



Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983-2000

Volume I: Main Report

J.J. Stoorvogel
E.M.A. Smaling

Report 28

Wageningen (The Netherlands), 1990

AF

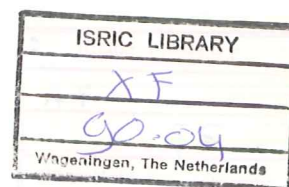
75

ERRATUM

- p. 8 : alinea 5, 3rd sentence: "Nutrient depletion rates were highest in East-Africa, exceeding 40 kg N, 15 kg P₂O₅ and 40 kg K₂O/ha,yr"
- p. 119 : Burkina Faso should be yellow-coloured (moderate depletion rate).
- p. 124 : Table 6.5

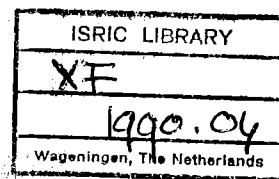
Control	+ crop	+ manure	+ NP	+ NP
	residues	(5 t/ha)	(60 kg/ha)	+ manure

Assessment of soil nutrient depletion in Sub-Saharan Africa:
1983-2000



Assessment of soil nutrient depletion in Sub-Saharan Africa:
1983-2000

Volume I: Main Report



J.J. Stoorvogel
E.M.A. Smaling

Scanned from original by ISRIC - World Soil Information, as ICSU World Data Centre for Soils. The purpose is to make a safe depository for endangered documents and to make the accrued information available for consultation, following Fair Use Guidelines. Every effort is taken to respect Copyright of the materials within the archives where the identification of the Copyright holder is clear and, where feasible, to contact the originators. For questions please contact soil.isric@wur.nl indicating the item reference number concerned.

Report 28

The WINAND STARING CENTRE, Wageningen (The Netherlands), 1990

ISN 25329

ABSTRACT

J.J. Stoorvogel, E.M.A. Smaling, 1990. Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983-2000. Wageningen (The Netherlands), The Winand Staring Centre. Report 28, 4 Volumes; Volume 1. 134 p.; 41 figs.; 96 tables.; 138 ref.

On request of FAO a methodology was developed to assess the state of soil nutrient depletion under agriculture in Sub-Saharan Africa for 1983 and the year 2000. The nutrient balance is described with five input and five output factors, which result in a nutrient loss rate. Production figures and data on fertilizer consumption for 1983 and projections for the year 2000 were provided by FAO. Data on nutrient balances as well as additional country information were collected from the literature. Nutrient depletion rates for Sub-Saharan Africa are approximately 20 kg N, 10 kg P_2O_5 and 20 kg K_2O per ha on average up to a maximum of 40 kg N, 20 kg P_2O_5 and 40 kg K_2O per ha in East Africa.

Keywords: nutrient depletion, nutrient balances, soil fertility, Sub-Saharan Africa.

ISSN 0924-3062

Copyright 1990, Food and Agricultural Organization of the United Nations

The WINAND STARING CENTRE for Integrated Land, Soil and Water Research, Postbus 125, 6700 AC Wageningen (The Netherlands).

Phone: +318370-19100; fax: +31837024812; telex: 75230 VISI-NL

The WINAND STARING CENTRE is continuing the research of:

Institute for Land and Water Management Research (ICW), Institute for Pesticide Research, Environment Division (IOB), Dorschkamp Research Institute for Forestry and Landscape Planning, Division of Landscape Planning (LB), and Soil Survey Institute (STIBOKA).

No part of this publication may be reproduced or published in any form or by any means, or stored in a data base or retrieval system, without the written permission of the Food and Agricultural Organization of the United Nations

Project 8563

VOLUME I: MAIN REPORT

TABLE OF CONTENTS	Page
Summary and conclusions	7
Acknowledgements	9
1 INTRODUCTION	11
2 MATERIALS	13
2.1 Experts and literature	13
2.2 The FAO database	13
3 METHODS	15
3.1 The basic calculation units: Land Use Systems	15
3.2 The model	17
3.2.1 Mineral fertilizers (IN 1)	18
3.2.2 Manure (IN 2)	19
3.2.3 Deposition (IN 3)	21
3.2.4 Biological N fixation (IN 4)	21
3.2.5 Sedimentation (IN 5)	23
3.2.6 Harvested product (OUT 1)	23
3.2.7 Crop residues (OUT 2)	25
3.2.8 Leaching (OUT 3)	26
3.2.9 Gaseous losses (OUT 4)	26
3.2.10 Erosion (OUT 5)	28
3.2.11 Cropping intensity	29
4 RESULTS	31
4.1 Nutrient balances per LWC and per country	31
4.2 Nutrient balances per crop and LUS; an example for N balance, Senegal, 1983.	108
5 EVALUATION OF THE MODEL	111
5.1 Assumptions	111
5.2 Sensitivity analysis	113
6 EVALUATION OF THE RESULTS	115
6.1 Present and future nutrient losses at country level	115
6.2 Evaluation for N, P and K	123
6.3 Cross-check with long term fertilizer experiments	123
6.4 Present and future nutrient losses in LWC UR in Senegal	125

REFERENCES

Volume II : Nutrient balances per crop and per LUS

Volume III: Literature review and description of
land use systems

Volume IV : Computer programmes

SUMMARY AND CONCLUSIONS

In the present study, the state of soil nutrient depletion in Sub-Saharan Africa is assessed for 1983 and the year 2000. It provides, on a country by country basis, data on the net removal of the macronutrients N, P and K from the rootable soil layer.

The development of a method to do this assessment is the focal point of the whole exercise. Production figures (1983) and projections (2000) are provided by FAO, per crop and per country, and further specified for six mainly climate-based 'Land/Water Classes' (LWC): low, uncertain and good rainfall areas (rainfed agriculture), problem areas, and naturally flooded and irrigated areas. Data on fertilizer use (1983 and projections for the year 2000) were given per country and per crop. Next, factors determining the flow of N, P and K into and out of the soil are defined and quantified for the smallest constituents of each LWC: the Land Use Systems (LUS). It is assumed that a LUS is homogeneous, being the basis for the calculation of the nutrient balance.

A LUS is made up of the attributes rainfall, soil fertility, cropping pattern, farm management level, fertilizer and manure application, crop residue management, and rate of erosion. Soil fertility dynamics in a LUS is governed by five input (IN) and five output (OUT) factors.

IN 1 Mineral fertilizers

The FAO database provides only country totals. The assumption is that the use of fertilizers is not evenly distributed within a country; therefore, each LWC is given a weighing factor.

IN 2 Manure

Two intensive forms of grazing are recognized, linked either with manure collection from bomas, kraals and other storage places, and applied to arable fields prior to planting, or with on-the-spot manuring by livestock that feeds on crop residues.

IN 3 Deposition by rain and dust

For areas within Harmattan influence (West Africa) point data allow interpolation; for other areas a correlation with rainfall was found and regression analysis was used for quantification

IN 4 N fixation

Fixed percentage of the total nitrogen demand of leguminous crops and wetland rice is supplied through N fixation. In addition, all crops benefit from small amounts of N that are fixed non-symbiotically

IN 5 Sedimentation

Only applicable to the LWCs 'naturally flooded' and 'irrigated'. Naturally flooded areas are assumed to be non-depleting. Irrigated areas have a fixed input for sedimentation.

OUT 1 Harvested product

Average values are given for each crop. They must be combined with the production figures provided by FAO.

OUT 2 Crop residues

First, an estimate of the amount of crop residues removed from the arable field is made. The actual removal is given in the LUS-description. This must be combined with the amount of nutrients in crop residues per ton harvest.

OUT 3 Leaching

Leaching only applies to nitrogen and potassium. Research on leaching is mainly confined to point observations, which have an uneven distribution over the continent. Multiple regression showed that leaching is correlated with: rainfall, soil fertility, fertilizer application, and crop nutrient uptake.

OUT 4 Gaseous losses

Gaseous losses encompass denitrification and volatilization. Information on both factors is scarce and unevenly distributed. Multiple regression analysis showed that denitrification is correlated with: soil fertility, fertilizer application and crop nutrient uptake. There is also an LWC-specific constant: the 'base' denitrification.

OUT 5 Erosion

Total soil loss is combined with the nutrient content of the eroded soil, and multiplied by an 'enrichment factor', which represents the ratio between the nutrient content of the sediment and the nutrient content of the original soil material.

The FAO database shows acreages of both harvested land and total arable land for each Land/Water Class. If cropping intensity is less than 1, some of the arable land is considered fallow. The nutrient input from fallow is treated as a constant. If cropping intensity exceeds 100%, multiple cropping is taking place.

The results show that nutrient depletion is quite severe in Sub-Saharan Africa. In almost all 38 countries, included in this study, more than 10 kg N, 4 kg P_2O_5 and 10 kg K_2O /ha,yr are lost from the soil. Nutrient depletion rates were most severe in East Africa where the depletion rates were almost twice as high as those given above. The projections given by FAO for the year 2000 resulted in an increase in nutrient depletion for all countries, and especially in the countries which already had a high depletion rate. The high increase in fertilizer consumption projected for the year 2000 by FAO (IN 1) does not help in lowering the depletion, as it is more than offset by increased nutrient withdrawal (OUT 1 and OUT 2).

A Land Use System defined for 1983 is not 'upgraded' in the year 2000. Hence, improvements as to land management that possibly reduce OUT 2-5, are not taken into account.

The sensitivity analysis performed on the model indicated that the soil fertility class and erosion have a high impact on the outcome of the model. A difference of one soil fertility class can change the balance for a land use system up to 10 kg N/ha,yr.

A cross-check of the model with long-term fertilizer experiments in East-Africa confirmed the conclusion of declining soil fertility, even on fertilized land.

ACKNOWLEDGEMENTS

In the course of the present study, a group of experts in the field of tropical soil fertility and plant nutrition were consulted three times. They contributed greatly to the development of the methods for this study and are therefore gratefully acknowledged.

Agricultural University, Wageningen

- Department of Soil Fertility and Plant Nutrition:

Dr B.H. Janssen

Ir F.C.T. Guiking

- Department of Soil Science and Geology:

Prof. dr J. Bouma

Dr P.M. Driessen

Ir D. Legger

- Department of Tropical Crop Science:

Dr L.O. Fresco

Institute for Soil Fertility, Haren

Dr K.W. Smilde

International Agricultural Centre, Wageningen

Ir C.D. Konstapel

International Soil Reference and Information Centre, Wageningen

Ir J.H. Kauffman

Larenstein International Agricultural College, Deventer

Ir R.A. Leyder

Research Station for Cattle, Sheep and Horse Husbandry, Lelystad

Ir S. Schukking

Ir A.P. Wouters

Royal Tropical Institute, Amsterdam

Dr F. van der Pol

Winand Staring Centre, Wageningen

Drs. R.F. van de Weg

Ir W. Andriessse

Ir C.A. van Diepen

1 INTRODUCTION

When food shortages in Africa hit the headlines, they are generally attributed to either extremely low rainfall or to excessively high rainfall, accompanied by flooding and erosion. As their effects are rather abrupt and dramatic, these calamities receive worldwide press coverage. At present, such environmental aspects are mapped and monitored on a continental scale (for example through the UNEP Global Environmental Monitoring System, and the FAO Early Warning Programme).

The decline in soil fertility, albeit not receiving similar press coverage, is an equally serious menace to future food production in Africa. Since the process of nutrient decline is more gradual, it is not readily linked to the malnutrition-related catastrophes of the recent past. Nonetheless, several studies have clearly shown that it is often the supply of plant nutrients that dictates the level of productivity of land (Qureshi, 1987; Haule et al., 1989; Twyford, 1988), even in the Sahelian area (Penning de Vries and Djiteye, 1982; Centre for World Food Studies, 1985). The temporal quantification of the dynamics of soil fertility is, however, a subject that has hardly been touched upon on a regional or global scale. In order to assess the rate of soil fertility decline and the future needs for fertilization, Food and Agriculture Organization of the United Nations (FAO) decided to try and gain more insight into this matter.

In addition, the Department of International Cooperation of the Winand Staring Centre for Integrated Land, Soil and Water Research, was requested by the Land and Water Development Division (AGL) of FAO, to assess the state of soil nutrient depletion in Sub-Saharan Africa,

- a. in the recent past (1983);
- b. in the near future (2000).

This assessment should provide, on a country basis, data on the net removal (depletion minus accumulation) of nutrients from the rootable soil layer. The present study, being of a general, exploratory nature, is entirely devoted to the macronutrients nitrogen (N), phosphorus (P), and potassium (K). Even though it is appreciated that secondary and micronutrients also limit crop production, they are not included at the present time.

The development of a method for this assessment is the focal point of this study. Production figures (1983) and forecasts (2000) were provided by FAO, per crop and per country, and further specified per mainly climate-based 'Land/Water Classes' (LWC). Similarly, data on fertilizer consumption were provided, but only as country totals (Section 2.2).

Next, factors determining the input and output of N, P, and K are defined and quantified for the smallest constituents of each LWC: the Land Use Systems (LUS, Section 3.1). The results for all countries per LWC and country are given in Section 4.1. As an example the N-balance per crop and LUS for Senegal, 1983 is given in Section 4.2. The procedure and results are discussed and evaluated in Chapters 5 and 6 respectively.

Volume 2 of this report provides the complete set of nutrient balances for 1983 and 2000, for all countries, per crop and per LUS.

Volume 3 describes the full calculation procedure; it also encompasses a list of all the Land Use Systems distinguished, and the raw data sets from the literature on which the estimates are based.

Volume 4 describes the computer programs developed for this study; they are written in Turbo-Pascal 5.0 and VAX-Pascal 3.5.

2 MATERIALS

2.1 Experts and literature

Two indispensable sources of information in shaping the methods were:

1. a group of Dutch scientists working in the field of tropical soil fertility and plant nutrition; in the course of the study, three rounds of discussion were organized with this group.
2. a plethora of literature: books, reports and articles from scientific journals dealing with one or more of the input and output factors.

2.2 The FAO database

All relevant information gathered by the FAO over the years concerning Africa was made available for the present study. It encompasses crop production figures from 38 African countries for the year 1983 as well as projections for the year 2000. The figures are further subdivided according to the so-called Land/Water Classes (LWC) as delimited in the FAO Agro-Ecological Zones Project (FAO, 1978). Information on 35 crops is taken from the publication 'Agriculture: towards 2000' (Alexandratos, 1988). Crops, countries and Land/Water Classes are listed in Tables 2.1-2.3. FAO also provided the data on N, P and K fertilizer consumption per crop. This data however is only available on a national basis.

Table 2.1 Crops included in the FAO data base

1. Wheat	19. Other fruit
2. Rice	20. Oil crops other than
3. Maize	21-26
4. Barley	21. Palm oil
5. Millet	22. Soybeans
6. Sorghum	23. Groundnuts
7. Other cereals	24. Sunflower seed
8. Potatoes	25. Sesame seed
9. Sweet potatoes and yams	26. Coconut
10. Cassava	27. Cocoa beans
11. Other roots	28. Coffee beans
12. Plantains	29. Tea
13. Beet ¹	30. Tobacco
14. Cane	31. Seed cotton
15. Pulses	32. Jute and hard fibres
16. Vegetables	33. Rubber
17. Bananas	34. Fodder
18. Citrus fruit	35. Other crops ¹

¹ Not relevant for Sub-Saharan Africa.

Table 2.2 Countries included in the FAO data base.

1. Angola	20. Malawi
2. Benin	21. Mali
3. Botswana	22. Mauritania
4. Burkina Faso	23. Mauritius
5. Burundi	24. Mozambique
6. Cameroon	25. Niger
7. Central African Republic	26. Nigeria
8. Chad	27. Rwanda
9. Congo	28. Senegal
10. Côte d'Ivoire	29. Sierra Leone
11. Ethiopia	30. Somalia
12. Gabon	31. Sudan
13. Gambia	32. Swaziland
14. Ghana	33. Tanzania
15. Guinea	34. Togo
16. Kenya	35. Uganda
17. Lesotho	36. Zaire
18. Liberia	37. Zambia
19. Madagascar	38. Zimbabwe

Table 2.3 Land/Water Classes included in the FAO data base (FAO, 1978).

Land/Water Class	Specification
Low rainfall, rainfed land (LR)	Rainfall providing 1-119 growing days and soil quality very suitable, suitable or marginally suitable
Uncertain rainfall, rainfed land (UR)	Rainfall providing 120-179 growing days and soil quality very suitable or suitable
Good rainfall, rainfed land (GR)	Rainfall providing 180-269 growing days and soil quality very suitable or suitable
Problem, rainfed land (PR)	Rainfall providing >269 growing days, and soil quality very suitable, suitable or marginally suitable; or rainfall providing 120-269 growing days and soil quality marginally suitable
Naturally flooded land (NF)	Land under water for part of the year and lowland non-irrigated paddy fields
Irrigated land (IR)	Fully and partially irrigated land

3 METHODS

3.1 The basic calculation units: Land Use Systems

Assumptions have to be made, describing and quantifying the various mechanisms that contribute to the flow of N, P and K into and out of the soil. This is the pivot stage of the exercise. A key decision in this respect is the further subdivision of Land/Water Classes into Land Use Systems (LUS). A Land Use System is defined as a well-defined tract of land with its pertinent Land Utilization Type (FAO, 1976). In this study, it is further assumed that a LUS is a homogeneous entity, which forms the basis for calculating nutrient balance.

A LUS is made up of the attributes listed in Table 3.1.

Each LWC is made up of one or more Land Use Systems. The description of a LUS is based on relevant, country-specific literature. A detailed account of this procedure is provided in Volume 3. As an example, Table 3.2 lists some Land Use Systems that were defined for Senegal.

Table 3.1 Attributes of Land Use Systems and their specification

Attribute	Specification
rainfall (R)	average for LWC, in mm/yr
soil fertility (F)	classes: 1-low; 2-moderate; 3-high
management level (L,H)	differentiated in low and high
fertilizer use	weighing factor 0.0 - 3.0, related to regional distribution of total national consumption;
manure application	0, 500, 1000, 1500 kg/ha,yr or 'during grazing';
residue removal	percentage of crop residues removed from the field or 'crop residues burned';
erosion	soil loss in ton/ha,yr;
crops	Table 2.1.

Table 3.2 Some Land Use Systems as defined for Senegal

LR	Rainfall	: 400 mm
	Soil fertility	: low
LR-L.1 ¹	Fertilizer use	: 0.2
	Manure applic.	: during grazing
	Residue removal	: 80%
	Erosion	: 10 ton/ha,yr
	Crops	: barl, mill, grou
UR	Rainfall	: 900 mm
	Soil fertility	: moderate
UR-L.2	Fertilizer use	: 0.3
	Manure applic.	: during grazing
	Residue removal	: 80%
	Erosion	: 10 ton/ha,yr
	Crops	: puls, grou
UR-L.4	Fertilizer use	: 1.0
	Manure applic.	: none
	Residue removal	: burning
	Erosion	: 15 ton/ha,yr
	Crops	: cott
GR	Rainfall	: 1200 mm
	Soil fertility	: moderate
GR-L.2	Fertilizer use	: 1.0
	Manure applic.	: none
	Residue removal	: 95%
	Erosion	: 15 ton/ha,yr
	Crops	: grou
PR	Rainfall	: 900 mm
	Soil fertility	: low
PR-L.1	Fertilizer use	: 1.0
	Manure applic.	: none
	Residue removal	: 20%
	Erosion	: 10 ton/ha,yr
	Crops	: rice, barl, mill, puls, grou
IR	Rainfall	: 600 mm
	Soil fertility	: high
IR-H.1	Fertilizer use	: 2.5
	Manure applic.	: none
	Residue removal	: 75%
	Erosion	: 0 ton/ha,yr
	Crops	: puls

¹ Land Use System nr.1, under low management (L) in the low rainfall area (LR)

3.2 The model

At any one time, a certain amount of organic and inorganic N, P and K is present in the soil, either in stable or labile, plant-available forms. When measured one year later, these amounts are not necessarily the same. This is due to various processes that cause nutrients to flow into and out of the rootable soil layers. In spite of the relatively 'volatile' nature of the many factors affecting soil fertility, a relatively simple model should serve the purpose of simulating the processes. The input and output factors considered in this study are listed in Table 3.3 and presented in Figure 3.1.

