in a similar response to that for the low scenario, except that the slight increase in economic contribution from household floodplain gardens in sites 4 and 7 would be more significant. At site 4 livelihoods would decrease slightly below those for the moderate scenario. In site 8, there would be an economic loss from floodplain gardens.

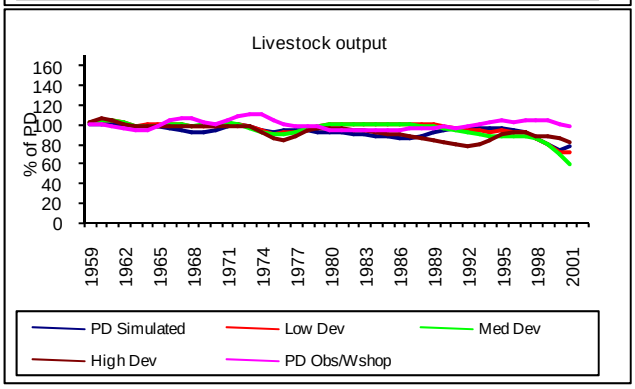
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.6. Household income and wealth - livestock (floodplain grazing)

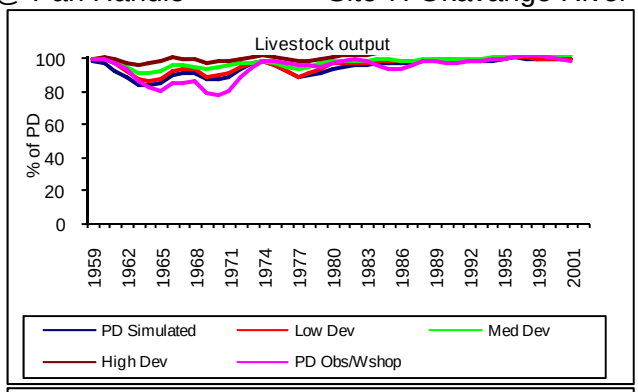
Site 3: Cuito River @ Cuito Cuanavale



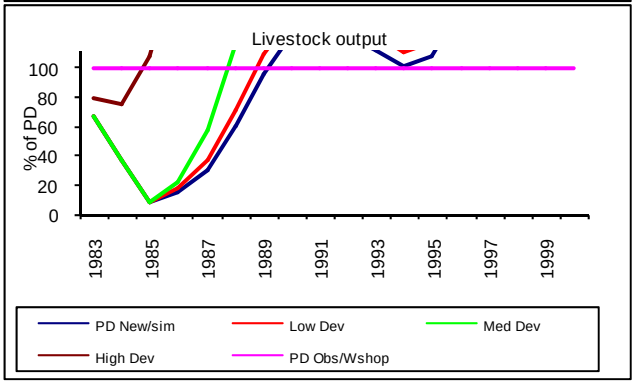
Site 4: Okavango River @ Rundu



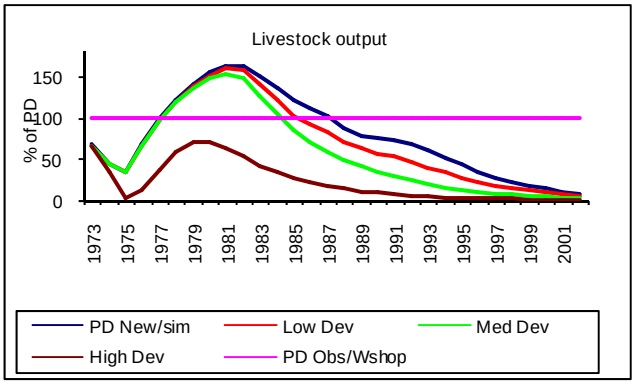
Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

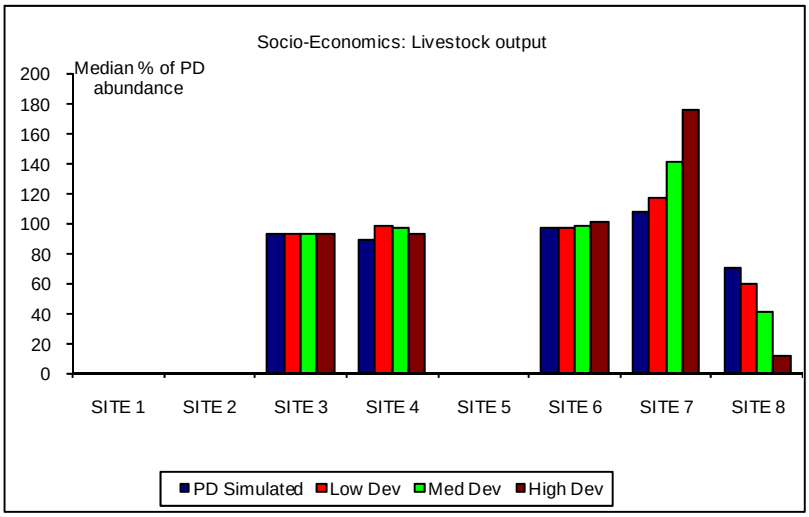


Site 8: Boteti River


Livestock output
% of PD
150
100
50
0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
PD New/sim
Low Dev
Med Dev
High Dev
PD Obs/Wshop

Floodplain grazing production - summary change per scenario

Floodplain grazing takes place in three indicator vegetation types; lower middle and upper floodplain and only at sites 3, 4, 6, 7 and 8. The grazing production response to scenarios is complex and tends to reflect change in the extent of these habitats. At sites 4 and 6 production will tend to be stable. At site 7 it is likely to expand significantly with increase in drier floodplains. At site 8 it would decrease as drier floodplains change to savanna.



Low Scenario
This situation would increase floodplain grazing production slightly at sites 4 and 7, and decrease it at site 8.