Table 3.3 Input and output factors governing nutrient flows in the soil (in kg/ha,yr).

Input	Output
IN 1 Mineral fertilizers	OUT 1 Harvested product
IN 2 Manure	OUT 2 Crop residues
IN 3 Deposition	OUT 3 Leaching
IN 4 Biol. N fixation	OUT 4 Gaseous losses
IN 5 Sedimentation	OUT 5 Erosion

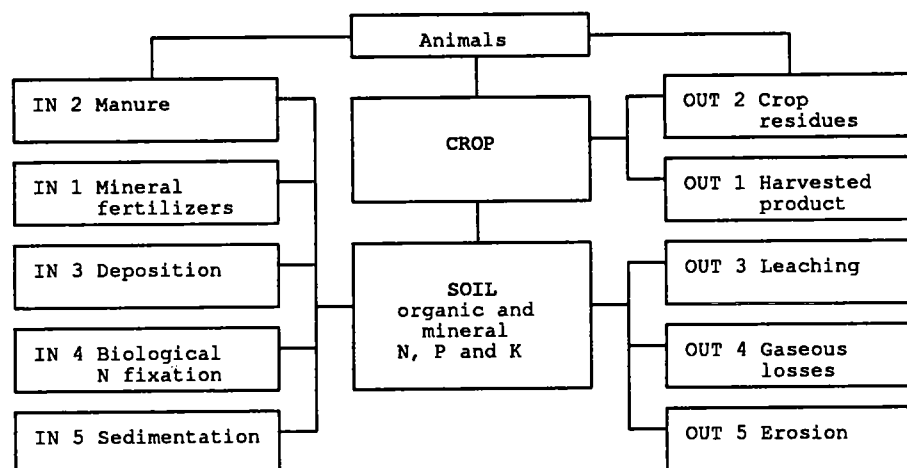


Figure 3.1 Nutrient flows in the soil.

Five input and five output factors are taken into account in this study. Eight factors have a clearcut role in enriching (IN) or depleting (OUT) the soil. Two factors (IN 2 Manure and OUT 2 Crop residues) can interact, since livestock in Africa largely feeds on crop residues. Consequently, part of the crop residues is only temporarily removed, being returned later as manure.

In the following paragraphs, the different factors are quantified on the basis of expert knowledge and data from the literature. The raw data and data sources are given in Volume 3. The explanations of the calculation procedures are augmented by Examples, that in all cases refer to the Senegalese LUS UR-L.2 (Table 3.2).

3.2.1 Mineral fertilizers (IN 1)

The FAO database contains information on the actual total fertilizer consumption per crop per country for 1983, as well as projections for the year 2000. These data however, are not specified per Land/Water Class. Hence, the total amount should be distributed over the Land/Water Classes. Two situations arise:

1. the literature provides raw data on regional distribution of fertilizers within a country; if so, these data are used.
2. such information was not found; in which case the assumption is made that the use of fertilizers is not evenly distributed within a country, and each LUS is given a weighing factor as indicated in Table 3.4.

Table 3.4 Weighing factors for calculating mineral fertilizers (IN 1) per Land Use System

Land/Water Class	Weighing factor	
	low management	high management
Low rainfall	0.2	0.4
Uncertain rainfall	0.6	1.2
Good rainfall	1.0	2.0
Problem area	1.0	2.0
Naturally flooded	0.6	1.2
Irrigated area	1.5	3.0

Example

The nitrogen input in LUS UR-L.2 in Senegal in 1983 is calculated. The two crops in this LUS are pulses and groundnuts. Total national fertilizer input for the two crops as given in the FAO data base, is 0 ton and 3500 tons respectively. The weighing factors for the regional distribution of fertilizer in Senegal are based on data from the literature (Vol. 3). For groundnut growing Land Use Systems in Senegal, the weighing factors are 0.2 (LR), 0.3 (UR), 1.0 (GR) and 1.0 (PR) (Table 3.2).

Groundnut is grown in four LWC's: LR (286,000 ha), UR (856,000 ha), GR (51,000 ha) and PR (60,000 ha). The fertilizer input for groundnuts in the LWC UR can now be calculated:

$$\begin{array}{rcl}
 \text{LR} & : & 0.2 * 286,000 * A \text{ kg} \\
 \text{UR} & : & 0.3 * 856,000 * A \text{ kg} \\
 \text{GR} & : & 1.0 * 51,000 * A \text{ kg} \\
 \text{PR} & : & 1.0 * 60,000 * A \text{ kg} \\
 \hline
 & & 425,000 * A \text{ kg} = 3,500,000 \text{ kg}
 \end{array}$$

Hence, $A = 8.2 \text{ kg/ha}$ and
 $\text{IN 1 (groundnut, UR-L.2)} = 0.3 * 8.2 \text{ kg/ha} = 2.4 \text{ kg/ha}$.

In the LWC UR an acreage of 9,000 ha is grown with pulses, which are not fertilized in Senegal. Hence,
 $\text{IN 1 (pulses, UR-L.2)} = 0 \text{ kg/ha}$.

The total nitrogen input IN 1 for LUS UR-L.2 is:

$$\frac{(0 * 9,000)_{\text{pulses}} + (2.4 * 856,000)_{\text{groundnuts}}}{865,000} = 2.4 \text{ kg N/ha, yr.}$$

3.2.2 Manure (IN 2)

Even though livestock is an essential element of African farming, extensive grazing is not considered in the present study. Only arable land is taken into account. However, in the LUS description two forms of manuring occur:

1. manure collection from bomas, kraals and other storage places, and application to arable fields prior to planting. (LUS 0, 500, 1000 or 1500 kg manure/ha)
2. on-the-spot manuring by livestock feeding on crop residues (LUS 'during grazing'; interaction with OUT 2).

Ad 1. LUS 0, 500, 1000 or 1500 kg manure/ha

- Amount of manure

Each LUS with a manure input, but without grazing on the arable field, is characterized by one of four classes indicating the amount applied to the fields. These amounts are set at 0, 500, 1000 and 1500 kg fresh weight/ha, yr.

- Chemical composition

Although the chemical composition of fresh manure varies widely according to its nature and moisture content, for calculation purposes it must be set at constant values for groups of Land/Water Classes. Based on (scarce) literature the subdivisions of Table 3.5 are made.

Table 3.5 Dry weight and chemical composition of manure in the Land/Water Classes (in % of fresh weight)

LWC	dry weight	N	P ₂ O ₅	K ₂ O
LR, UR, IR PR (<1200 mm/yr rain)	75	0.48	0.40	0.65
GR, NF PR (>1200 mm/yr rain)	50	0.42	0.35	0.55

Example

Knowing the amount of manure applied and its nutrient content (Table 3.5), IM 2 can be calculated. If, for example, 1000 kg/ha is applied in a LUS-UR, the nitrogen input is 0.0048 * 1000 = 4.8 kg N/ha,yr.

Ad 2. LUS 'during grazing'

If livestock feed on crop residues which have been left on the field, some of the manure input is realized 'during grazing'.

Three questions now need to be answered to arrive at a calculation:

1. What is the fraction of the crop residues that is grazed?
2. How many hours a day do the animals spend on the grazed field?
3. What is the fraction of the nutrients that remains inside the animals?

The answers have been stipulated as follows:

1. This differs for each LUS and is indicated as such in its description (for LUS UR-L.2 in Senegal, it is 80%);
2. 12 hours (fixed value for all LUS);
3. 10% (fixed value for all LUS).

Example

LUS UR-L.2 in Senegal is almost entirely made up of two crops: pulses and groundnuts. The LUS description of UR-L.2 indicates that 80% of the crop residues is removed during grazing. Data from OUT 2 crop residues are needed to calculate IM 2. Although the values for OUT 2 will be calculated in Paragraph 3.2.6 they are already used here.

OUT 2 (UR-L.2) equals 1.7 kg/ha,yr for pulses and 11.0 kg/ha,yr for groundnuts. 90% of the removed nutrients leaves the animals as manure and urine, half of which is dropped on the grazed field, resulting in 45% of the nutrients of OUT 2 to return through IM 2. The calculation of IM 2 (UR-L.2) can now be completed:

$$\frac{\Sigma (\text{OUT 2} * \text{AREA})}{\text{TOTAL AREA}} * 45\% =$$

$$\frac{(1.7 * 9,000)_{\text{pulses}} + (11.0 * 856,000)_{\text{groundnuts}}}{865,000} * 0.45 = \underline{4.9 \text{ kg N/ha,yr.}}$$

Note

A special case is fodder. The harvested product of fodder is grazed, like the crop residues in a LUS 'during grazing'. The same three questions now need to be answered:

1. The fraction of the harvested product fodder that is grazed is set at 80% in all cases. Consequently will OUT 1 equal 80% of the nutrients in the harvested product.
 2. The animals spend 12 hours on the grazed fodder.
 3. 10% of the nutrients will remain in the animal.
- It can be concluded that 45% of the nutrients in OUT 1 will return to the system by Manure (IN 1).

3.2.3 Deposition (IN 3)

Considerable amounts of nutrients are supplied to soils by the processes of wet and dry deposition. Due to a very uneven distribution of data over the continent, the calculation procedure is split into two, relating to:

1. areas within Harmattan influence (West Africa): the literature provides sufficient point data to allow interpolation.
2. areas outside Harmattan influence: data on the factors themselves are scarce, but there is a correlation with rainfall; regression analysis for the different nutrients resulted in the equations listed below. They are used to calculate the contribution to soil fertility by IN 3 for areas outside Harmattan influence.

$$\begin{aligned} \text{IN 3 (N)} &= 0.14 * (\text{rainfall})^{\frac{1}{2}} \\ \text{IN 3 (P}_2\text{O}_5) &= 0.053 * (\text{rainfall})^{\frac{1}{2}} \\ \text{IN 3 (K}_2\text{O)} &= 0.11 * (\text{rainfall})^{\frac{1}{2}} \end{aligned}$$

(IN in kg/ha,yr; rainfall in mm/yr).

Example

In LUS UR-L.2 in Senegal, average annual rainfall is 900 mm. On the basis of the regression equation this would yield a deposition of $0.14 * 30 = 4.2 \text{ kg N/ha,yr}$. Since Senegal is in the Harmattan area, direct calculation from point data is possible.

3.2.4 Biological N fixation (IN 4)

N₂ from the atmosphere is an important source of nitrogen in several agricultural systems. Leguminous species and wetland rice draw considerably from this source. Based on information from the literature, three stipulations could be presented, depending on total N demand by crops as laid down in Table 3.7.

1. Of the total nitrogen demand of leguminous crops (soybean, groundnuts and pulses) 60% is supplied through symbiotic N fixation (Rhizobia).

2. Of the total nitrogen demand of wetland rice (LWC NF and IR) 80% is supplied through chemo-autotrophic N fixation (Azolla, other algae), up to a maximum of 30 kg/ha,yr. Higher uptakes are drawn from soil N.
3. All crops benefit from N that is fixed non-symbiotically (Azotobacter, Beyerinckia, Clostridium) or by N-fixing trees that are left on the field (Rhizobia, Actinomycetes).

The latter contribution is partitioned in Table 3.6 according to LWC.

Table 3.6 Contribution of scattered trees and of non-symbiotic N fixation to Biological N-fixation (in kg N/ha)

LWC	Input
low rainfall	3
uncertain rainfall	4
good rainfall	5
problem area - >1200 mm rain/yr	5
- <1200 mm rain/yr	2
naturally flooded	2
irrigated area	2

Example

LUS UR-L.2 in Senegal comprises leguminous crops (pulses and groundnuts). According to stipulation 1 above, 60% of the total uptake of nitrogen is supplied by biological N fixation. For OUT 1 and OUT 2 the total uptake of nitrogen is calculated in Paragraphs 3.2.6 and 3.2.7. These values are used for calculating IN 4.

Total uptake of nitrogen by pulses (UN_{pulses}) is 6.1 kg N/ha,yr. Of this amount 60% will be supplied by biological N fixation. A certain 'base' amount of N fixation is fixed non-symbiotically. According to Table 3.6, the latter is 4 kg N/ha,yr. IN 4 (UR-L.2, pulses) can now be calculated:

$$\text{'base'} + 60\% * UN_{pulses} = 4 + 0.6 * 6.1 = 8 \text{ kg N/ha,yr.}$$

Total uptake of nitrogen by groundnuts ($UN_{groundnuts}$) is 39.7 kg N/ha,yr. The calculation procedure is the same as for pulses. IN 4 (UR-L.2, groundnuts) will be:

$$\text{'base'} + 60\% * UN_{groundnuts} = 4 + 0.6 * 39.7 = 28 \text{ kg N/ha.}$$

For LUS UR-L.2 the average biological N fixation is:

$$\frac{(\text{AREA} * IN 4)_{pulses} + (\text{AREA} * IN 4)_{groundnuts}}{\text{TOTAL AREA}} =$$

$$\frac{(9,000 * 8) + (856,000 * 28)}{865,000} = 28 \text{ kg N/ha,yr.}$$

3.2.5 Sedimentation (IN 5)

In parts of the LWC 'naturally flooded', sedimentation takes place. Hardly any information on the nutrient content of this sediment could be traced. Still, an assumption must be made on the importance of this input factor. After discussions, the group of experts reached consensus on a nutrient balance being in equilibrium in this LWC. Input and output factors are calculated, but the deficit (IN 5) is assumed to be supplied by the floodwater and its sediment.

In LWC 'irrigated area', the nutrient content of the irrigation water is also considered as an input factor. Literature and consultations led to the assumption that, on average, 300 mm of irrigation water per ha,yr is supplied to irrigated land. The calculation of IN 5 is now governed by the concentration of the three macronutrients in this amount of water. Limited information on this aspect indicates that the following values can be used:

N: 10 kg/ha,yr,
 P₂O₅: 3 kg/ha,yr,
 K₂O: 5 kg/ha,yr.

Example

IN 5 is only applicable to the Land Water Classes NF and IR. The input to LUS UR-L.2 in Senegal is thus 0 kg/ha,yr.

3.2.6 Harvested product (OUT 1)

Different crops withdraw different amounts of the various nutrients from the soil. A good deal of literature is available on this subject. The complete listing of raw data on N, P and K uptake in the harvested parts of crops and in their above-ground residues is given in Volume 3. Average values for each crop (excluding outliers) are given in Table 3.7. In order to obtain an estimate of OUT 1, the data in this Table should be combined with the production figures provided by FAO.

$$\text{OUT 1} = \frac{\Sigma (\text{area} * \text{content} * \text{yield})}{\text{total area}}$$

Example

For LUS UR-L.2 in Senegal (1983), the nitrogen withdrawn by the harvested product (pulses and groundnuts) can be calculated by combining the relevant data from the FAO database with those from Table 3.7. OUT 1 equals:

$$\frac{(9,000 * 20.0 * 0.2)_{\text{pulses}} + (856,000 * 37.2 * 0.7)_{\text{groundnuts}}}{865,000} = \underline{25.8 \text{ kg N/ha,yr.}}$$

Note

The crop 'Fodder' is grazed by animals. It is assumed that only 80% of the nutrients in fodder actually leaves the system through OUT 1.

Table 3.7 N,P and K content of harvested product and crop residues
(in kg/ton harvested product)

Crop	Harvested Product			Crop residues (minimum - maximum)		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
Wheat	22.3	9.9	7.0	4.3	4.1	32.0
Rice	11.6	7.8	4.1	9.0-13.6	3.6-7.0	34.0-51.8
Maize	16.8	9.4	5.7	7.6-11.8	3.0-5.8	23.0-28.4
Barley	15.5	6.4	7.2	7.0	2.3	25.2
Millet	19.2	13.7	6.5	16.1-24.6	8.4-9.8	66.3-77.1
Sorghum	14.5	12.6	4.5	8.1-13.5	7.8-13.2	30.5-39.5
O cereals	16.7	10.1	5.8	8.2-13.6	4.2-6.4	27.0-38.6
Potatoes	4.4	3.0	8.3	2.3	1.6	5.4
S. potatoes	4.8	1.8	8.8	2.1	2.7	3.9
Cassava	4.2	1.1	5.1	2.4-6.8	0.7-3.5	1.6- 1.8
Other roots	4.6	0.7	3.5	1.9	1.1	3.7
Plantain	0.7	0.2	4.1	1.2	0.7	7.7
Beet	not relevant for Sub-Saharan Africa					
Cane	0.6	0.5	1.4	0.3	0.7	0.4
Pulses	20.0	7.8	13.3	10.4	2.3	15.7
Vegetables	9.0	2.1	3.1	3.2	3.2	9.4
Bananas	1.2	0.7	5.4	1.6	0.7	14.3
Citrus	1.8	0.5	2.8	0.6	0.5	5.3
Other fruit	2.0	0.5	2.4	1.8	0.5	5.9
Oil crops	2.6	1.1	5.3	0.3	1.4	6.5
Palm oil	2.9	1.6	4.9	3.3- 4.1	1.2- 1.4	2.5- 5.5
Soybeans	62.1	25.1	24.0	13.0-22.2	6.3- 7.3	16.4-18.2
Groundnuts	37.2	13.7	9.8	12.2-19.6	2.8- 8.2	11.6-24.2
Sunflowers	24.0	8.0	6.6	23.0	7.3	49.6
Sesam	30.0	14.0	8.1	15.0	12.4	25.3
Coconut	61.0	16.5	11.8	27.0	13.1	30.4
Cacao	40.0	19.5	23.1	19.9	10.8	39.9
Coffee	35.0	6.0	20.2	4.3	8.7	11.1
Tea	35.0	8.7	16.1	0.1	0.0	0.0
Tobacco	56.0	18.8	87.2	0.1	0.0	0.2
Cotton	18.7	22.2	10.8	11.4-16.4	11.1-16.7	31.4-40.2
Fibres	5.0	0.9	7.2	2.1	1.6	10.8
Rubber	6.9	2.7	5.5	1.0	0.5	4.8
Fodder	6.8	3.0	5.7	0.0	0.0	0.0
Other crops	not relevant for Sub-Saharan Africa					

3.2.7 Crop residues (OUT 2)

- Residue removal

An estimate of the amount of crop residues removed from the arable field is obtained from the literature. It was found that farmers' attitude towards utilizing crop residues differs greatly among and even within the countries studied.

The actual removal is given in the LUS-description. The removal can be complete (e.g. if used for fuel, roofing, manufacturing) or incomplete (e.g. if grazed or burned).

If there is grazing, this is mentioned in the LUS description. The effect of grazing on soil fertility is outlined in IN 2, and calculated for LUS UR-L.2 in Senegal.

Burning practices are very difficult to portray on a continental scale. In this text, it is only the residues of COTTON, which are assumed to be burned completely for reasons of field hygiene. Removal of N and K through burning is calculated in OUT 3 and 4.