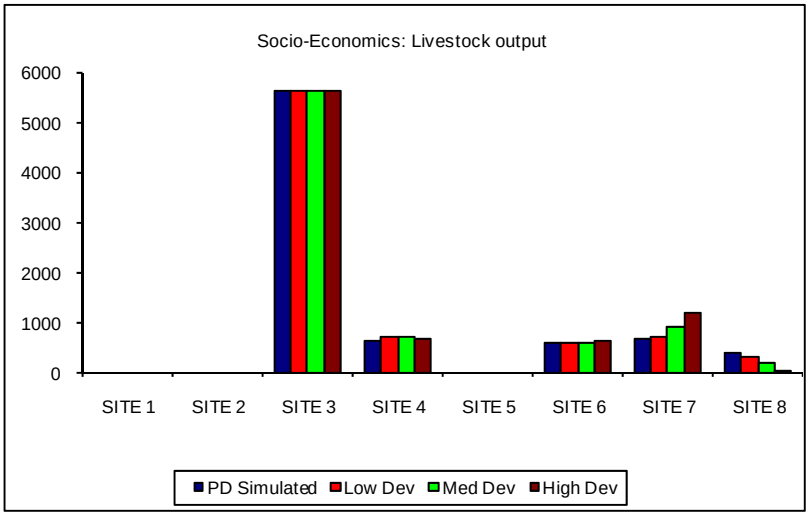
Moderate Scenario
This situation would result in little change at site 4 but an increase of some 20% in grazing production in site 7. There would be a bigger drop in grazing production at site 8.

High Scenario
This scenario would also result in a similar response to that for the moderate scenario, except that the increase in grazing production in site 7 would be much greater, and the decrease in grazing production at site 8, would be much greater, almost eliminating it.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Floodplain grazing livelihood - summary change per scenario

The net income or livelihood from household floodplain grazing is expected to remain relatively stable in sites 4 and 6, but at sites 7 and 8 will follow the same patterns noted for grazing production. Thus there will be increases in household floodplain grazing livelihoods at site 7 and decreases will be experienced at site 8.



Low Scenario
This situation would cause livelihood from household floodplain grazing to follow the same pattern as that for production, above. Thus it would increase livelihoods slightly in site 7, and reduce them in site 8.

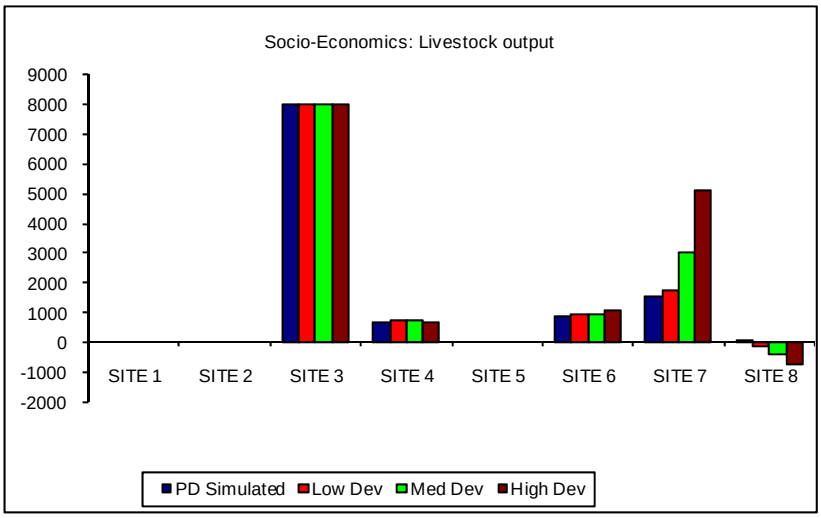
Moderate Scenario
This situation would result in a similar response to that for the low scenario, the slight increase in livelihood from household floodplain grazing in site 7 would be more significant, and the reduction at site 8 would be greater.

High Scenario
This scenario would also result in a similar response to that for the medium scenario, except that the slight increase in livelihood from household floodplain grazing in site 7 would be more significant. At site 8, there would be almost no livelihoods from floodplain grazing.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Floodplain grazing contribution to national income - summary change per scenario

The pattern for the contribution of household floodplain grazing to national income is very similar to that for livelihoods. It is expected to remain relatively stable in sites 4 and 6, but will increase significantly in site 7 and will decrease to result in a short term economic loss in site 8.



Low Scenario
This situation would cause economic contribution from household floodplain grazing production to follow the same pattern as that for production, above. It would increase economic contribution slightly in site 7, and reduce them below zero in site 8.

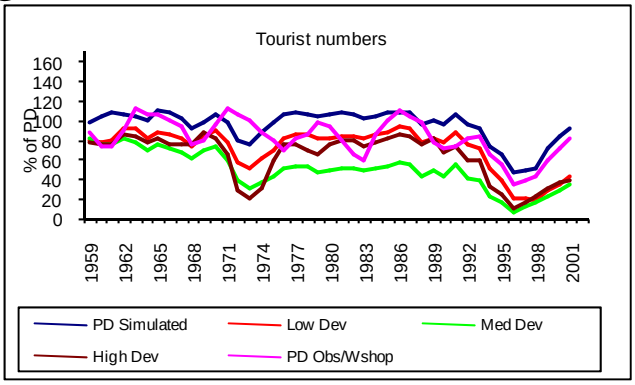
Moderate Scenario
This situation would result in a similar response to that for the low scenario, the slight increase in economic contribution from household floodplain grazing in site 7 would be more significant, and the reduction at site 8 would be greater, with a short term economic loss.

High Scenario
This scenario would also result in a similar response to that for the medium scenario, except that the slight increase in economic contribution from household floodplain grazing in site 7 would be more significant. In site 8, there would be an economic loss from floodplain gardens.