- Nutrient content

A complete raw data set on the uptake of nutrients by above-ground crop residues is given in Volume 3. Average values (and, for several crops, ranges) of the amount of nutrients in crop residues per ton harvest are given in Table 3.7. Whenever ranges are given, the general level of management and thus the LUS description is used. The lower value of the range (few nutrients in residue per ton harvested product) represents a high level of management, whereas the higher value represents a low level of management. More favourable grain/straw ratios related to genetic improvements are the reason for these differences.

For groundnuts in Table 3.7, this implies that the value of 12.2 kg N/ton harvest is valid for each LUS-H and 19.6 kg N/ton harvest is valid for each LUS-L.

For the calculation of OUT 2 the following formula can be used:

$$\text{OUT 2} = \frac{\sum (\text{area} * \text{content} * \text{yield})}{\text{Total area}} * 80\%$$

Example

The residue nutrient contents of Table 3.7 must be combined with the amount of residues removed to calculate OUT 2.

LUS UR-L.2 in Senegal has a residue removal of 80% for the crops pulses and groundnuts (Table 3.2). The nitrogen withdrawn can be calculated by combining data from the FAO database with those from Table 3.7. OUT 2 equals:

$$\frac{(9,000 * 10.4 * 0.2)_{\text{pulses}} + (856,000 * 19.6 * 0.7)_{\text{groundnuts}}}{865,000} * 0.8 = 10.9 \text{ kg N/ha, yr}$$

3.2.8 Leaching (OUT 3)

Leaching is a significant loss mechanism for some nutrients. In tropical soils, phosphorus is often tightly bound by soil particles. In this study, leaching is therefore only assumed to play a part with respect to nitrogen and potassium. Research on leaching is mainly confined to point observations, which have an uneven distribution over the continent. These few data are not enough to support a model which should have a spatial significance. Therefore, the literature was extensively reviewed (Volume III) and it provided, together with expert consultations, clues for correlation. Multiple regression showed that leaching is positively correlated with:

R : rainfall (annual average, mm),
 F : soil fertility class
 (1 low; 2 moderate; 3 high),
 IN 1 + IN 2 : total application of fertilizer and manure (LUS-specific, in kg/ha,yr),

and negatively correlated with:

UN, UK : total uptake of N and K₂O respectively (crop and yield-specific, see Table 3.7 in kg/ha,yr).

The following regression equations were found (in kg/ha,yr):

OUT 3 (N) =

$$2.3 + (0.0021 + 0.0007 * F) * R + 0.3 * (IN\ 1 + IN\ 2) - 0.1 * UN$$

OUT 3 (K₂O) =

$$0.6 + (0.0011 + 0.002 * F) * R + 0.5 * (IN\ 1 + IN\ 2) - 0.1 * UK$$

Example

LUS UR-L.2 in Senegal (Table 3.2) has a moderate fertility (F = 2), an average annual rainfall of 900 mm, IN 1 + IN 2 is (2.4 + 4.9) = 7.3 kg/ha, and UN = (25.8 + 13.6) = 39.4 kg/ha.

Hence, OUT 3 (N) =

$$2.3 + (0.0021 + 0.0007 * F) * R + 0.3 * (IN\ 1 + IN\ 2) - 0.1 * UN =$$

$$2.3 + (0.0021 + 0.0007 * 2) * 900 + 0.3 * (7.3) - 0.1 * 39.4 = \underline{3.7\ kg/ha,yr}.$$

Note

1. A special case is cotton, which loses 50% of the residue-K through leaching, after burning practices.
2. For the extensive areas of Vertisols in the Sudan, K-leaching is set at 0%.

3.2.9 Gaseous losses (OUT 4)

Nitrogen is lost to the atmosphere by two processes: denitrification and volatilization.

Denitrification is a process which takes place under anaerobic conditions. A soil does not have to be entirely saturated for denitrification to be set in motion. A moist soil already loses nitrate through microbial processes in wet films and pockets.

The loss through denitrification is expected to be greatest in wet climates, on highly fertilized and clayey soils, and for crops which withdraw relatively small amounts of nitrogen.

Ammonia volatilization is another loss mechanism. It plays a role mainly in alkaline environments. Because such soils are not very common in sub-Sahara Africa, volatilization and denitrification are not treated separately.

In general, information on both factors is scarce and unevenly distributed. Therefore, correlations were looked for once again. Multiple regression analysis provided the following equation for the output factor (in kg/ha,yr):

$$\text{OUT 4 (N)} = \text{'Base'} + 2.5 * F + 0.3 * (\text{IN 1} + \text{IN 2}) - 0.1 * \text{UN}$$

In which:

'Base': a constant value, covering relative wetness of the soils specific for Land/Water Classes (Table 3.8).
 F : soil fertility class (1 low; 2 moderate; 3 high),
 IN 1 + IN 2 : total application of fertilizer and manure (LUS-specific, see Table 3.2; in kg/ha,yr),
 UN : total uptake of nitrogen (crop and yield specific, see Table 3.7; in kg/ha,yr).

Table 3.8 'Base' denitrification per LWC (in kg/ha,yr).

LWC	Denitrification
low	3
uncertain	5
good	8
problem - >1200 mm rainfall	12
- <1200 mm rainfall	5
naturally flooded	12
irrigated	11

Example

LUS UR-L.2 (Senegal) has a moderate soil fertility of class 2, a total fertilizer and manure input of 7.3 kg/ha, a 'base' denitrification of 5 kg/ha, and an uptake of 39.4 kg/ha.

Hence, OUT 4 is

$$\begin{aligned} \text{'Base'} + 2.5 * F + 0.3 * (\text{IN 1} + \text{IN 2}) - 0.1 * \text{UN} &= \\ 5 + 2.5 * 2 + 0.3 * 7.3 - 0.1 * 39.4 &= \underline{8.3 \text{ kg N/ha,yr.}} \end{aligned}$$

Note

In the special case of burning of cotton residues, all nitrogen is lost through volatilization.

3.2.10 Erosion (OUT 5)

- Total soil loss

Research findings on the soil loss through erosion are reasonably well documented for most countries. An estimate of soil loss based on this information is given in the description of each LUS.

- Soil fertility

A soil with a high fertility has more to lose than a poor soil. Table 3.9 lists the assumed nutrient contents of eroded soil material of the three fertility classes. These classes are indicated in the LUS description (Table 3.9). They have been used before to assess OUT 3 (leaching) and OUT 4 (gaseous losses).

Table 3.9 Nutrient contents of eroded soil at three levels of soil fertility (in %)

Soil fertility class	N	P ₂ O ₅	K ₂ O
1	0.05	0.02	0.05
2	0.1	0.05	0.1
3	0.2	0.1	0.2

- Nutrient loss

The difficult point is the assessment of the nutrient content in the eroded soil material. Based on the limited literature available on this particular subject a so-called 'enrichment factor' was established. As the finest soil particles are the first to be dislodged during erosion, eroded soil material tends to contain more nutrients than the original soil. In the present study, the enrichment factor is set at 2.0 for N, P and K, implying that the ratio between the nutrient content of the eroding soil material and the nutrient content of the original soil material is 2.

As topsoil erodes, the roots of crops start entering layers which were previously beyond the root zone. Hence, part of what is lost on top, is gained at the bottom of the described system. The implication being that the calculated P and K losses through erosion are partially offset by the downward extension of the root zone. The contributions are set at 25% of the calculated losses for the two elements.

Example

LUS UR-L.2 (Table 3.2) is subjected to an annual soil loss of 10 ton/ha, while the area has a moderate soil fertility. This results in an N loss through erosion of:

$$\text{enrichment factor} \times \text{N concentration} \times \text{soil loss} = \\ 2 \quad \times \quad 0.001 \quad \times \quad 10,000 = \underline{20 \text{ kg/ha.yr.}}$$

$$\text{The P}_2\text{O}_5 \text{ loss through erosion will be} \\ 2 \quad \times \quad 0.0005 \quad \times \quad 10,000 = \underline{10 \text{ kg/ha.yr.}}$$

Compensating for the extension of the root zone, only 75% of OUT 5 (P₂O₅) will be used in the balance = 0.75 * 10 = 7.5 kg/ha.yr.

3.2.11 Cropping intensity

The FAO database provides acreages of both harvested land and total arable land for each Land/Water Class. The ratio between the two, expressed as a percentage, is called the 'cropping intensity' (CI). If this ratio is less than 100%, part of the arable land is considered fallow. Its hectareage is calculated as follows:

Fallow area= $((100/CI) - 1) * \text{Harvested area (in ha)}$

During a fallow period, a gradual build-up of nutrients takes place. IN 3, IN 4 and IN 5 provide external contributions to soil fertility. In addition, part of the plant-available nutrients is retained in the fallow biomass instead of being leached or eroded. During years of fallow, the on-going processes of weathering and mineralization do not increase the total amount of nutrients in the soil, but they replenish the labile pools of the nutrients.

On the other hand, woody species from a fallow are often used as a source of fuel or sold along the roadside (OUT 1), a fallow is partly depleted by grazing animals that do not return all they have taken (OUT 2-IN 2), and the slash and burn practices prior to cultivation strongly enhance the loss processes OUT 3-5. Also, extra input in West-Africa through deposition of dust (IN 3) is offset by extra output due to the scarcity of fuelwood (OUT 1) in that region.

These considerations, combined with findings in literature and expert consultations, led to the decision to set the nutrient input by fallow at fixed values of 2 kg N, 2 kg P₂O₅, and 1 kg K₂O/ha.yr, irrespective of the LUS.

If cropping intensity equals 100%, the fallow acreage is set at 0 ha. If the cropping intensity exceeds 100%, multiple cropping takes place and it is assumed that there is no fallow. In this case the harvested areas and yields of the annual crops are adapted so that the total area equals the arable area and the total production remains the same.

Example

The cropping intensity for the uncertain rainfall area in Senegal is 45% . The total harvested area is 1,436,000 ha. The fallow area will then be 1,755,100 ha.

For 38 countries in Sub-Saharan Africa the nutrient balances per crop and per LUS were calculated. The complete set of results is presented in Volume II. For an example (the N-balance for Senegal, 1983) reference is made to Section 4.2. According to the original aim of this study the nutrient balances per crop and per LUS are merged into nutrient balances per LWC and per country, which are presented in Section 4.1. All values are rounded to kg/ha or ton/country.

The following abbreviations are used in the Tables and Figures of this chapter:

FERT:	Mineral fertilizers	(IN 1)
MANU:	Manure	(IN 2)
DEPO:	Deposition	(IN 3)
FIXA:	Biological N fixation	(IN 4)
SEDI:	Sedimentation	(IN 5)
PROD:	Harvested product	(OUT 1)
RESI:	Crop residues	(OUT 2)
LEAC:	Leaching	(OUT 3)
GASE:	Gaseous losses	(OUT 4)
EROS:	Erosion	(OUT 5)
FALL:	Fallow	

4.1 Nutrient balances per LWC and per country

All nutrient balances per LWC and per country are presented in this section. The nutrient balance of the countries is displayed graphically while the LWC distribution as well as the nutrient balances for the separate Land Water Classes are listed in Tables.

Figure 4.1 Nutrient balance for Angola, 1983 (in kg/ha,yr)

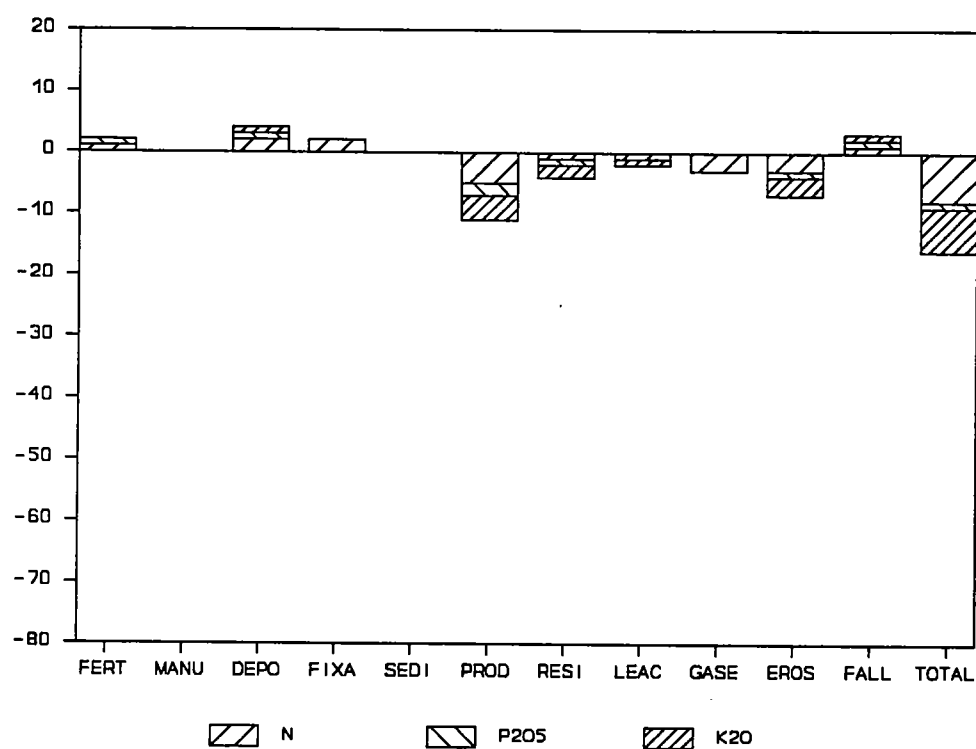


Table 4.1 LWC-distribution in Angola (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	5	15	66	13	2	0
2000	2	20	62	13	3	0

Table 4.2 Angola; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 200	16	89	97	135	0	221	197	117	303	400	320	-582 -3
	2000 125	18	163	133	209	0	420	361	148	404	550	140	-1220 -10
P205	1983 200	2	35	37	0	0	150	78	0	0	150	320	15 0
	2000 125	21	64	50	0	0	279	142	0	0	206	140	-351 -3
K20	1983 200	0	270	76	0	0	80	601	132	0	300	160	-607 -3
	2000 125	0	490	105	0	0	158	1089	201	0	412	70	-1195 -10
* UNCERTAIN RAINFALL													
N	1983 658	127	198	313	366	0	1080	522	296	696	1046	1159	-1477 -2
	2000 1036	238	333	451	550	0	2334	928	333	899	1456	1845	-2532 -2
P205	1983 658	85	81	118	0	0	531	228	0	0	392	1159	293 0
	2000 1036	231	138	171	0	0	1072	431	0	0	546	1845	336 0
K20	1983 658	7	579	246	0	0	708	1339	434	0	784	579	-1855 -3
	2000 1036	9	954	355	0	0	2044	2260	576	0	1092	922	-3732 -4
* GOOD RAINFALL													
N	1983 2897	1956	502	5340	6622	0	14425	3444	4590	10128	9750	3593	-24326 -8
	2000 3300	3631	894	6882	8887	0	24539	5556	5469	12980	12740	3762	-37227 -11
P205	1983 2897	1642	230	2021	0	0	5958	1879	0	0	2925	3593	-3276 -1
	2000 3300	3499	410	2605	0	0	10076	2978	0	0	3822	3762	-6600 -2
K20	1983 2897	108	1178	4195	0	0	12112	4443	3673	0	7312	1796	-20262 -7
	2000 3300	100	2129	5407	0	0	19270	7486	4438	0	9555	1881	-31232 -9
* PROBLEM AREA													
N	1983 567	937	0	1428	1521	0	5274	1394	1214	2961	3757	623	-10090 -18
	2000 684	1795	0	2033	2136	0	8928	2292	1594	3763	5246	642	-15218 -22
P205	1983 567	855	0	541	0	0	1878	738	0	0	1127	623	-1724 -3
	2000 684	1667	0	770	0	0	3330	1247	0	0	1574	642	-3073 -4
K20	1983 567	173	0	1122	0	0	5614	792	853	0	2818	312	-8470 -15
	2000 684	282	0	1597	0	0	9576	1393	995	0	3935	321	-13699 -20
* NATURALLY FLOODED													
N	1983 100	163	0	112	246	756	672	199	75	331	0	0	0 0
	2000 143	218	0	160	366	963	858	246	103	500	0	0	0 0
P205	1983 100	119	0	42	0	208	268	101	0	0	0	0	0 0
	2000 143	182	0	61	0	263	381	124	0	0	0	0	0 0
K20	1983 100	12	0	88	0	794	627	228	40	0	0	0	0 0
	2000 143	10	0	126	0	1000	719	366	51	0	0	0	0 0
* IRRIGATED AREA													
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0 0
* TOTAL													
N	1983 4422	3199	788	7289	8890	756	21672	5756	6292	14419	14953	5695	-36475 -8
	2000 5289	5901	1390	9659	12147	963	37078	9384	7647	18545	19992	6389	-56197 -11
P205	1983 4422	2702	346	2759	0	208	8786	3023	0	0	4594	5695	-4693 -1
	2000 5289	5601	612	3657	0	263	15139	4922	0	0	6148	6389	-9688 -2
K20	1983 4422	300	2027	5727	0	794	19140	7403	5132	0	11215	2847	-31194 -7
	2000 5289	402	3572	7590	0	1000	31767	12593	6262	0	14994	3194	-49858 -9

Figure 4.2 Nutrient balance for Benin, 1983 (in kg/ha,yr)

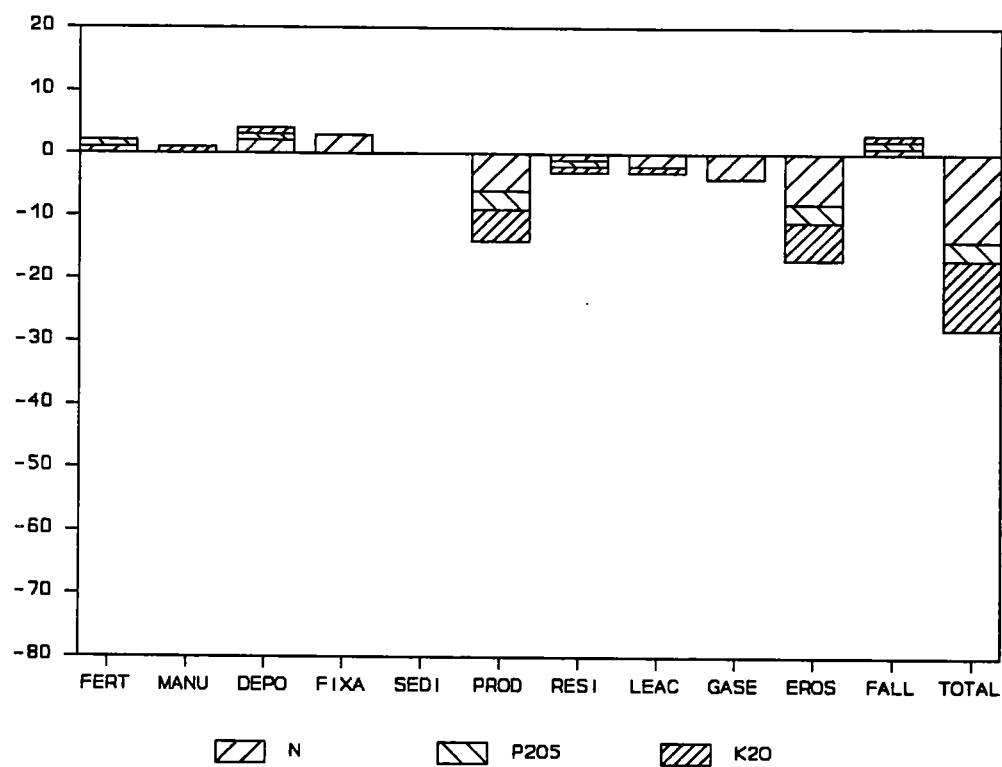


Table 4.3 LWC-distribution in Benin (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	7	57	35	0	0
2000	0	8	57	34	1	0