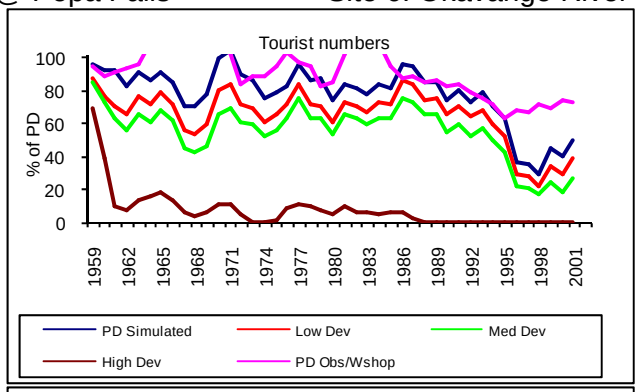
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.7. Household income and macro effects - tourism

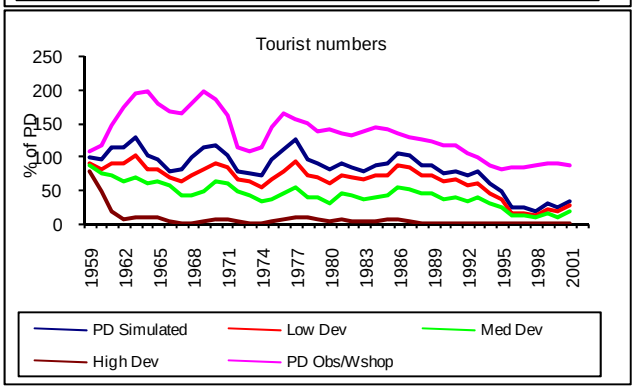
Site 4: Okavango River @ Rundu



Site 5: Okavango River @ Popa Falls

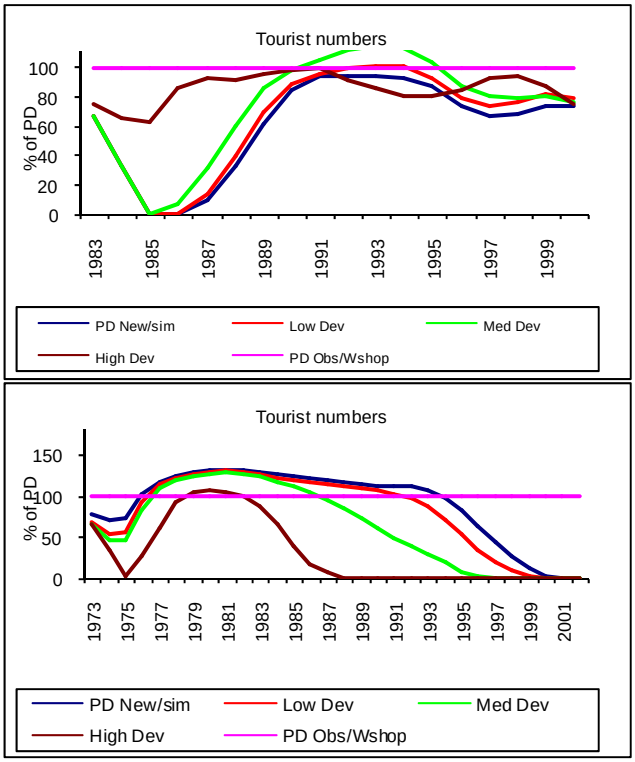


Site 6: Okavango River @ Pan Handle



Site 7: Okavango River @ Xakanaxa

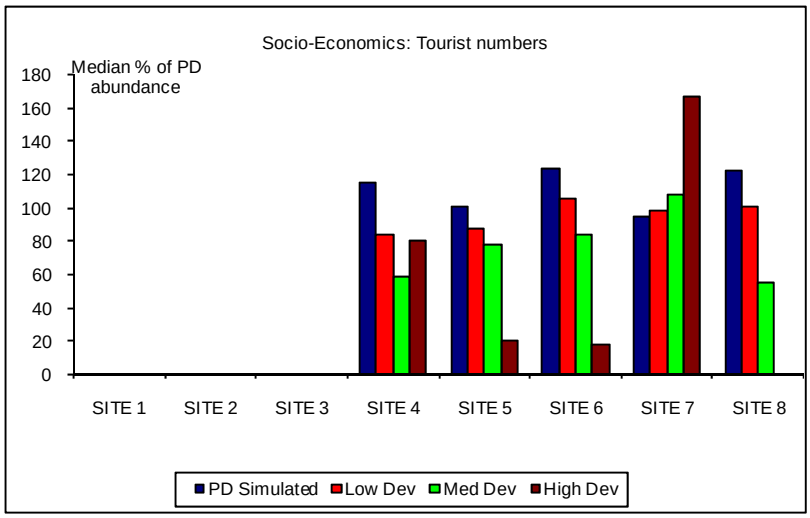
Site 8: Boteti River


Tourist numbers
% of PD
100
80
60
40
20
0
1983
1985
1987
1989
1991
1993
1995
1997
1999
PD New/sim
Low Dev
Med Dev
High Dev
PD Obs/Wshop

Tourist numbers
% of PD
150
100
50
0
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
PD New/sim
Low Dev
Med Dev
High Dev
PD Obs/Wshop

Tourism numbers - summary change per scenario

Tourism makes use of a complex range of habitats including river banks channels, and floodplains at sites 4 to 8. It appears to be responsive to changes in dry season low flow, flood type, and wildlife abundance. The response to scenarios shows a generally sharply declining trend with increasing water use development upstream. The only exception is in the central delta (site 7). In site 4 the high scenario gives higher numbers than is better than the medium scenario but both are lower than present day. Site 8 shows complete elimination of tourism with high scenario.



Low Scenario
This situation would decrease tourism numbers at all downstream sites (4 to 8) except 7, where they would increase slightly.