Table 4.4 Benin; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983 5	0	19	19	15	0	87	42	13	19	50	0	-158 -32
	2000 6	0	21	22	18	0	86	46	17	24	60	0	-172 -29
P205	1983 5	0	13	7	0	0	45	28	0	0	15	0	-68 -14
	2000 6	0	13	8	0	0	46	28	0	0	18	0	-71 -12
K20	1983 5	0	41	15	0	0	25	92	20	0	37	0	-118 -24
	2000 6	0	49	17	0	0	25	109	24	0	45	0	-137 -23
* UNCERTAIN RAINFALL													
N	1983 202	195	232	359	438	0	1052	413	417	785	2260	243	-3460 -17
	2000 274	382	304	412	522	0	1485	550	495	909	2570	361	-4028 -15
P205	1983 202	117	135	136	0	0	571	270	0	0	847	243	-1058 -5
	2000 274	221	178	156	0	0	778	373	0	0	964	361	-1198 -4
K20	1983 202	7	548	282	0	0	865	1052	513	0	1695	122	-3167 -16
	2000 274	23	714	324	0	0	1381	1391	572	0	1927	181	-4030 -15
* GOOD RAINFALL													
N	1983 1698	2194	577	3705	5683	0	13493	1360	2900	7204	18200	1868	-29131 -17
	2000 1914	5489	686	3991	7902	0	22318	2175	2844	7173	19490	2182	-33749 -18
P205	1983 1698	1273	289	1403	0	0	6611	1040	0	0	5460	1868	-8278 -5
	2000 1914	2863	343	1511	0	0	10313	1615	0	0	5847	2182	-10876 -6
K20	1983 1698	93	907	2911	0	0	10802	1933	2106	0	13650	934	-23646 -14
	2000 1914	379	1078	3136	0	0	16501	3175	1053	0	14617	1091	-29662 -15
* PROBLEM AREA													
N	1983 1052	294	0	1328	1512	0	3928	652	1210	3783	3700	1578	-8562 -8
	2000 1141	1460	0	1842	2307	0	9380	1330	1632	5093	5140	1551	-15415 -14
P205	1983 1052	193	0	503	0	0	1458	361	0	0	1387	1578	-933 -1
	2000 1141	781	0	697	0	0	3353	747	0	0	1927	1551	-2997 -3
K20	1983 1052	402	0	1043	0	0	2658	544	1504	0	2775	789	-5247 -5
	2000 1141	900	0	1448	0	0	6073	1191	1832	0	3855	776	-9829 -9
* NATURALLY FLOODED													
N	1983 10	6	0	39	116	138	101	18	42	139	0	0	0 0
	2000 25	337	0	112	406	331	458	92	178	458	0	0	0 0
P205	1983 10	4	0	15	0	59	64	14	0	0	0	0	0 0
	2000 25	76	0	42	0	233	293	58	0	0	0	0	0 0
K20	1983 10	1	0	30	0	143	81	57	37	0	0	0	0 0
	2000 25	2	0	88	0	549	290	325	23	0	0	0	0 0
* IRRIGATED AREA													
N	1983 4	15	0	19	48	40	142	17	5	36	0	0	-77 -17
	2000 8	246	0	34	94	70	381	57	47	102	0	1	-141 -19
P205	1983 4	15	0	7	0	12	50	12	0	0	0	0	-28 -6
	2000 8	70	0	13	0	21	168	36	0	0	0	1	-100 -13
K20	1983 4	0	0	15	0	20	49	57	0	0	0	0	-71 -16
	2000 8	0	0	27	0	35	133	203	0	0	0	1	-274 -36
* TOTAL													
N	1983 2972	2704	828	5468	7812	178	18804	2501	4587	11965	24210	3689	-41388 -14
	2000 3367	7915	1010	6413	11249	401	34108	4249	5213	13760	27260	4095	-53506 -16
P205	1983 2972	1602	436	2070	0	71	8799	1725	0	0	7710	3689	-10366 -3
	2000 3367	4011	534	2428	0	254	14951	2857	0	0	8756	4095	-15242 -5
K20	1983 2972	502	1497	4296	0	163	14480	3735	4179	0	18157	1844	-32249 -11
	2000 3367	1304	1841	5039	0	584	24403	6394	3505	0	20445	2048	-43931 -13

Figure 4.3 Nutrient balance for Botswana, 1983 (in kg/ha,yr)

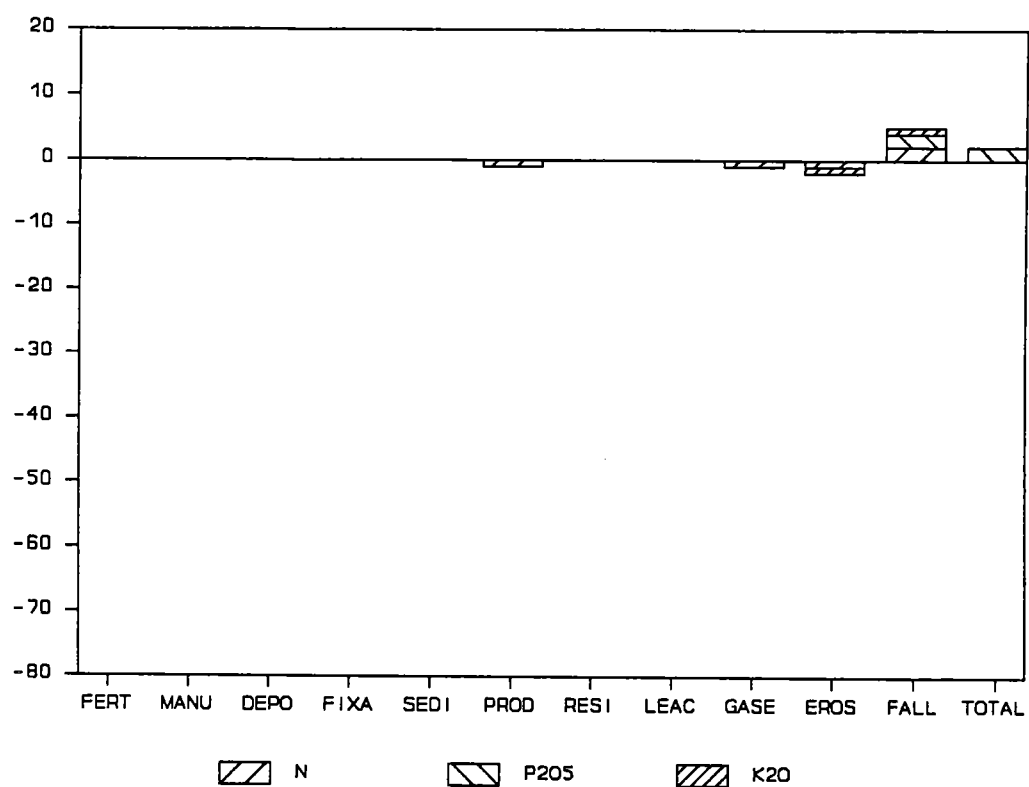


Table 4.5 LWC-distribution in Botswana (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	99	1	0	0	0	0
2000	99	1	0	0	0	0

Table 4.6 Botswana; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL	
	000 HA												(TON) (KG/HA)	
* LOW RAINFALL														
N	19831400	200	112	274	598	0	552	249	366	788	980	2604	853	1
	20001544	1428	517	692	1447	0	2137	1148	1126	2189	2470	2594	-2394	-2
P205	19831400	300	48	104	0	0	261	106	0	0	367	2604	2321	2
	20001544	1414	327	262	0	0	1277	726	0	0	926	2594	1667	1
K20	19831400	300	229	216	0	0	297	509	421	0	735	1302	85	0
	20001544	940	1261	543	0	0	979	2803	1268	0	1852	1297	-2861	-2
* UNCERTAIN RAINFALL														
N	1983 10	0	0	14	16	0	36	4	11	25	40	11	-74	-8
	2000 10	0	0	24	28	0	50	10	18	43	70	7	-132	-13
P205	1983 10	0	0	5	0	0	7	2	0	0	12	11	-4	0
	2000 10	0	0	9	0	0	17	3	0	0	21	7	-25	-2
K20	1983 10	0	0	11	0	0	24	8	6	0	30	6	-51	-5
	2000 10	0	0	19	0	0	14	21	5	0	52	3	-70	-7
* GOOD RAINFALL														
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
* PROBLEM AREA														
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
* NATURALLY FLOODED														
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
* IRRIGATED AREA														
N	1983 3	250	0	8	6	30	185	5	71	127	0	0	-94	-31
	2000 7	700	0	20	14	70	583	16	154	317	0	0	-266	-38
P205	1983 3	125	0	3	0	9	91	5	0	0	0	0	41	14
	2000 7	500	0	7	0	21	258	16	0	0	0	0	255	36
K20	1983 3	0	0	7	0	15	76	14	34	0	0	0	-102	-34
	2000 7	300	0	15	0	35	241	49	182	0	0	0	-122	-17
* TOTAL														
N	19831413	450	112	297	620	30	774	258	447	940	1020	2615	686	0
	20001561	2128	517	735	1489	70	2770	1174	1298	2549	2540	2600	-2792	-2
P205	19831413	425	48	112	0	9	359	113	0	0	379	2615	2358	2
	20001561	1914	327	278	0	21	1551	745	0	0	947	2600	1897	1
K20	19831413	300	229	233	0	15	397	531	460	0	765	1308	-68	0
	20001561	1240	1261	578	0	35	1234	2873	1456	0	1905	1300	-3053	-2

Figure 4.4 Nutrient balance for Burkina Faso, 1983 (in kg/ha,yr)

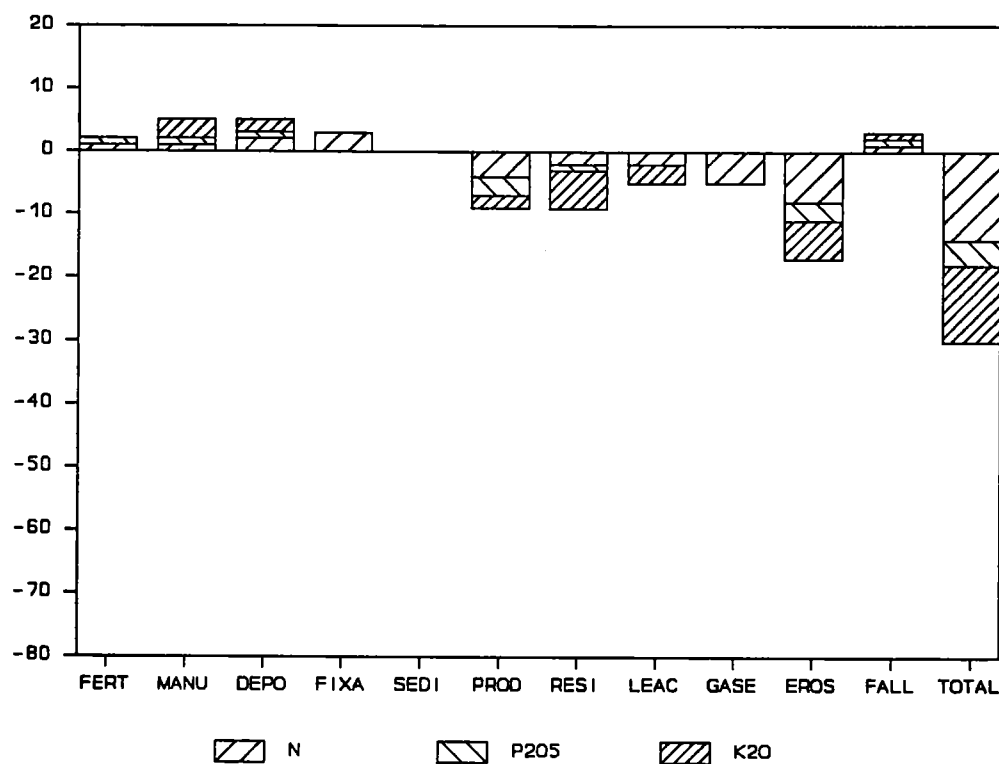


Table 4.7 LWC-distribution in Burkina Faso (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	9	60	20	11	1	0
2000	9	59	19	12	1	0

Table 4.8 Burkina Faso; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983 593	72	520	1303	1684	0	1721	1159	1680	4018	7940	391	-12547 -21
	2000 614	215	841	1330	1822	0	2631	1873	1670	4055	8100	417	-13704 -22
P205	1983 593	111	291	493	0	0	1104	649	0	0	2977	391	-3443 -6
	2000 614	256	452	503	0	0	1715	1007	0	0	3037	417	-4131 -7
K20	1983 593	47	1425	1024	0	0	687	3177	2029	0	5955	196	-9156 -15
	2000 614	104	2365	1045	0	0	984	5267	2254	0	6075	209	-10858 -18
* UNCERTAIN RAINFALL													
N	1983 3996	1812	5299	8620	12312	0	18788	11775	9706	20526	21460	3756	-50457 -13
	2000 4214	4750	8096	9433	15413	0	28816	17992	10598	22675	23615	3791	-62211 -15
P205	1983 3996	1877	3238	3263	0	0	12881	7196	0	0	8047	3756	-15990 -4
	2000 4214	4793	4878	3571	0	0	19487	10840	0	0	8856	3791	-22149 -5
K20	1983 3996	1505	14714	6772	0	0	7859	32698	14079	0	16095	1878	-45861 -11
	2000 4214	3119	22364	7412	0	0	12115	49698	17277	0	17711	1896	-62010 -15
* GOOD RAINFALL													
N	1983 1325	830	1897	3070	4122	0	5544	1331	4102	7249	22205	1536	-28976 -22
	2000 1379	2514	2261	3649	5410	0	11438	2835	4429	8210	26400	1434	-38044 -28
P205	1983 1325	867	948	1162	0	0	3588	791	0	0	8327	1536	-8192 -6
	2000 1379	2396	1130	1381	0	0	7505	1735	0	0	9900	1434	-12799 -9
K20	1983 1325	657	2981	2412	0	0	2275	3538	5364	0	16654	768	-21013 -16
	2000 1379	1662	3553	2867	0	0	4609	7678	5516	0	19800	717	-28803 -21
* PROBLEM AREA													
N	1983 704	181	0	827	1256	0	1155	209	784	1311	2955	1013	-3137 -4
	2000 867	897	0	1092	1749	0	2273	400	1095	1792	3900	1213	-4509 -5
P205	1983 704	272	0	313	0	0	760	120	0	0	886	1013	-169 0
	2000 867	921	0	413	0	0	1505	241	0	0	1170	1213	-368 0
K20	1983 704	86	0	650	0	0	461	577	376	0	2216	507	-2388 -3
	2000 867	334	0	858	0	0	881	1093	414	0	2925	607	-3514 -4
* NATURALLY FLOODED													
N	1983 60	195	0	130	376	439	354	82	176	528	0	0	0 0
	2000 65	663	0	302	1130	864	1054	246	420	1238	0	0	0 0
P205	1983 60	132	0	49	0	115	251	44	0	0	0	0	0 0
	2000 65	348	0	114	0	400	732	130	0	0	0	0	0 0
K20	1983 60	66	0	102	0	356	122	291	110	0	0	0	0 0
	2000 65	328	0	237	0	924	367	897	225	0	0	0	0 0
* IRRIGATED AREA													
N	1983 14	426	0	53	82	110	510	57	133	252	0	6	-274 -19
	2000 21	1158	0	97	200	200	1117	134	324	538	0	2	-458 -22
P205	1983 14	346	0	20	0	33	299	67	0	0	0	6	40 3
	2000 21	981	0	37	0	60	718	152	0	0	0	2	209 10
K20	1983 14	566	0	42	0	55	605	156	250	0	0	3	-346 -25
	2000 21	1661	0	76	0	100	1415	371	688	0	0	1	-637 -31
* TOTAL													
N	1983 6691	3516	7716	14004	19832	549	28072	14613	16580	33884	54560	6702	-95391 -14
	2000 7159	10197	11198	15903	25723	1064	47331	23481	18535	38507	62015	6858	-118926 -17
P205	1983 6691	3605	4478	5301	0	148	18883	8868	0	0	20238	6702	-27754 -4
	2000 7159	9695	6460	6020	0	460	31663	14105	0	0	22963	6858	-39237 -5
K20	1983 6691	2926	19120	11003	0	411	12010	40437	22209	0	40920	3351	-78764 -12
	2000 7159	7209	28282	12495	0	1024	20371	65005	26374	0	46511	3429	-105822 -15

Figure 4.5 Nutrient balance for Burundi, 1983 (in kg/ha,yr)

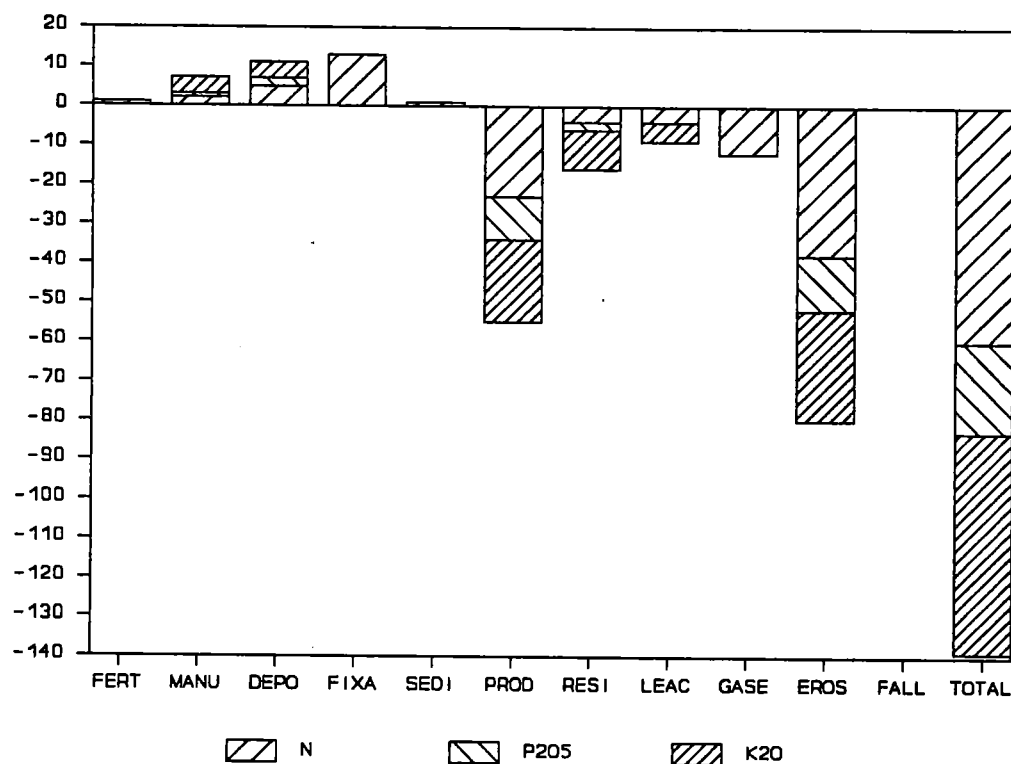


Table 4.9 LWC-distribution in Burundi (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	53	44	2	1
2000	0	0	51	46	2	1