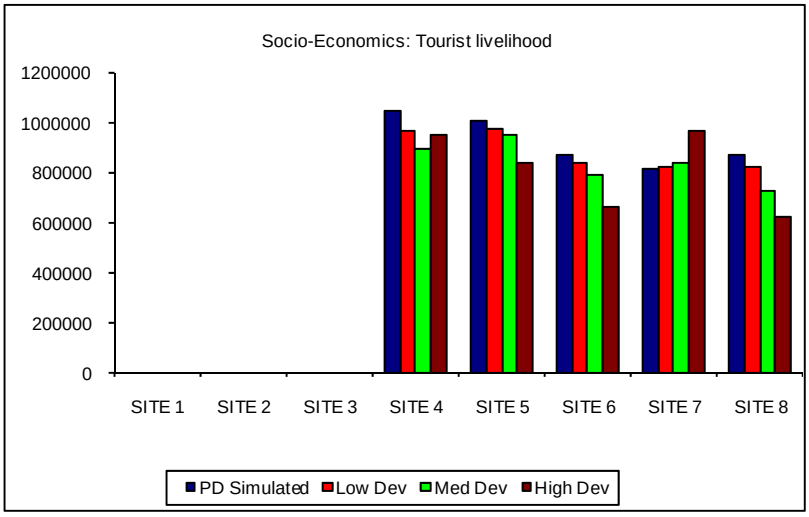
Moderate Scenario
This situation would decrease tourism numbers significantly at all downstream sites (4 to 8) except 7, where they would increase slightly.

High Scenario
This scenario would also decrease tourism numbers significantly at most downstream sites (4 to 8) except 7, where they would increase significantly. The impact of the high scenario at site 4 would be less than that of scenario 3.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Tourism livelihood - summary change per scenario

The net income or household livelihoods from tourism shows the same trends as for tourism numbers, but the changes are not as extreme. This because the household income is made up of wages and salaries, which are less sensitive than other income such as profits.



Low Scenario
This situation would decrease tourism livelihood at all downstream sites (4 to 8) except 7, where they would increase slightly.

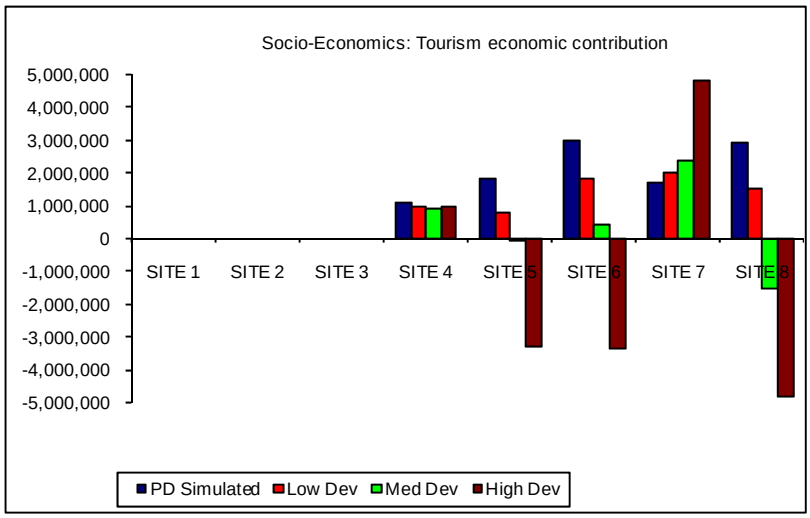
Moderate Scenario
This situation would decrease tourism livelihood significantly at all downstream sites (4 to 8) except 7, where they would increase slightly.

High Scenario
This scenario would also decrease tourism livelihood significantly at most downstream sites (4 to 8) except 7, where they would increase. The impact of the high scenario at site 4 would be less than that of scenario 3.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

Tourism contribution to national income - summary change per scenario

The contribution to the national income from tourism shows the same trends as for tourism numbers and livelihoods, but the changes are less extreme at site 4 and much more extreme at the other sites. In particular at sites 5, 6, and 8 the short term impacts of the high scenario are major economic losses. This will in the longer term result in a much reduced tourism industry in the basin. The medium scenario will have a similar impact, but not as large.



Low Scenario
This situation would decrease the economic contribution of tourism moderately significantly at all downstream sites (except 4, where the drop would be small) and except 7 (where it would increase slightly).

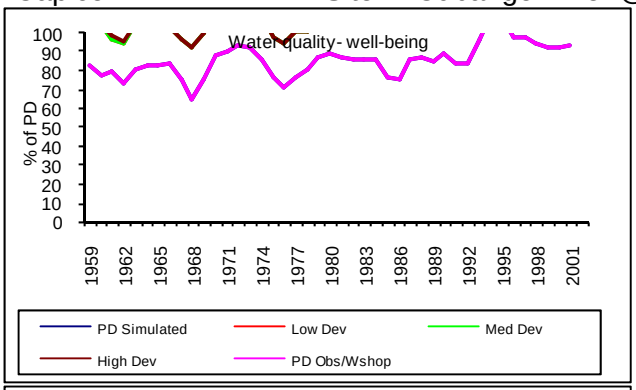
Moderate Scenario
This situation would decrease the economic contribution of tourism moderately significantly at all downstream sites (except 4, where the drop would be small) and except 7 (where it would increase slightly). Economic losses would result in the short term at site 8.

High Scenario
This situation would decrease the economic contribution of tourism very significantly at all downstream sites (except 4, where the drop would be small) and except 7 (where it would increase significantly). Significant economic losses would result in the short term at sites 5, 6, and 8.