Table 4.10 Burundi; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* GOOD RAINFALL													
N	1983	578	298	2352	2803	8379	0	13792	2749	2378	6102	27541	0 -38731 -67
	2000	606	775	2527	2940	11298	0	21564	4353	1665	5307	28657	0 -44005 -73
P205	1983	578	265	1176	1061	0	0	6511	1612	0	0	10328	0 -15948 -28
	2000	606	601	1264	1113	0	0	10110	2525	0	0	10747	0 -20404 -34
K20	1983	578	222	3695	2202	0	0	10022	5879	3219	0	20656	0 -33656 -58
	2000	606	470	3971	2310	0	0	15987	9562	2381	0	21493	0 -42673 -70
* PROBLEM AREA													
N	1983	475	296	287	2576	5130	0	10278	1567	2050	6441	13384	0 -25430 -54
	2000	554	878	356	3004	7155	0	16825	2599	1765	6807	15500	0 -32102 -58
P205	1983	475	228	143	975	0	0	4589	919	0	0	5019	0 -9181 -19
	2000	554	487	178	1137	0	0	7507	1517	0	0	5813	0 -13035 -24
K20	1983	475	272	450	2024	0	0	12115	5005	2067	0	10038	0 -26479 -56
	2000	554	695	560	2360	0	0	19949	8304	1651	0	11625	0 -37914 -68
* NATURALLY FLOODED													
N	1983	23	5	0	97	186	618	388	65	75	379	0	0 0 0
	2000	24	16	0	101	241	664	490	82	66	383	0	0 0 0
P205	1983	23	6	0	37	0	207	211	39	0	0	0	0 0 0
	2000	24	12	0	38	0	253	258	45	0	0	0	0 0 0
K20	1983	23	4	0	76	0	395	267	135	73	0	0	0 0 0
	2000	24	5	0	79	0	490	339	180	55	0	0	0 0 0
* IRRIGATED AREA													
N	1983	6	0	0	30	52	60	598	50	0	29	0	0 -535 -89
	2000	9	31	0	45	98	90	997	90	0	38	0	0 -860 -96
P205	1983	6	0	0	11	0	18	176	42	0	0	0	0 -189 -31
	2000	9	0	0	17	0	27	334	69	0	0	0	0 -359 -40
K20	1983	6	0	0	24	0	30	207	156	0	0	0	0 -310 -52
	2000	9	31	0	36	0	45	345	296	0	0	0	0 -529 -59
* TOTAL													
N	1983	1082	599	2638	5506	13747	678	25056	4431	4503	12951	40925	0 -64696 -60
	2000	1193	1700	2883	6091	18793	754	39876	7124	3496	12534	44158	0 -76967 -64
P205	1983	1082	499	1319	2085	0	225	11487	2612	0	0	15347	0 -25318 -23
	2000	1193	1099	1442	2306	0	280	18209	4156	0	0	16559	0 -33798 -28
K20	1983	1082	498	4146	4326	0	425	22611	11176	5359	0	30694	0 -60444 -56
	2000	1193	1201	4531	4785	0	535	36621	18342	4087	0	33118	0 -81116 -68

Figure 4.6 Nutrient balance for Cameroon, 1983 (in kg/ha,yr)

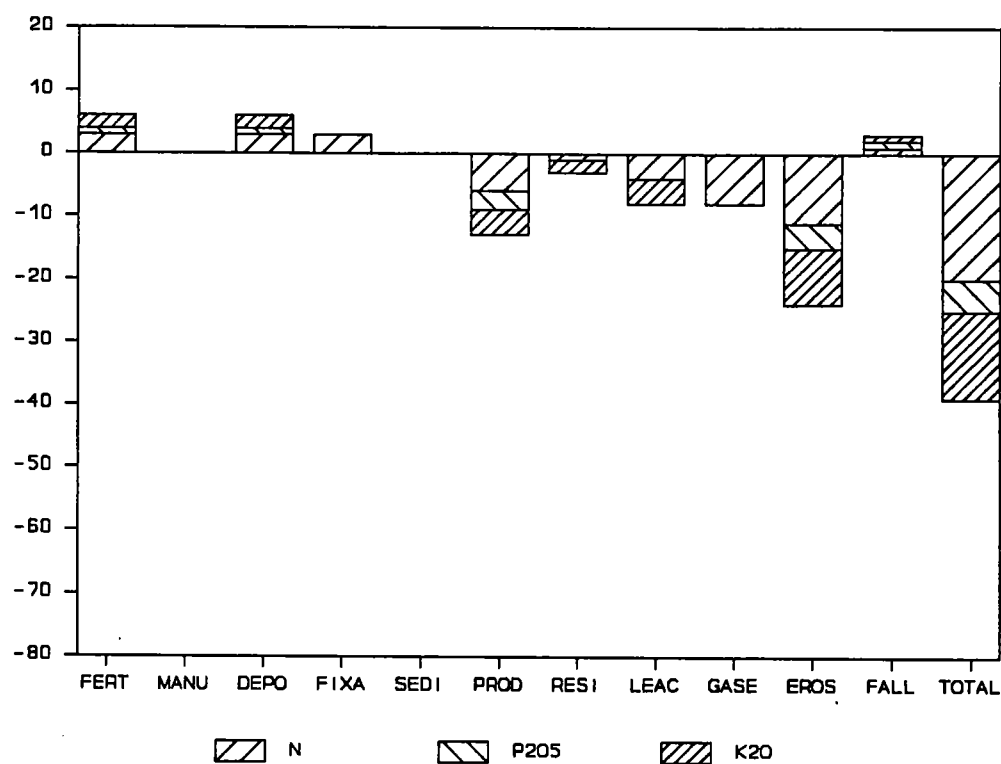


Table 4.11 LWC-distribution in Cameroon (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	4	12	83	1	0
2000	1	4	12	82	1	0

Table 4.12 Cameroon; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 37	21	37	89	103	0	274	84	63	93	96	26	-335 -9
	2000 52	52	46	96	119	0	366	105	67	99	104	52	-375 -7
P205	1983 37	6	15	34	0	0	166	35	0	0	29	26	-148 -4
	2000 52	17	19	36	0	0	211	44	0	0	31	52	-161 -3
K20	1983 37	7	110	70	0	0	96	250	29	0	72	13	-248 -7
	2000 52	19	136	76	0	0	129	312	28	0	78	26	-290 -6
* UNCERTAIN RAINFALL													
N	1983 302	917	98	748	960	0	2995	278	890	2308	5696	247	-9197 -30
	2000 345	1895	136	811	1112	0	3783	386	1141	2669	6176	303	-9898 -29
P205	1983 302	187	40	283	0	0	1538	140	0	0	2136	247	-3057 -10
	2000 345	452	57	307	0	0	1905	191	0	0	2316	303	-3294 -10
K20	1983 302	202	272	587	0	0	1638	748	1179	0	4272	124	-6651 -22
	2000 345	465	381	637	0	0	2098	1025	1278	0	4632	152	-7399 -21
* GOOD RAINFALL													
N	1983 906	4453	0	2607	4716	0	9288	1327	3400	6869	9650	833	-17925 -20
	2000 1124	10259	0	3838	8434	0	18702	2577	5324	10578	14245	809	-28085 -25
P205	1983 906	864	0	987	0	0	4708	617	0	0	3619	833	-6260 -7
	2000 1124	2400	0	1453	0	0	8943	1215	0	0	5342	809	-10838 -10
K20	1983 906	913	0	2048	0	0	4923	3180	3341	0	7237	417	-15304 -17
	2000 1124	2471	0	3016	0	0	9628	5903	4858	0	10684	404	-25181 -22
* PROBLEM AREA													
N	1983 6363	15353	0	17635	19087	0	35297	4381	23890	50610	72710	6617	-128197 -20
	2000 7536	35777	0	20884	25303	0	60167	7944	30303	61949	88000	7837	-158562 -21
P205	1983 6363	4912	0	6676	0	0	15337	2357	0	0	27266	6617	-26755 -4
	2000 7536	12184	0	7906	0	0	25610	4267	0	0	33000	7837	-34951 -5
K20	1983 6363	12002	0	13856	0	0	26780	9654	26276	0	54532	3308	-88076 -14
	2000 7536	28958	0	16409	0	0	44676	15984	34793	0	66000	3918	-112167 -15
* NATURALLY FLOODED													
N	1983 62	1804	0	230	342	868	782	171	747	1177	0	0	366 6
	2000 98	1917	0	358	768	1043	1231	269	895	1565	0	0	126 1
P205	1983 62	286	0	87	0	193	483	83	0	0	0	0	0 0
	2000 98	300	0	136	0	455	760	131	0	0	0	0	0 0
K20	1983 62	236	0	180	0	792	342	585	282	0	0	0	0 0
	2000 98	301	0	282	0	1276	532	928	399	0	0	0	0 0
* IRRIGATED AREA													
N	1983 11	1765	0	38	198	90	564	87	484	596	0	5	364 32
	2000 21	1548	0	84	440	200	882	137	430	678	0	3	149 7
P205	1983 11	260	0	14	0	27	379	35	0	0	0	5	-109 -10
	2000 21	194	0	32	0	60	593	55	0	0	0	3	-360 -17
K20	1983 11	208	0	30	0	45	199	330	0	0	0	2	-245 -22
	2000 21	194	0	66	0	100	312	517	0	0	0	1	-468 -22
* TOTAL													
N	1983 7681	24312	135	21345	25406	958	49200	6328	29475	61653	88152	7728	-154924 -20
	2000 9177	51448	182	26072	36177	1243	85131	11417	38159	77538	108525	9004	-196645 -21
P205	1983 7681	6515	56	8081	0	220	22612	3267	0	0	33050	7728	-36329 -5
	2000 9177	15547	75	9870	0	515	38023	5902	0	0	40689	9004	-49603 -5
K20	1983 7681	13568	383	16771	0	837	33978	14748	31107	0	66114	3864	-110524 -14
	2000 9177	32408	517	20485	0	1376	57374	24669	41356	0	81394	4502	-145505 -16

Figure 4.7 Nutrient balance for Central African Republic, 1983 (in kg/ha,yr)

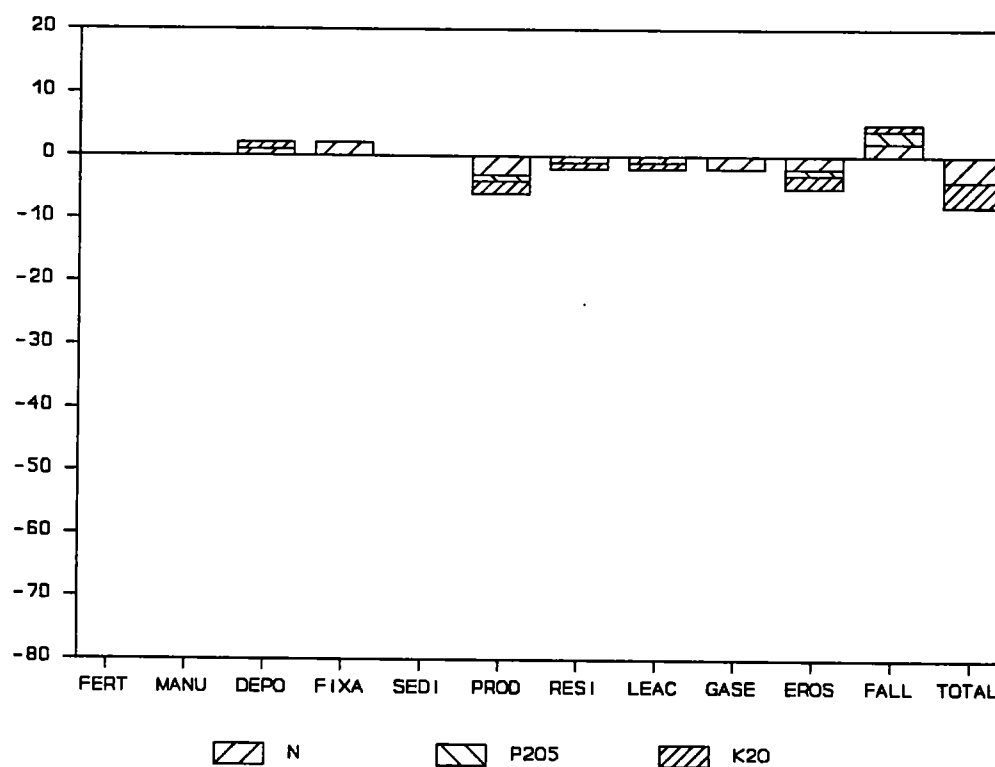


Table 4.13 LWC-distribution in Central African Republic (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	3	37	59	0	0
2000	0	3	43	53	0	0

Table 4.14 Central Africa Republique ; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	142	5	104	107	228	0	421	195	98	230	480	230 -749 -5
	2000	200	18	106	111	236	0	469	203	101	238	500	344 -696 -3
P205	1983	142	0	46	40	0	0	187	91	0	0	180	230 -141 -1
	2000	200	1	49	42	0	0	204	101	0	0	187	344 -56 0
K20	1983	142	1	237	84	0	0	246	470	151	0	360	115 -788 -6
	2000	200	1	235	87	0	0	278	468	152	0	375	172 -778 -4
* GOOD RAINFALL													
N	1983	1792	322	591	2441	5228	0	7536	1532	1750	4163	5680	2653 -9425 -5
	2000	2519	820	724	3431	7793	0	12237	2420	2283	5707	8205	3728 -14355 -6
P205	1983	1792	0	296	924	0	0	3206	750	0	0	1704	2653 -1787 -1
	2000	2519	70	362	1299	0	0	5303	1213	0	0	2461	3728 -3518 -1
K20	1983	1792	67	929	1918	0	0	5131	2092	2017	0	4260	1326 -9260 -5
	2000	2519	70	1138	2696	0	0	7886	3585	2621	0	6154	1864 -14476 -6
* PROBLEM AREA													
N	1983	2853	172	0	2397	3676	0	5851	1033	1838	5214	4990	4851 -7831 -3
	2000	3094	528	0	2946	4874	0	9020	1585	2009	6170	6125	5136 -11425 -4
P205	1983	2853	0	0	907	0	0	2139	556	0	0	1497	4851 1566 1
	2000	3094	29	0	1115	0	0	3311	849	0	0	1837	5136 282 0
K20	1983	2853	32	0	1883	0	0	4844	1078	1479	0	3742	2425 -6803 -2
	2000	3094	29	0	2314	0	0	7380	1707	1649	0	4594	2568 -10418 -3
* NATURALLY FLOODED													
N	1983	21	0	0	26	70	84	74	12	23	72	0	0 0 0
	2000	24	33	0	47	158	137	173	34	40	129	0	0 0 0
P205	1983	21	0	0	10	0	31	34	7	0	0	0	0 0 0
	2000	24	0	0	18	0	100	99	19	0	0	0	0 0 0
K20	1983	21	0	0	21	0	79	41	47	11	0	0	0 0 0
	2000	24	0	0	37	0	182	81	136	2	0	0	0 0 0
* IRRIGATED AREA													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
* TOTAL													
N	1983	4809	499	695	4971	9203	84	13882	2772	3708	9678	11150	7733 -18005 -4
	2000	5837	1400	831	6535	13061	137	21899	4242	4433	12243	14830	9209 -26475 -5
P205	1983	4809	0	342	1882	0	31	5566	1404	0	0	3381	7733 -362 0
	2000	5837	100	412	2474	0	100	8917	2183	0	0	4486	9209 -3292 -1
K20	1983	4809	100	1167	3906	0	79	10262	3687	3658	0	8362	3867 -16852 -4
	2000	5837	100	1374	5134	0	182	15625	5896	4424	0	11122	4604 -25672 -4

Figure 4.8 Nutrient balance for Chad, 1983 (in kg/ha,yr)

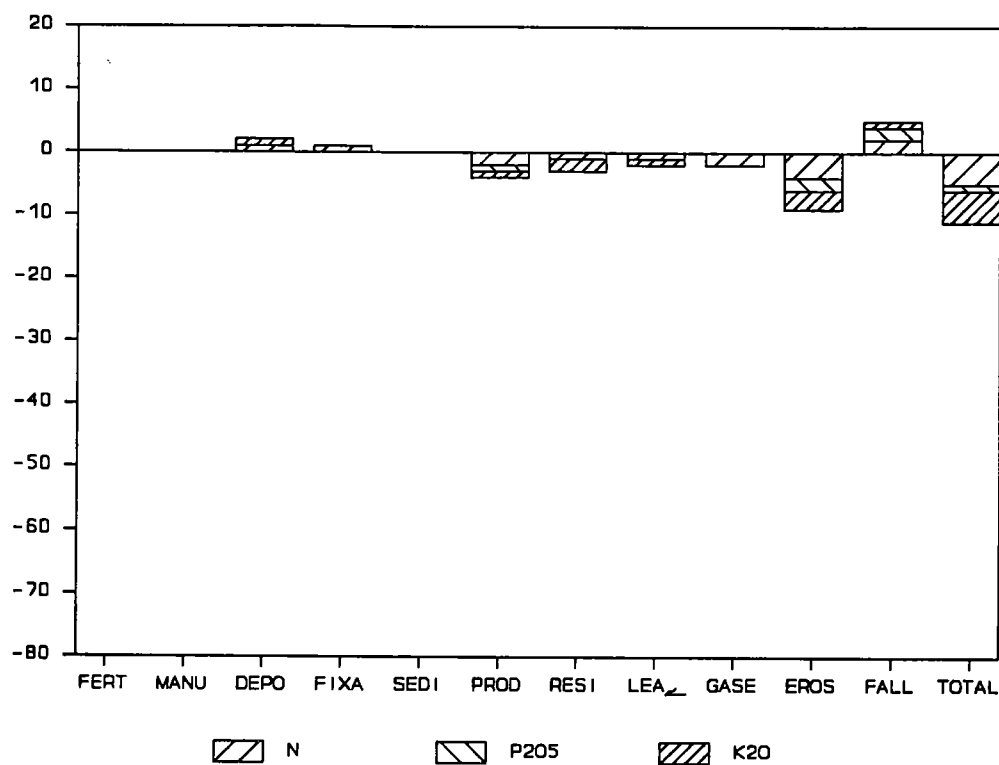


Table 4.15 LWC-distribution in Chad (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	15	54	26	3	1	0
2000	15	54	26	3	1	0