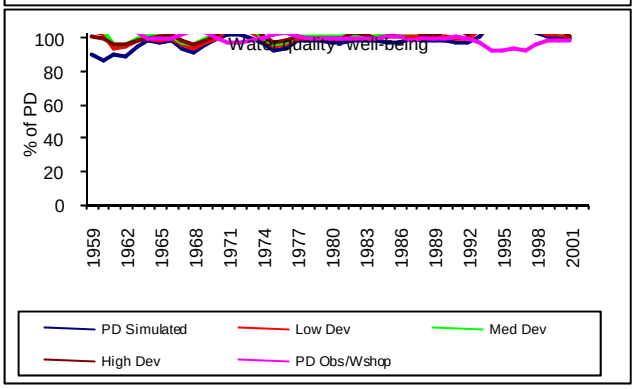
References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.8. Potable water/water quality

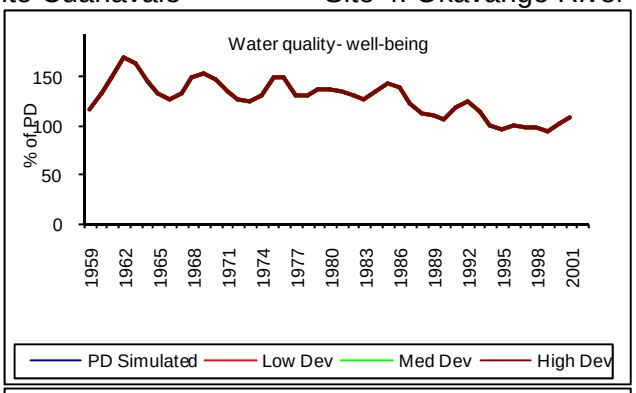
Site 1: Cubango River @ Capico



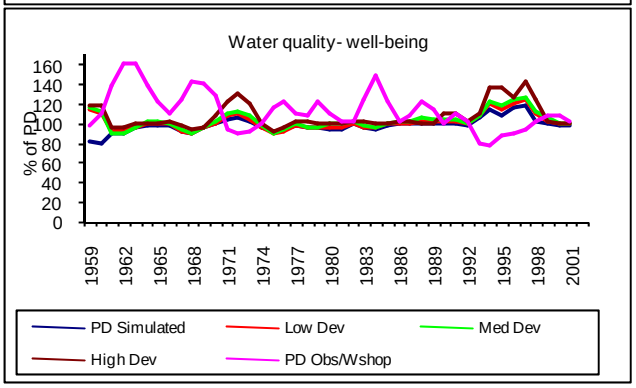
Site 2: Cubango River @ Mucundi



Site 3: Cuito River @ Cuito Cuanavale

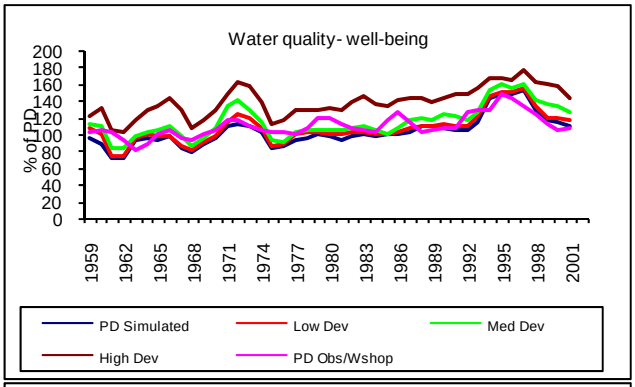


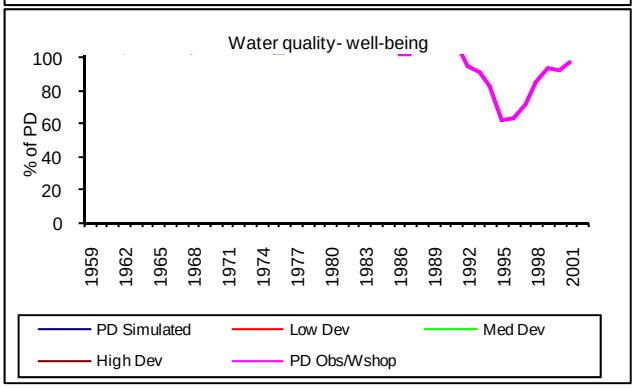
Site 4: Okavango River @ Rundu



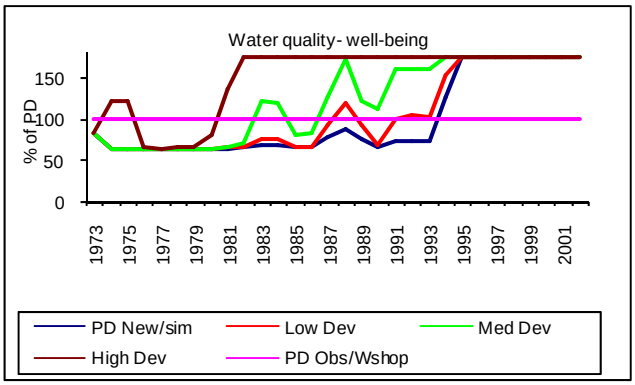
Site 5: Okavango River @ Popa Falls

Site 6: Okavango River @ Pan Handle



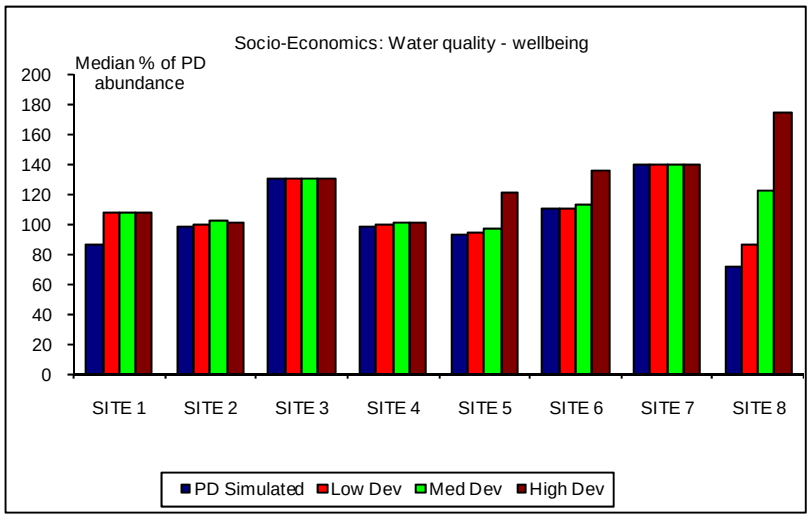


Site 8: Boteti River



Potable water/water quality - summary change per scenario

Potable water quality as a measure of dissatisfaction (non-wellbeing), was not valued, and the impact on this from scenarios was only assessed subjectively in terms of percentage of PD (present day). At most sites a small increase was predicted, while at site 8, drying of channels would result in significant increase in negative effects increasing with scenario. A moderate impact would be seen at site 1 with all scenarios, and at sites 5 and 6 a moderate impact would be seen with high scenario.



Low Scenario
This situation would have little effect, except at site 1 and site 8, where small or moderate negative effects may be seen

Moderate Scenario
This situation would have little effect, except at site 1, where a moderate negative effect may be experienced, and at site 8 where a significant negative effect may be experienced.

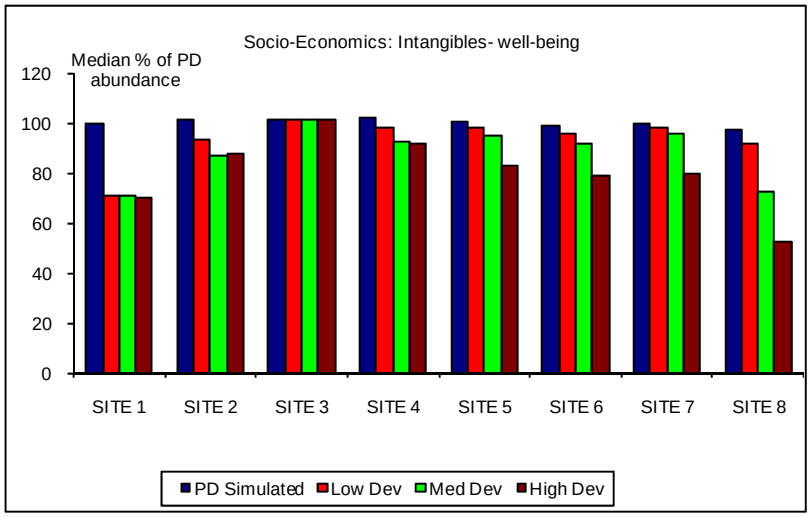
High Scenario
This situation would have little effect, except at site 1, 5, and 6, where a moderate negative effect may be experienced, and at site 8 where a very significant negative effect may be experienced.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.9. Wellbeing/welfare from intangibles

Wellbeing/welfare from intangibles - summary change per scenario

Household and community wellbeing from intangibles was not valued but assessed in terms of percentage deviation for PD (present day). It is intended to reflect household perception of ecosystem integrity. The response to scenarios shows a generally declining trend with increasing water use development upstream. Declines are mostly small, but greater in site 8 and site 1, where effects on flow and flooding may be most noticeable.



Low Scenario
This situation would decrease wellbeing slightly at nearly all sites, but moderately at site 1.

Moderate Scenario
This situation would decrease wellbeing slightly at nearly all sites, but moderately at site 1, 2 and 8.

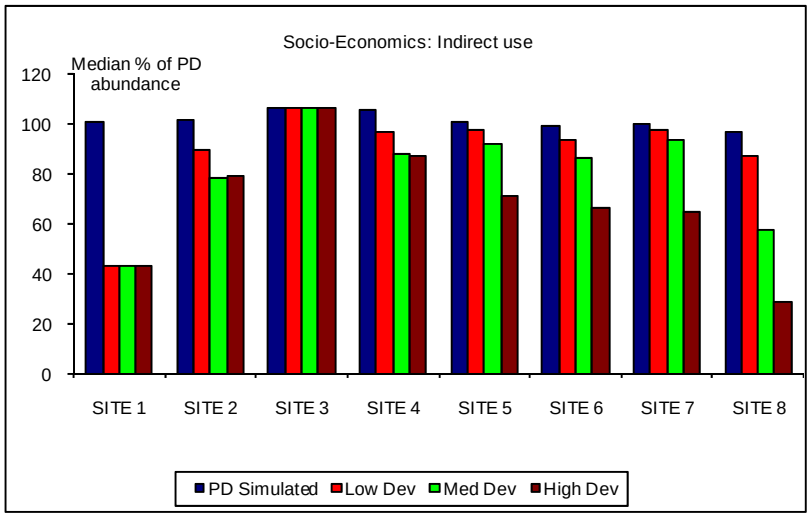
High Scenario
This situation would decrease wellbeing slightly at site 4, moderately to severely at sites 1, 2, 5, 6, 7, and 8.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.10. Indirect use

Indirect use - summary change per scenario

Effects of scenarios on indirect use values were not valued for lack of data, but were subjectively assigned impacts in terms of percentage change from PD (present day). These showed quite significant progressive declines with increasing water use. These were most noticeable with site 1 and site 8.



Low Scenario
This situation would decrease indirect use value slightly at nearly all sites, but significantly at site 1.

Moderate Scenario
This situation would decrease indirect use value slightly or moderately at nearly all sites, but significantly at sites 1, and 8.