Table 4.16 Chad; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983 1181	62	699	860	1208	0	1940	1539	963	2284	6140	1748	-8290 -7
	2000 1283	241	1609	1473	1901	0	4099	3562	1614	3876	10520	1514	-16933 -13
P205	1983 1181	51	283	325	0	0	1213	624	0	0	2302	1748	-1733 -1
	2000 1283	153	646	558	0	0	2722	1432	0	0	3945	1514	-5228 -4
K20	1983 1181	38	2047	675	0	0	714	4545	1171	0	4605	874	-7401 -6
	2000 1283	107	4878	1157	0	0	1456	10847	2282	0	7890	757	-15576 -12
* UNCERTAIN RAINFALL													
N	1983 4136	796	0	2293	4032	0	7199	2611	1817	5409	12350	7113	-15152 -4
	2000 4800	1583	0	3991	6645	0	14613	6757	2679	8207	22030	7584	-34483 -7
P205	1983 4136	547	0	868	0	0	4255	1132	0	0	4631	7113	-1490 0
	2000 4800	1058	0	1511	0	0	8837	2826	0	0	8261	7584	-9771 -2
K20	1983 4136	707	0	1801	0	0	3968	6537	2050	0	9262	3557	-15753 -4
	2000 4800	1204	0	3136	0	0	7093	18713	2379	0	16522	3792	-36575 -8
* GOOD RAINFALL													
N	1983 2005	1080	0	2139	4170	0	6860	1120	1935	5890	12600	3127	-17889 -9
	2000 2319	2180	0	3487	6422	0	11843	2523	3070	8807	20890	3201	-31844 -14
P205	1983 2005	732	0	810	0	0	4035	491	0	0	4725	3127	-4582 -2
	2000 2319	1371	0	1320	0	0	6886	1079	0	0	7834	3201	-9907 -4
K20	1983 2005	1068	0	1680	0	0	4030	2533	3231	0	9450	1564	-14931 -7
	2000 2319	1855	0	2740	0	0	6459	6521	3968	0	15667	1600	-26421 -11
* PROBLEM AREA													
N	1983 238	43	0	123	245	0	322	55	94	185	520	415	-351 -1
	2000 293	116	0	162	329	0	606	122	109	221	685	504	-632 -2
P205	1983 238	48	0	46	0	0	127	32	0	0	156	415	195 1
	2000 293	104	0	61	0	0	237	68	0	0	205	504	159 1
K20	1983 238	100	0	96	0	0	299	69	81	0	390	207	-435 -2
	2000 293	204	0	128	0	0	583	140	100	0	514	252	-753 -3
* NATURALLY FLOODED													
N	1983 86	26	0	190	636	721	437	87	192	856	0	0	0 0
	2000 108	401	0	261	912	1269	1177	247	253	1166	0	0	0 0
P205	1983 86	26	0	72	0	225	281	42	0	0	0	0	0 0
	2000 108	182	0	99	0	605	767	120	0	0	0	0	0 0
K20	1983 86	1	0	149	0	433	152	288	143	0	0	0	0 0
	2000 108	28	0	205	0	1028	411	845	6	0	0	0	0 0
* IRRIGATED AREA													
N	1983 10	337	0	40	60	100	284	23	113	222	0	0	-103 -10
	2000 15	791	0	59	110	150	749	55	211	375	0	0	-280 -19
P205	1983 10	225	0	15	0	30	190	41	0	0	0	0	40 4
	2000 15	542	0	22	0	45	441	72	0	0	0	0	97 6
K20	1983 10	225	0	31	0	50	396	64	88	0	0	0	-241 -24
	2000 15	405	0	47	0	75	666	217	117	0	0	0	-473 -32
* TOTAL													
N	1983 7655	2345	699	5643	10350	821	17042	5436	5114	14846	31610	12403	-41785 -5
	2000 8818	5312	1609	9434	16319	1419	33088	13266	7937	22651	54125	12802	-84171 -10
P205	1983 7655	1629	283	2136	0	255	10101	2361	0	0	11815	12403	-7571 -1
	2000 8818	3410	646	3572	0	650	19890	5596	0	0	20245	12802	-24651 -3
K20	1983 7655	2140	2047	4434	0	483	9559	14036	6763	0	23707	6201	-38761 -5
	2000 8818	3804	4878	7413	0	1103	16668	37283	8852	0	40594	6401	-79797 -9

Figure 4.9 Nutrient balance for Congo, 1983 (in kg/ha,yr)

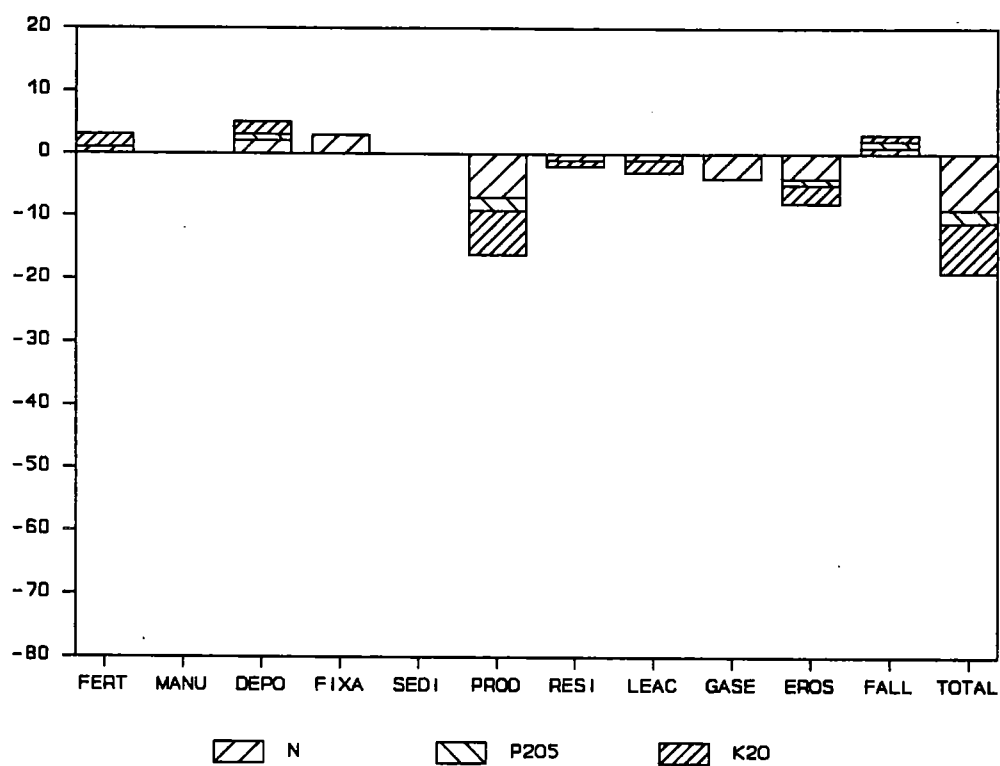


Table 4.17 LWC-distribution in Congo (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	7	84	8	0
2000	0	0	8	82	9	0

Table 4.18 Congo; nutrient balances for LWC s and for country total

		AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)	
		000 HA													
* LOW RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* GOOD RAINFALL															
N	1983	53	113	0	179	345	0	715	87	99	275	350	32	-856	-16
	2000	73	345	0	257	465	0	1228	150	173	411	510	39	-1366	-19
P205	1983	53	0	0	68	0	0	217	42	0	0	105	32	-265	-5
	2000	73	0	0	97	0	0	402	74	0	0	153	39	-492	-7
K20	1983	53	80	0	141	0	0	709	86	70	0	262	16	-890	-17
	2000	73	181	0	202	0	0	1145	168	94	0	382	20	-1386	-19
* PROBLEM AREA															
N	1983	597	574	0	1204	1551	0	3788	475	808	2468	2351	764	-5797	-10
	2000	738	1726	0	1613	2198	0	6525	813	1168	3302	3243	901	-8613	-12
P205	1983	597	0	0	456	0	0	1154	251	0	0	705	764	-890	-1
	2000	738	0	0	611	0	0	2055	425	0	0	973	901	-1941	-3
K20	1983	597	1007	0	946	0	0	4198	397	983	0	1763	382	-5006	-8
	2000	738	2099	0	1267	0	0	6931	759	1397	0	2432	450	-7703	-10
* NATURALLY FLOODED															
N	1983	55	5	0	36	52	158	111	17	32	90	0	0	0	0
	2000	85	9	0	65	142	238	193	28	64	170	0	0	0	0
P205	1983	55	0	0	13	0	29	34	9	0	0	0	0	0	0
	2000	85	0	0	25	0	66	76	15	0	0	0	0	0	0
K20	1983	55	5	0	28	0	162	124	9	61	0	0	0	0	0
	2000	85	9	0	51	0	253	180	34	100	0	0	0	0	0
* IRRIGATED AREA															
N	1983	3	12	0	16	46	30	48	5	15	37	0	0	-1	0
	2000	4	30	0	21	68	40	108	14	16	45	0	0	-24	-6
P205	1983	3	0	0	6	0	9	38	9	0	0	0	0	-32	-11
	2000	4	0	0	8	0	12	80	14	0	0	0	0	-74	-19
K20	1983	3	12	0	12	0	15	88	12	6	0	0	0	-66	-22
	2000	4	15	0	16	0	20	128	43	0	0	0	0	-119	-30
* TOTAL															
N	1983	708	705	0	1435	1994	188	4661	585	954	2870	2701	796	-6654	-9
	2000	900	2110	0	1956	2874	278	8054	1005	1421	3928	3753	940	-10003	-11
P205	1983	708	0	0	543	0	38	1443	311	0	0	810	796	-1187	-2
	2000	900	0	0	741	0	78	2613	527	0	0	1126	940	-2507	-3
K20	1983	708	1105	0	1127	0	177	5119	504	1121	0	2026	398	-5963	-8
	2000	900	2305	0	1537	0	273	8385	1003	1592	0	2815	470	-9209	-10

Figure 4.10 Nutrient balance for Côte d'Ivoire, 1983 (in kg/ha,yr)

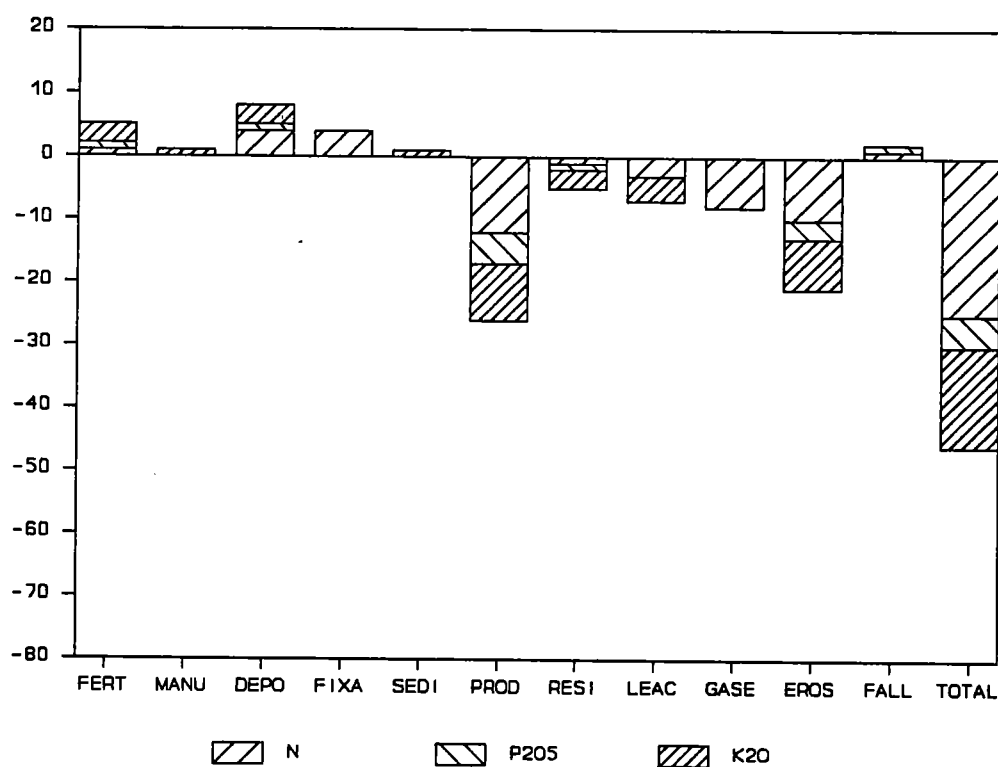


Table 4.19 LWC-distribution in Côte d'Ivoire (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	30	64	5	1
2000	0	0	25	70	4	1

Table 4.20 Côte d'Ivoire; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* GOOD RAINFALL													
N	1983 2093	2244	1358	3170	5326	0	12267	2104	2800	7651	6764	2931	-16558 -8
	2000 2141	4390	2243	4432	7876	0	21113	3854	3755	11027	9310	2527	-27590 -13
P205	1983 2093	1394	677	1200	0	0	7180	1120	0	0	2029	2931	-4127 -2
	2000 2141	2940	1122	1678	0	0	12415	2092	0	0	2793	2527	-9033 -4
K20	1983 2093	1630	2730	2491	0	0	7940	4612	5155	0	5073	1465	-14464 -7
	2000 2141	3180	4750	3482	0	0	13776	8782	7990	0	6982	1263	-24855 -12
* PROBLEM AREA													
N	1983 4479	5763	565	21319	19724	0	66862	6143	19121	48268	64851	1343	-156532 -35
	2000 6007	12394	1661	33638	30855	0	115368	11025	30109	76137	96625	0	-250716 -42
P205	1983 4479	4974	283	8071	0	0	24424	3781	0	0	19455	1343	-32989 -7
	2000 6007	9434	835	12734	0	0	43863	6715	0	0	28987	0	-56563 -9
K20	1983 4479	18441	1651	16751	0	0	52121	12267	20255	0	48638	672	-95766 -21
	2000 6007	39094	5005	26430	0	0	83441	23826	35549	0	72469	0	-144756 -24
* NATURALLY FLOODED													
N	1983 335	432	0	1053	3762	2274	3508	1046	651	2316	0	0	0 0
	2000 331	1230	0	1545	5650	4563	6847	2149	775	3217	0	0	0 0
P205	1983 335	204	0	399	0	2067	2089	565	0	0	0	0	16 0
	2000 331	593	0	585	0	4287	4283	1146	0	0	0	0	36 0
K20	1983 335	119	0	827	0	4989	2132	3741	62	0	0	0	0 0
	2000 331	281	0	1214	0	10217	3643	7978	90	0	0	0	0 0
* IRRIGATED AREA													
N	1983 39	868	0	197	298	390	1358	153	315	672	0	0	-745 -19
	2000 58	2184	0	293	596	580	2984	360	574	1105	0	0	-1370 -24
P205	1983 39	631	0	75	0	117	1082	264	0	0	0	0	-524 -13
	2000 58	1434	0	111	0	174	2308	506	0	0	0	0	-1095 -19
K20	1983 39	610	0	155	0	195	2562	320	187	0	0	0	-2109 -54
	2000 58	1550	0	230	0	290	4758	902	435	0	0	0	-4025 -69
* TOTAL													
N	1983 6946	9306	1922	25739	29110	2664	83994	9445	22888	58907	71615	4274	-173835 -25
	2000 8538	20197	3904	39908	44977	5143	146312	17387	35213	91485	105935	2527	-279676 -33
P205	1983 6946	7204	960	9744	0	2184	34776	5730	0	0	21484	4274	-37624 -5
	2000 8538	14401	1957	15108	0	4461	62869	10459	0	0	31780	2527	-66655 -8
K20	1983 6946	20801	4381	20223	0	5184	64755	20940	25659	0	53711	2137	-112338 -16
	2000 8538	44105	9755	31356	0	10507	105619	41489	44063	0	79451	1263	-173636 -20

Figure 4.11 Nutrient balance for Ethiopia, 1983 (in kg/ha,yr)

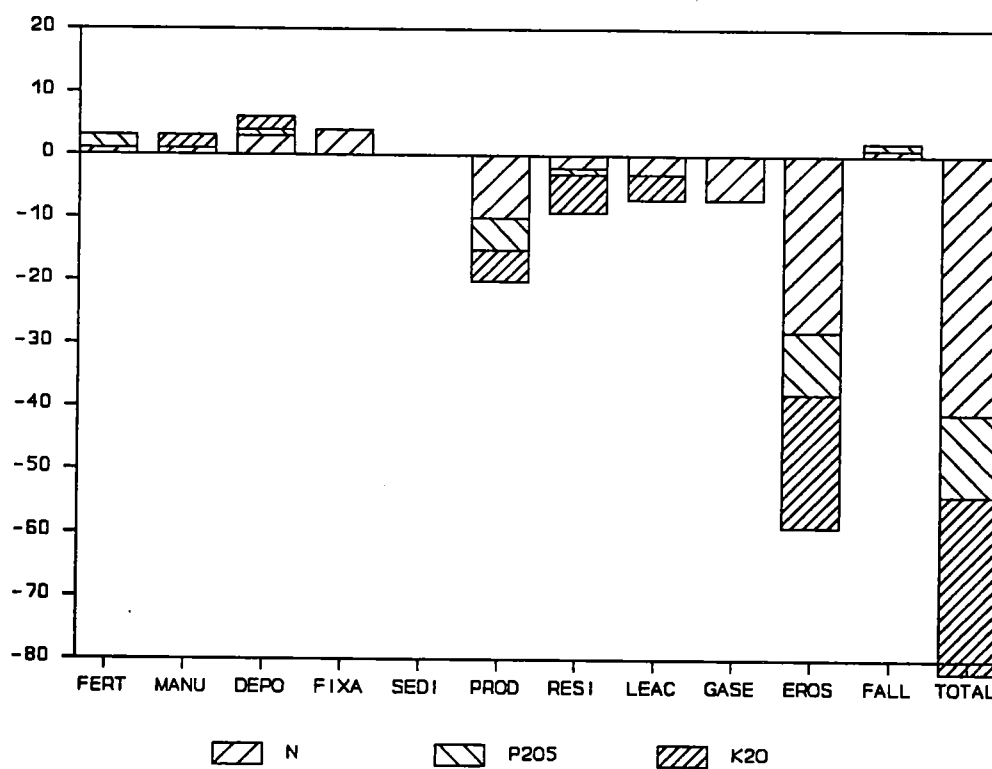


Table 4.21 LWC-distribution in Ethiopia (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	20	21	40	18	0	0
2000	23	19	36	22	1	1

Table 4.22 Ethiopia; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 2964	1113	2658	3651	4379	0	13461	5907	4188	12690	52160	3319	-73285 -25
	2000 3758	2972	4970	4525	5614	0	21836	11044	5158	15694	64640	4284	-96008 -26
P205	1983 2964	1598	1953	1382	0	0	7932	4341	0	0	19560	3319	-23580 -8
	2000 3758	4172	3868	1713	0	0	14087	8595	0	0	24240	4284	-32885 -9
K20	1983 2964	0	9038	2869	0	0	4970	20084	5830	0	39120	1660	-56438 -19
	2000 3758	26	15975	3555	0	0	7978	35499	8028	0	48480	2142	-78287 -21
* UNCERTAIN RAINFALL													
N	1983 3023	2034	5455	5267	8418	0	23499	10326	6002	15147	74960	3385	-105375 -35
	2000 3102	4931	8674	6387	10831	0	38019	17390	7022	18123	91280	2978	-138032 -44
P205	1983 3023	3172	2951	1994	0	0	12336	5780	0	0	28110	3385	-34724 -11
	2000 3102	7683	4936	2418	0	0	20756	10155	0	0	34230	2978	-47127 -15
K20	1983 3023	0	14407	4138	0	0	10596	29449	10514	0	56220	1693	-86542 -29
	2000 3102	29	23851	5018	0	0	16411	50434	13619	0	68460	1489	-118537 -38
* GOOD RAINFALL													
N	1983 5783	7673	3048	20382	32337	0	79081	13087	23064	49253	205120	4048	-302116 -52
	2000 5962	18984	3395	25538	43927	0	131050	22529	26316	59222	259660	2504	-404427 -68
P205	1983 5783	13049	1524	7716	0	0	39607	6711	0	0	76920	4048	-96900 -17
	2000 5962	32230	1697	9668	0	0	67403	11660	0	0	97372	2504	-130336 -22
K20	1983 5783	0	4790	16014	0	0	37735	35164	28885	0	153840	2024	-232795 -40
	2000 5962	83	5335	20066	0	0	60261	61683	29668	0	194745	1252	-319622 -54
* PROBLEM AREA													
N	1983 2672	3572	0	8866	7576	0	21510	1884	13066	25527	69960	2511	-109422 -41
	2000 3650	9836	0	10969	9563	0	37192	3700	16039	31456	89280	3796	-143503 -39
P205	1983 2672	4590	0	3356	0	0	9738	1384	0	0	26235	2511	-26899 -10
	2000 3650	12705	0	4153	0	0	18200	2650	0	0	33480	3796	-33678 -9
K20	1983 2672	0	0	6966	0	0	10116	5822	16844	0	52470	1256	-77030 -29
	2000 3650	62	0	8619	0	0	16786	11244	18388	0	66960	1898	-102799 -28
* NATURALLY FLOODED													
N	1983 60	27	0	201	107	1274	810	95	150	554	0	0	0 0
	2000 85	68	0	271	155	1773	1201	139	191	736	0	0	0 0
P205	1983 60	35	0	76	0	480	552	38	0	0	0	0	1 0
	2000 85	99	0	103	0	680	814	56	0	0	0	0	12 0
K20	1983 60	0	0	158	0	517	287	292	96	0	0	0	0 0
	2000 85	0	0	213	0	735	428	426	94	0	0	0	0 0
* IRRIGATED AREA													
N	1983 69	895	0	216	189	690	2817	72	185	1679	0	0	-2762 -40
	2000 97	1840	0	291	279	930	5039	107	310	2499	0	8	-4607 -48
P205	1983 69	868	0	82	0	207	2145	131	0	0	0	0	-1119 -16
	2000 97	1821	0	110	0	279	3640	188	0	0	0	8	-1611 -17
K20	1983 69	0	0	170	0	345	3416	148	660	0	0	0	-3710 -54
	2000 97	0	0	229	0	465	5802	233	1078	0	0	4	-6415 -66
* TOTAL													
N	1983 4570	15314	11162	38582	53006	1964	141177	31371	46654	104848	402200	13264	-592959 -41
	2000 6654	38632	17039	47982	70369	2703	234337	54909	55036	127730	504860	13570	-786577 -47
P205	1983 4570	23313	6428	14606	0	687	72310	18384	0	0	150825	13264	-183220 -13
	2000 6654	58709	10501	18165	0	959	124901	33305	0	0	189322	13570	-245625 -15
K20	1983 4570	0	28235	30314	0	862	67120	90959	62828	0	301650	6632	-456513 -31
	2000 6654	200	45161	37700	0	1200	107666	159518	70876	0	378645	6785	-625659 -38

Figure 4.12 Nutrient balance for Gabon, 1983 (in kg/ha,yr)

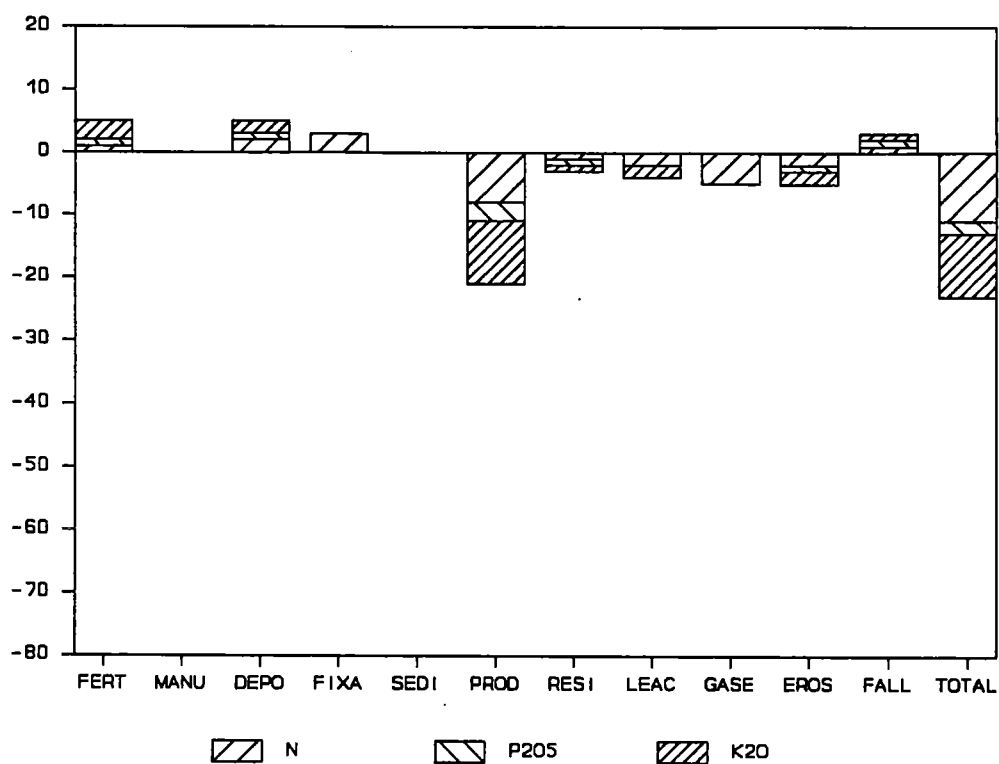


Table 4.23 LWC-distribution in Gabon (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	0	100	0	0
2000	0	0	0	100	0	0

Table 4.24 Gabon; nutrient balances for LWC s and for country total

		AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL	
		000 HA												(TON)	(KG/HA)
* LOW RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* GOOD RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* PROBLEM AREA															
N	1983	347	400	0	848	995	0	2855	512	622	1578	770	417	-3677	-11
	2000	411	1100	0	1178	1527	0	4625	807	904	2232	1065	435	-5393	-13
P205	1983	347	200	0	321	0	0	926	308	0	0	231	417	-527	-2
	2000	411	900	0	446	0	0	1603	484	0	0	319	435	-626	-2
K20	1983	347	1152	0	666	0	0	3539	518	793	0	577	209	-3402	-10
	2000	411	2300	0	925	0	0	5625	829	1323	0	799	218	-5133	-12
* NATURALLY FLOODED															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	2	0	0	13	44	0	7	2	14	27	0	0	6	3
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	2	0	0	5	0	1	5	1	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	2	0	0	10	0	9	2	6	10	0	0	0	0	0
* IRRIGATED AREA															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* TOTAL															
N	1983	347	400	0	848	995	0	2855	512	622	1578	770	417	-3677	-11
	2000	413	1100	0	1190	1571	0	4632	808	919	2260	1065	435	-5387	-13
P205	1983	347	200	0	321	0	0	926	308	0	0	231	417	-527	-2
	2000	413	900	0	451	0	1	1608	485	0	0	319	435	-626	-2
K20	1983	347	1152	0	666	0	0	3539	518	793	0	577	209	-3402	-10
	2000	413	2300	0	935	0	9	5627	835	1333	0	799	218	-5133	-12

Figure 4.13 Nutrient balance for Gambia, 1983 (in kg/ha,yr)

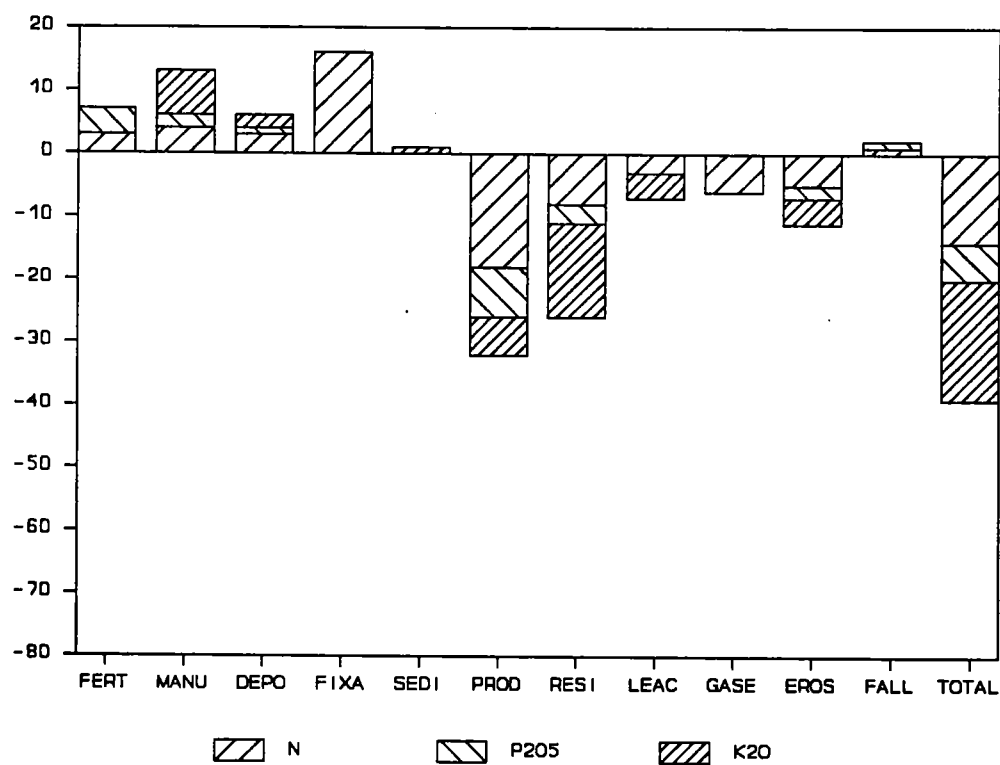


Table 4.25 LWC-distribution in Gambia (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	76	0	11	9	4
2000	0	70	0	16	9	5

Table 4.26 Gambia; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	248	833	1125	776	4654	0	5324	2493	738	1466	1710	154 -4189 -17
	2000	253	2367	1728	989	6601	0	8051	3836	1205	2153	2180	71 -5670 -22
P205	1983	248	1070	466	294	0	0	2265	1035	0	0	641	154 -1957 -8
	2000	253	3085	717	374	0	0	3496	1599	0	0	817	71 -1666 -7
K20	1983	248	99	2020	610	0	0	1543	4479	1361	0	1282	77 -5861 -24
	2000	253	419	3221	777	0	0	2350	7172	1989	0	1635	35 -8693 -34
* GOOD RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* PROBLEM AREA													
N	1983	35	42	56	109	238	0	309	128	99	143	80	25 -289 -8
	2000	57	457	278	270	1969	0	2096	622	197	310	244	0 -495 -9
P205	1983	35	37	23	41	0	0	162	53	0	0	24	25 -114 -3
	2000	57	627	116	102	0	0	845	260	0	0	73	0 -333 -6
K20	1983	35	2	140	86	0	0	118	314	90	0	60	12 -342 -10
	2000	57	85	450	212	0	0	601	1003	241	0	183	0 -1281 -23
* NATURALLY FLOODED													
N	1983	29	39	0	59	286	59	151	35	57	200	0	0 0 0
	2000	32	192	0	104	506	140	374	88	114	367	0	0 0 0
P205	1983	29	39	0	22	0	58	101	18	0	0	0	0 0 0
	2000	32	115	0	40	0	142	251	45	0	0	0	0 0 0
K20	1983	29	0	0	46	0	146	53	135	5	0	0	0 0 0
	2000	32	0	0	82	0	384	132	334	0	0	0	0 0 0
* IRRIGATED AREA													
N	1983	14	111	0	41	178	90	227	32	48	139	0	11 -16 -1
	2000	18	335	0	73	332	160	493	74	110	270	0	4 -43 -2
P205	1983	14	61	0	15	0	27	147	13	0	0	0	11 -46 -3
	2000	18	210	0	27	0	48	327	30	0	0	0	4 -66 -4
K20	1983	14	0	0	32	0	45	79	117	0	0	0	5 -114 -8
	2000	18	0	0	57	0	80	174	276	0	0	0	2 -311 -17
* TOTAL													
N	1983	326	1025	1180	985	5356	149	6011	2688	942	1947	1790	189 -4494 -14
	2000	360	3351	2005	1436	9408	300	11013	4619	1626	3101	2424	75 -6208 -17
P205	1983	326	1207	489	373	0	85	2676	1119	0	0	665	189 -2117 -6
	2000	360	4037	833	544	0	190	4919	1933	0	0	891	75 -2065 -6
K20	1983	326	101	2160	774	0	191	1794	5045	1456	0	1342	94 -6317 -19
	2000	360	504	3671	1128	0	464	3256	8785	2230	0	1818	38 -10285 -29

Figure 4.14 Nutrient balance for Ghana, 1983 (in kg/ha,yr)

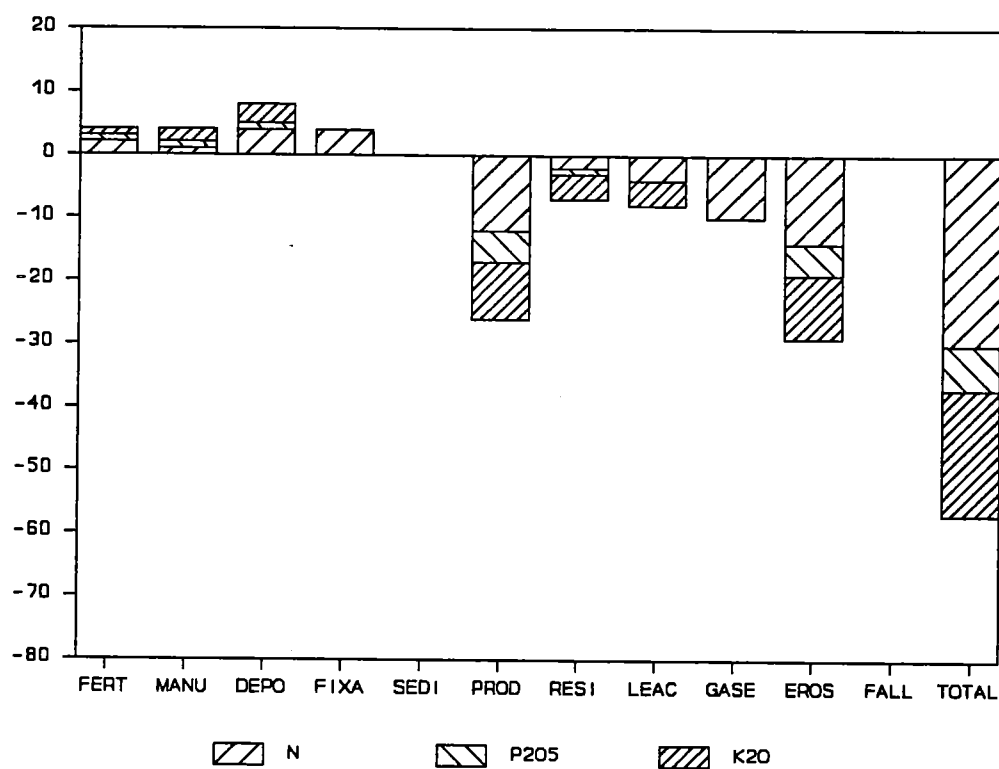


Table 4.27 LWC-distribution in Ghana (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	4	31	62	2	0
2000	0	4	27	66	3	1

Table 4.28 Ghana; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	200	291	362	459	495	0	2434	1057	339	920	3480	168 -6455 -32
	2000	214	994	554	602	659	0	4441	1883	449	1209	4560	124 -9608 -45
P205	1983	200	128	184	174	0	0	712	669	0	0	1305	168 -2032 -10
	2000	214	408	286	228	0	0	1377	1208	0	0	1710	124 -3249 -15
K20	1983	200	123	625	361	0	0	2391	1046	499	0	2610	84 -5353 -27
	2000	214	369	1014	473	0	0	4147	2187	637	0	3420	62 -8473 -40
* GOOD RAINFALL													
N	1983	1394	3095	5152	5437	5538	0	26834	6725	4475	10541	14210	446 -43117 -31
	2000	1518	10769	7260	5990	8905	0	49364	12417	4897	11418	15505	455 -60222 -40
P205	1983	1394	1590	2620	2058	0	0	9348	4088	0	0	4263	446 -10985 -8
	2000	1518	5367	3792	2268	0	0	18451	7621	0	0	4651	455 -18841 -12
K20	1983	1394	1488	9314	4272	0	0	20039	10856	5416	0	10657	223 -31671 -23
	2000	1518	4415	14329	4706	0	0	33615	23321	5741	0	11629	228 -50628 -33
* PROBLEM AREA													
N	1983	2787	5706	0	10513	10051	0	24367	3063	12458	31984	43400	1561 -87440 -31
	2000	3630	16812	0	12740	12187	0	51829	5515	16402	39879	53170	2396 -122661 -34
P205	1983	2787	2789	0	3980	0	0	9698	1591	0	0	16275	1561 -19233 -7
	2000	3630	7171	0	4823	0	0	18912	2840	0	0	19939	2396 -27302 -8
K20	1983	2787	3084	0	8260	0	0	16189	3531	13136	0	32550	780 -53281 -19
	2000	3630	7663	0	10010	0	0	26749	7204	15584	0	39877	1198 -70544 -19
* NATURALLY FLOODED													
N	1983	103	186	0	292	812	1011	592	123	364	1222	0	0 0 0
	2000	145	1465	0	642	2390	1889	2172	488	921	2806	0	0 0 0
P205	1983	103	83	0	111	0	265	393	65	0	0	0	0 0 0
	2000	145	363	0	243	0	1129	1478	257	0	0	0	0 0 0
K20	1983	103	3	0	230	0	669	204	416	281	0	0	0 0 0
	2000	145	87	0	504	0	2124	755	1752	208	0	0	0 0 0
* IRRIGATED AREA													
N	1983	21	143	0	32	56	80	276	13	45	131	0	25 -128 -6
	2000	31	1188	0	115	178	290	1451	66	296	609	0	4 -648 -21
P205	1983	21	13	0	12	0	24	122	15	0	0	0	25 -62 -3
	2000	31	503	0	43	0	87	688	87	0	0	0	4 -138 -4
K20	1983	21	8	0	25	0	40	219	35	0	0	0	13 -168 -8
	2000	31	279	0	90	0	145	1395	169	20	0	0	2 -1067 -35
* TOTAL													
N	1983	4505	9422	5514	16734	16952	1091	54503	10981	17681	44799	61090	2200 -137140 -30
	2000	5537	31228	7814	20088	24320	2179	109257	20368	22965	55922	73235	2979 -193139 -35
P205	1983	4505	4603	2804	6335	0	289	20273	6428	0	0	21843	2200 -32313 -7
	2000	5537	13811	4078	7605	0	1216	40906	12012	0	0	26300	2979 -49530 -9
K20	1983	4505	4706	9938	13148	0	709	39041	15883	19333	0	45817	1100 -90474 -20
	2000	5537	12812	15343	15783	0	2269	66660	34632	22191	0	54926	1489 -130712 -24

Figure 4.15 Nutrient balance for Guinea, 1983 (in kg/ha,yr)

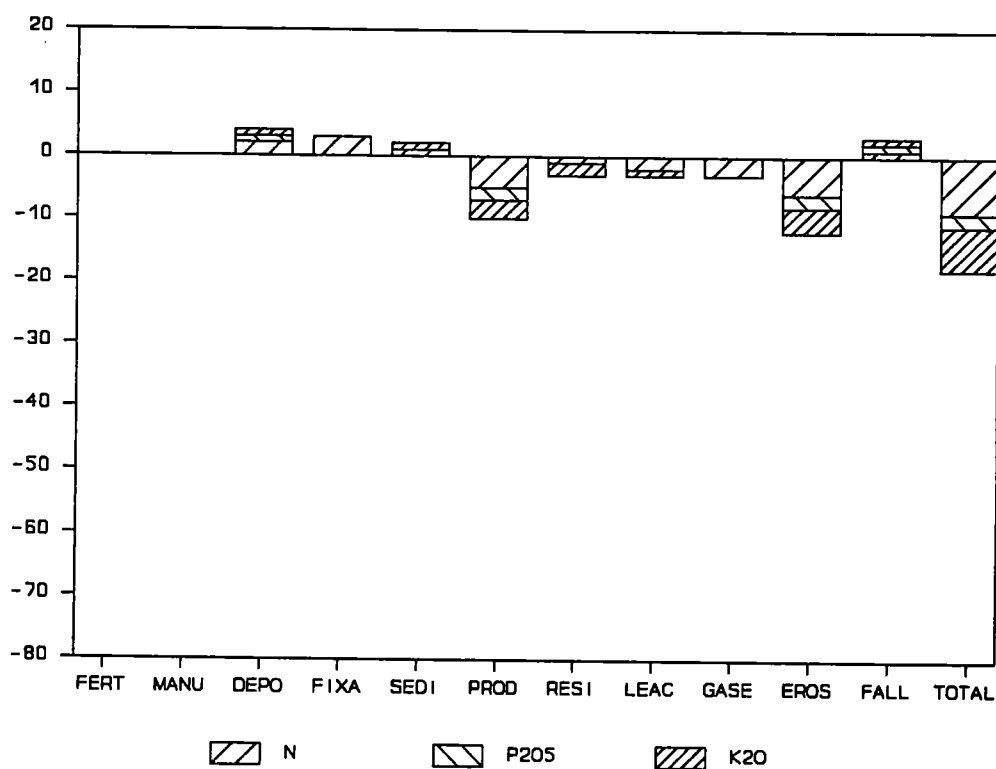


Table 4.29 LWC-distribution in Guinea (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	1	57	37	4	1
2000	0	1	53	41	4	1