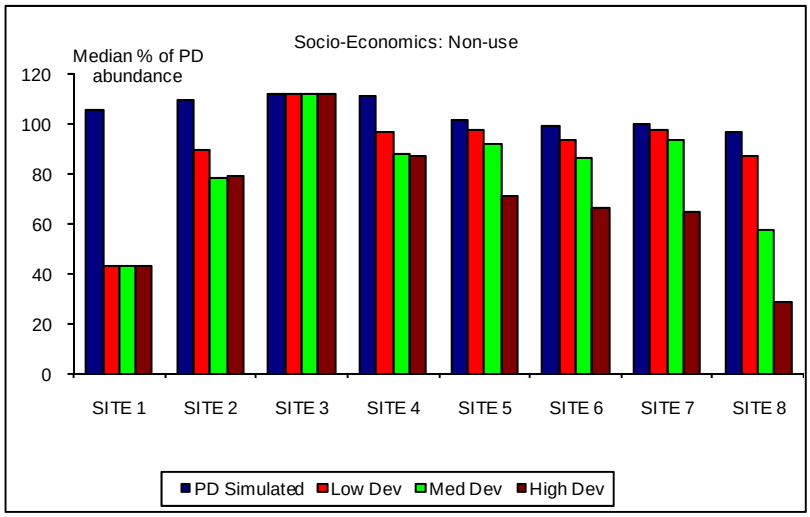
High Scenario
This situation would decrease indirect use value moderately at sites 2, 4, 5, 6, and severely at site 1, and site 8.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

10.11. Non use

Non use - summary change per scenario

Effects of scenarios on non-use values were not valued for lack of data, but were subjectively assigned impacts in terms of percentage change from PD (present day). Here again the effects on ecosystem integrity were considered key. The assessment showed quite significant progressive declines with increasing water use. These were most noticeable with site 1 and site 8.



Low Scenario
This situation would decrease non-use value slightly at nearly all sites, but significantly at site 1.

Moderate Scenario
This situation would decrease non-use value slightly or moderately at nearly all sites, but significantly at sites 1, 2, and 8.

High Scenario
This situation would decrease non-use value moderately at sites 2, 4, 5, 6, and severely at site 1, and site 8.

References
Southern Waters. 2009. Okavango EF Assessment Databases. Response curves for indicator. MS Excel.

The Okavango River Basin Transboundary Diagnostic Analysis Technical Reports

In 1994, the three riparian countries of the Okavango River Basin – Angola, Botswana and Namibia – agreed to plan for collaborative management of the natural resources of the Okavango, forming the Permanent Okavango River Basin Water Commission (OKACOM). In 2003, with funding from the Global Environment Facility, OKACOM launched the Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO) Project to coordinate development and to anticipate and address threats to the river and the associated communities and environment. Implemented by the United Nations Development Program and executed by the United Nations Food and Agriculture Organization, the project produced the Transboundary Diagnostic Analysis to establish a base of available scientific evidence to guide future decision making. The study, created from inputs from multi-disciplinary teams in each country, with specialists in hydrology, hydraulics, channel form, water quality, vegetation, aquatic invertebrates, fish, birds, river-dependent terrestrial wildlife, resource economics and socio-cultural issues, was coordinated and managed by a group of specialists from the southern African region in 2008 and 2009.

The following specialist technical reports were produced as part of this process and form substantive background content for the Okavango River Basin Transboundary Diagnostic Analysis.

Final Study Reports	***Reports integrating findings from all country and background reports, and covering the entire basin.***		
		Aylward, B.	*Economic Valuation of Basin Resources: Final Report to EPSMO Project of the UN Food & Agriculture Organization as an Input to the Okavango River Basin Transboundary Diagnostic Analysis*
		Barnes, J. et al.	*Okavango River Basin Transboundary Diagnostic Analysis: Socio-Economic Assessment Final Report*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Project Initiation Report (Report No: 01/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment EFA Process Report (Report No: 02/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Guidelines for Data Collection, Analysis and Scenario Creation (Report No: 03/2009)*
		Bethune, S. Mazvimavi, D. and Quintino, M.	*Okavango River Basin Environmental Flow Assessment Delineation Report (Report No: 04/2009)*
		Beuster, H.	*Okavango River Basin Environmental Flow Assessment Hydrology Report: Data And Models(Report No: 05/2009)*
		Beuster, H.	*Okavango River Basin Environmental Flow Assessment Scenario Report : Hydrology (Report No: 06/2009)*
		Jones, M.J.	*The Groundwater Hydrology of The Okavango Basin (FAO Internal Report, April 2010)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 1 of 4)(Report No. 07/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions (Volume 2 of 4: Indicator results) (Report No. 07/2009)*
		King, J.M. and Brown, C.A.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Ecological and Social Predictions: Climate Change Scenarios (Volume 3 of 4) (Report No. 07/2009)*
		King, J., Brown, C.A., Joubert, A.R. and Barnes, J.	*Okavango River Basin Environmental Flow Assessment Scenario Report: Biophysical Predictions (Volume 4 of 4: Climate Change Indicator Results) (Report No: 07/2009)*
		King, J., Brown, C.A. and Barnes, J.	*Okavango River Basin Environmental Flow Assessment Project Final Report (Report No: 08/2009)*
		Malzbender, D.	*Environmental Protection And Sustainable Management Of The Okavango River Basin (EPSMO): Governance Review*
		Vanderpost, C. and Dhliwayo, M.	*Database and GIS design for an expanded Okavango Basin Information System (OBIS)*
		Veríssimo, Luis	*GIS Database for the Environment Protection and Sustainable Management of the Okavango River Basin Project*
		Wolski, P.	*Assessment of hydrological effects of climate change in the Okavango Basin*
Country Reports Biophysical Series	***Angola***	*Andrade e Sousa, Helder André de*	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Sedimentologia &*

			Geomorfologia
		Gomes, Amândio	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Vegetação*
		Gomes, Amândio	*Análise Técnica, Biofísica e Socio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final:Vegetação da Parte Angolana da Bacia Hidrográfica Do Rio Cubango*
		Livramento, Filomena	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina:Macroinvertebrados*
		Miguel, Gabriel Luís	*Análise Técnica, Biofísica E Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Subsídio Para o Conhecimento Hidrogeológico Relatório de Hidrogeologia*
		Morais, Miguel	*Análise Diagnóstica Transfronteiriça da Bacia do Análise Rio Cubango (Okavango): Módulo da Avaliação do Caudal Ambiental: Relatório do Especialista País: Angola Disciplina: Ictiofauna*
		Morais, Miguel	*Análise Técnica, Biófisica e Sócio-Económica do Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final: Peixes e Pesca Fluvial da Bacia do Okavango em Angola*
		Pereira, Maria João	*Qualidade da Água, no Lado Angolano da Bacia Hidrográfica do Rio Cubango*
		Santos, Carmen Ivelize Van-Dúnem S. N.	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório de Especialidade: Angola: Vida Selvagem*
		Santos, Carmen Ivelize Van-Dúnem S.N.	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango:Módulo Avaliação do Caudal Ambiental: Relatório de Especialidade: Angola: Aves*
	Botswana	*Bonyongo, M.C.*	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Wildlife*
		Hancock, P.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report: Country: Botswana: Discipline: Birds*
		Mosepele, K.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Fish*
		Mosepele, B. and Dallas, Helen	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Botswana: Discipline: Aquatic Macro Invertebrates*
	Namibia	*Collin Christian & Associates CC*	*Okavango River Basin: Transboundary Diagnostic Analysis Project: Environmental Flow Assessment Module: Geomorphology*
		Curtis, B.A.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report Country: Namibia Discipline: Vegetation*
		Bethune, S.	*Environmental Protection and Sustainable Management of the Okavango River Basin (EPSMO): Transboundary Diagnostic Analysis: Basin Ecosystems Report*
		Nakanwe, S.N.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Aquatic Macro Invertebrates*
		Paxton, M.	*Okavango River Basin Transboundary Diagnostic Analysis: Environmental Flow Module: Specialist Report:Country:Namibia: Discipline: Birds (Avifauna)*
		Roberts, K.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Wildlife*
		Waal, B.V.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia:Discipline: Fish Life*
Country Reports Socioeconomic Series	***Angola***	*Gomes, Joaquim Duarte*	*Análise Técnica dos Aspectos Relacionados com o Potencial de Irrigação no Lado Angolano da Bacia Hidrográfica do Rio Cubango: Relatório Final*
		Mendelsohn, .J.	*Land use in Kavango: Past, Present and Future*
		Pereira, Maria João	*Análise Diagnóstica Transfronteiriça da Bacia do Rio Okavango: Módulo do Caudal Ambiental: Relatório do Especialista: País: Angola: Disciplina: Qualidade da Água*
		Saraiva, Rute et al.	*Diagnóstico Transfronteiriço Bacia do Okavango: Análise Socioeconómica Angola*
	Botswana	*Chimbari, M. and Magole, Lapologang*	*Okavango River Basin Trans-Boundary Diagnostic Assessment (TDA): Botswana Component: Partial Report: Key Public Health*

			Issues in the Okavango Basin, Botswana
		Magole, Lapologang	*Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Land Use Planning*
		Magole, Lapologang	*Transboundary Diagnostic Analysis (TDA) of the Botswana p Portion of the Okavango River Basin: Stakeholder Involvement in the ODMP and its Relevance to the TDA Process*
		Masamba, W.R.	*Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Output 4: Water Supply and Sanitation*
		Masamba,W.R.	*Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin: Irrigation Development*
		Mbaiwa.J.E.	*Transboundary Diagnostic Analysis of the Okavango River Basin: the Status of Tourism Development in the Okavango Delta: Botswana*
		Mbaiwa.J.E. & Mmopelwa, G.	*Assessing the Impact of Climate Change on Tourism Activities and their Economic Benefits in the Okavango Delta*
		Mmopelwa, G.	*Okavango River Basin Trans-boundary Diagnostic Assessment: Botswana Component: Output 5: Socio-Economic Profile*
		Ngwenya, B.N.	*Final Report: A Socio-Economic Profile of River Resources and HIV and AIDS in the Okavango Basin: Botswana*
		Vanderpost, C.	*Assessment of Existing Social Services and Projected Growth in the Context of the Transboundary Diagnostic Analysis of the Botswana Portion of the Okavango River Basin*
	Namibia	*Barnes, J and Wamunyima, D*	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module: Specialist Report: Country: Namibia: Discipline: Socio-economics*
		Collin Christian & Associates CC	*Technical Report on Hydro-electric Power Development in the Namibian Section of the Okavango River Basin*
		Liebenberg, J.P.	*Technical Report on Irrigation Development in the Namibia Section of the Okavango River Basin*
		Ortmann, Cynthia L.	*Okavango River Basin Technical Diagnostic Analysis: Environmental Flow Module : Specialist Report Country: Namibia: discipline: Water Quality*
		Nashipili, Ndinomwaameni	*Okavango River Basin Technical Diagnostic Analysis: Specialist Report: Country: Namibia: Discipline: Water Supply and Sanitation*
		Paxton, C.	*Transboundary Diagnostic Analysis: Specialist Report: Discipline: Water Quality Requirements For Human Health in the Okavango River Basin: Country: Namibia*

Environmental protection and sustainable management of the Okavango River Basin

EPSMO

Boteti River shoreline, Botswana

Republic of Botswana

GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

Sida

UNDP

OKACOM

Tel +267 680 0023 Fax +267 680 0024 Email okasec@okacom.org www.okacom.org
PO Box 35, Airport Industrial, Maun, Botswana