Table 4.30 Guinea; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL													
N	1983	45	0	41	62	115	0	209	87	60	108	480	-662 -15
	2000	58	0	70	90	158	0	333	149	83	153	670	-993 -17
P205	1983	45	0	18	23	0	0	77	43	0	0	180	-195 -4
	2000	58	0	33	34	0	0	117	80	0	0	251	-303 -5
K20	1983	45	0	77	48	0	0	104	162	88	0	360	-555 -12
	2000	58	0	129	71	0	0	168	234	134	0	502	-800 -14
* GOOD RAINFALL													
N	1983	2381	0	864	2886	5362	0	9023	1586	2227	3946	11250	-15158 -6
	2000	2688	69	1398	3729	7930	0	14708	2479	2660	4730	14367	-21732 -8
P205	1983	2381	0	402	1093	0	0	3265	814	0	0	3375	-2197 -1
	2000	2688	69	652	1412	0	0	5315	1290	0	0	4310	-4697 -2
K20	1983	2381	0	1488	2268	0	0	6296	2632	1992	0	8437	-13722 -6
	2000	2688	0	2407	2930	0	0	9814	4271	2405	0	10776	-19887 -7
* PROBLEM AREA													
N	1983	1532	73	0	3932	3595	0	7453	1253	3649	7776	12130	-22854 -15
	2000	2040	328	0	5748	5345	0	14707	2342	5091	10983	18065	-37524 -18
P205	1983	1532	0	0	1489	0	0	3282	686	0	0	3639	-4310 -3
	2000	2040	105	0	2176	0	0	6384	1254	0	0	5419	-8533 -4
K20	1983	1532	100	0	3089	0	0	5164	3073	2234	0	9097	-15476 -10
	2000	2040	274	0	4516	0	0	9227	5730	2688	0	13549	-25282 -12
* NATURALLY FLOODED													
N	1983	180	19	0	868	2790	1882	2955	358	527	1719	0	0
	2000	191	56	0	1014	2962	3232	4449	542	437	1835	0	0
P205	1983	180	0	0	329	0	1341	1441	229	0	0	0	0
	2000	191	14	0	384	0	2120	2174	344	0	0	0	0
K20	1983	180	0	0	682	0	2315	1738	1256	3	0	0	0
	2000	191	14	0	796	0	3696	2590	1906	10	0	0	0
* IRRIGATED AREA													
N	1983	45	8	0	121	450	250	850	82	13	200	0	-276 -6
	2000	59	47	0	257	986	530	2298	248	9	334	0	-1058 -18
P205	1983	45	0	0	46	0	75	453	41	0	0	0	-334 -7
	2000	59	12	0	97	0	159	1410	109	0	0	0	-1240 -21
K20	1983	45	0	0	95	0	125	298	297	0	0	0	-355 -8
	2000	59	12	0	202	0	265	810	923	0	0	0	-1248 -21
* TOTAL													
N	1983	4182	100	905	7869	12312	2132	20490	3365	6476	13749	23860	-38951 -9
	2000	5035	500	1468	10837	17381	3762	36495	5760	8281	18036	33102	-61308 -12
P205	1983	4182	0	420	2979	0	1416	8517	1813	0	0	7194	-7037 -2
	2000	5035	200	686	4103	0	2279	15400	3077	0	0	9981	-14773 -3
K20	1983	4182	100	1565	6183	0	2440	13600	7420	4317	0	17895	-30109 -7
	2000	5035	300	2535	8515	0	3961	22609	13065	5237	0	24827	-47217 -9

Figure 4.16 Nutrient balance for Kenya, 1983 (in kg/ha,yr)

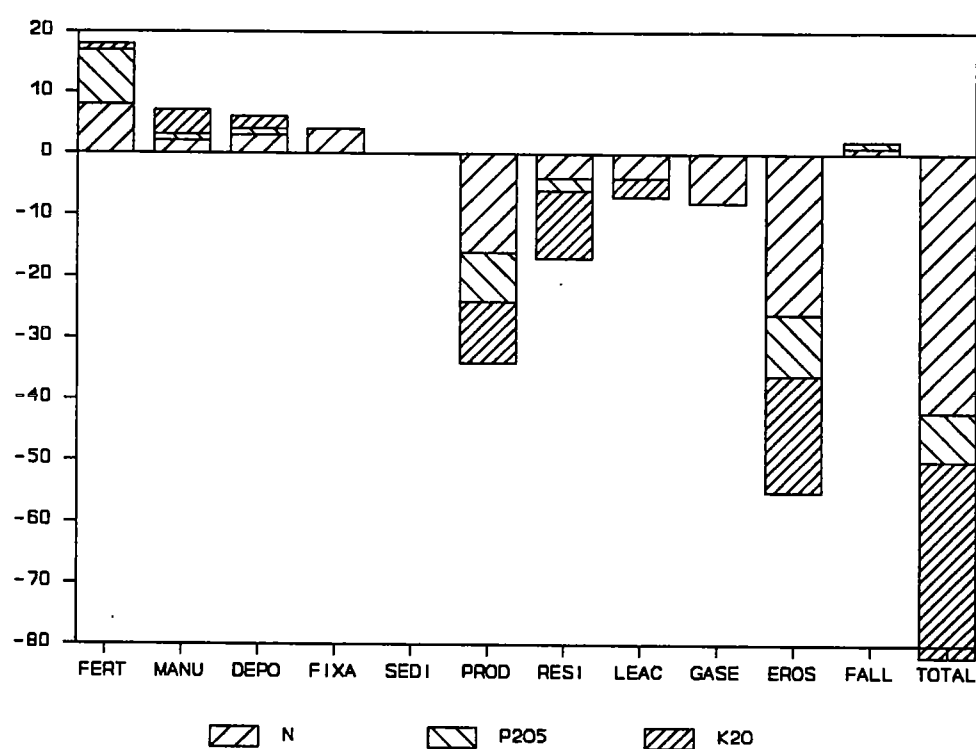


Table 4.31 LWC-distribution in Kenya (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	41	20	27	11	0	1
2000	43	18	25	11	1	1

Table 4.32 Kenya; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 1833	1953	2102	1392	2340	0	4971	2236	2250	4387	11895	2671	-15281 -8
	2000 2440	5528	4495	2461	4522	0	12610	6643	4095	7874	21255	3122	-32348 -13
P205	1983 1833	3080	1066	527	0	0	2566	1148	0	0	4461	2671	-830 0
	2000 2440	8316	2324	932	0	0	7144	3597	0	0	7971	3122	-4018 -2
K20	1983 1833	99	4063	1093	0	0	2255	5865	2326	0	8921	1336	-12777 -7
	2000 2440	517	9168	1934	0	0	5149	17958	4221	0	15941	1561	-30090 -12
* UNCERTAIN RAINFALL													
N	1983 890	4744	3530	3090	4382	0	17979	7911	3546	7159	29310	267	-49892 -56
	2000 1036	14049	5745	3849	6739	0	30192	13289	5971	10581	36290	187	-65753 -63
P205	1983 890	6717	1752	1170	0	0	9315	4135	0	0	10991	267	-14536 -16
	2000 1036	19246	2891	1457	0	0	15669	7052	0	0	13609	187	-12549 -12
K20	1983 890	531	8494	2428	0	0	9493	18922	4648	0	21982	133	-43459 -49
	2000 1036	1562	13965	3024	0	0	16420	31448	6481	0	27217	93	-62922 -61
* GOOD RAINFALL													
N	1983 1185	14236	3379	5689	8057	0	34151	7761	7604	15603	52670	24	-86405 -73
	2000 1431	40138	4185	6941	10943	0	60360	13718	13211	23180	63703	0	-111965 -78
P205	1983 1185	16541	1690	2154	0	0	15492	4086	0	0	19751	24	-18921 -16
	2000 1431	46106	2093	2628	0	0	27664	7270	0	0	23889	0	-7998 -6
K20	1983 1185	2331	5310	4470	0	0	20994	18999	5705	0	39502	12	-73078 -62
	2000 1431	6314	6577	5454	0	0	37731	33906	6264	0	47778	0	-107334 -75
* PROBLEM AREA													
N	1983 490	7694	0	2263	2193	0	12603	1311	3866	7068	21580	196	-34083 -70
	2000 614	21011	0	2909	2928	0	27629	2843	7412	11649	27620	221	-50084 -82
P205	1983 490	7418	0	857	0	0	5234	751	0	0	8092	196	-5607 -11
	2000 614	20546	0	1101	0	0	10909	1592	0	0	10357	221	-990 -2
K20	1983 490	1229	0	1778	0	0	5518	2718	2426	0	16185	98	-23742 -48
	2000 614	3071	0	2286	0	0	11072	5672	2824	0	20715	110	-34816 -57
* NATURALLY FLOODED													
N	1983 22	969	0	97	66	472	564	67	344	630	0	0	0 0
	2000 38	2272	0	168	109	777	1219	180	717	1211	0	0	0 0
P205	1983 22	1130	0	37	0	52	447	115	0	0	0	0	656 30
	2000 38	2723	0	64	0	5	954	223	0	0	0	0	1616 43
K20	1983 22	188	0	77	0	1037	1085	122	94	0	0	0	0 0
	2000 38	423	0	132	0	1875	1858	419	152	0	0	0	0 0
* IRRIGATED AREA													
N	1983 41	4280	0	141	262	410	2721	166	1092	1647	0	0	-533 -13
	2000 82	11751	0	281	524	820	6581	420	2964	4086	0	0	-676 -8
P205	1983 41	4245	0	53	0	123	1759	232	0	0	0	0	2430 59
	2000 82	11709	0	106	0	246	4072	538	0	0	0	0	7451 91
K20	1983 41	847	0	110	0	205	4152	423	99	0	0	0	-3512 -86
	2000 82	2238	0	221	0	410	9251	1134	275	0	0	0	-7791 -95
* TOTAL													
N	1983 4461	33876	9011	12671	17299	882	72989	19452	18702	36494	115455	3158	-186194 -42
	2000 5642	94750	14425	16610	25765	1597	138592	37092	34369	58582	148868	3529	-260827 -46
P205	1983 4461	39131	4508	4797	0	175	34813	10467	0	0	43296	3158	-36808 -8
	2000 5642	108647	7307	6288	0	251	66412	20273	0	0	55826	3529	-16488 -3
K20	1983 4461	5224	17867	9956	0	1242	43498	47049	15297	0	86591	1579	-156567 -35
	2000 5642	14124	29710	13051	0	2284	81481	90538	20218	0	111651	1765	-242953 -43

Figure 4.17 Nutrient balance for Lesotho, 1983 (in kg/ha,yr)

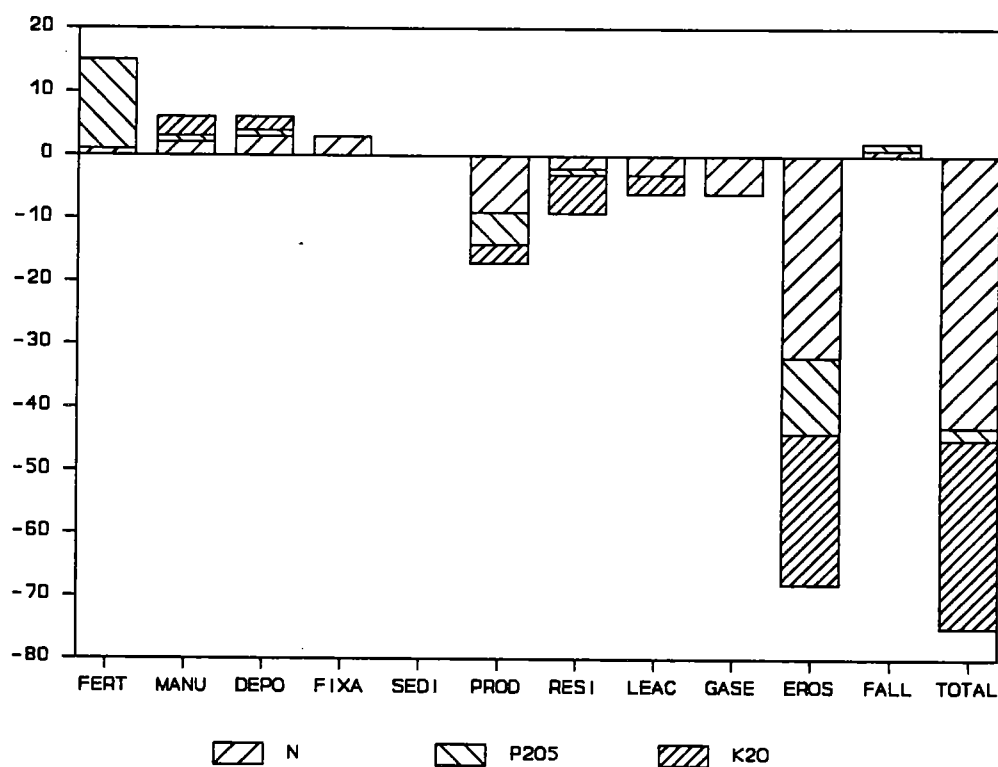


Table 4.33 LWC-distribution in Lesotho (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	8	44	30	19	0	0
2000	8	43	30	19	0	0

Table 4.34 Lesotho; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	22	7	20	48	53	0	99	45	53	103	550	16 -706 -32
	2000	25	69	41	62	72	0	212	90	78	143	710	14 -975 -39
P205	1983	22	110	12	18	0	0	54	27	0	0	206	16 -132 -6
	2000	25	516	28	23	0	0	120	62	0	0	266	14 134 5
K20	1983	22	0	52	38	0	0	45	116	55	0	412	8 -531 -24
	2000	25	0	120	48	0	0	86	266	79	0	532	7 -789 -32
* UNCERTAIN RAINFALL													
N	1983	124	136	179	333	400	0	1287	384	317	726	4110	79 -5696 -46
	2000	129	1121	405	459	595	0	2846	879	585	1151	5650	26 -8504 -66
P205	1983	124	1394	113	126	0	0	710	247	0	0	1541	79 -786 -6
	2000	129	8653	278	174	0	0	1648	610	0	0	2119	26 4753 37
K20	1983	124	0	483	261	0	0	466	1067	365	0	3082	40 -4195 -34
	2000	129	0	1130	361	0	0	1042	2504	491	0	4237	13 -6769 -53
* GOOD RAINFALL													
N	1983	86	163	248	274	188	0	960	174	330	775	3680	48 -4997 -58
	2000	89	1131	308	341	285	0	2553	465	466	1021	4560	23 -6977 -79
P205	1983	86	1664	124	104	0	0	521	114	0	0	1380	48 -75 -1
	2000	89	9190	154	129	0	0	1421	313	0	0	1710	23 6051 68
K20	1983	86	0	403	216	0	0	341	479	359	0	2760	24 -3296 -38
	2000	89	0	500	268	0	0	889	1311	168	0	3420	12 -5008 -57
* PROBLEM AREA													
N	1983	54	97	0	111	151	0	302	56	104	187	700	52 -938 -17
	2000	56	507	0	150	223	0	701	131	202	314	950	36 -1383 -25
P205	1983	54	853	0	42	0	0	182	32	0	0	210	52 523 10
	2000	56	3994	0	57	0	0	436	81	0	0	285	36 3284 59
K20	1983	54	0	0	87	0	0	105	140	23	0	525	26 -680 -13
	2000	56	0	0	118	0	0	245	333	4	0	712	18 -1158 -21
* NATURALLY FLOODED													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
* IRRIGATED AREA													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
* TOTAL													
N	1983	285	402	447	766	792	0	2648	658	804	1790	9040	195 -12338 -43
	2000	298	2828	754	1012	1176	0	6312	1565	1331	2629	11870	99 -17839 -60
P205	1983	285	4020	249	290	0	0	1467	419	0	0	3337	195 -470 -2
	2000	298	22353	460	383	0	0	3626	1067	0	0	4380	99 14222 48
K20	1983	285	0	939	602	0	0	957	1802	802	0	6780	97 -8703 -30
	2000	298	0	1751	795	0	0	2262	4414	743	0	8902	49 -13725 -46

Figure 4.18 Nutrient balance for Liberia, 1983 (in kg/ha,yr)

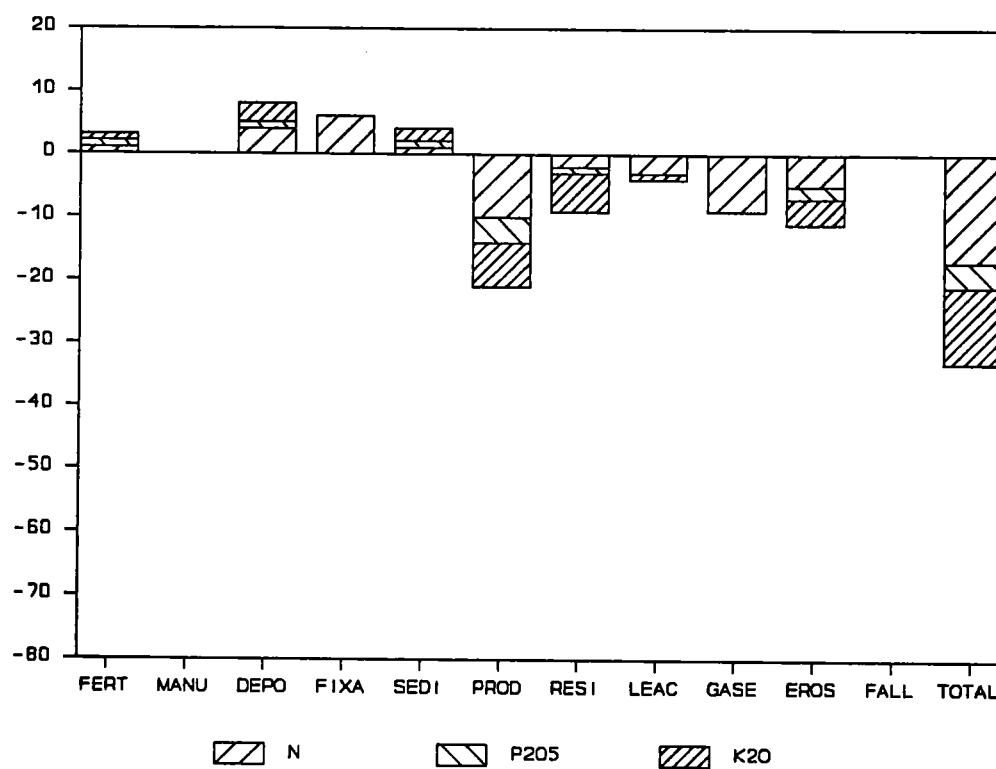


Table 4.35 LWC-distribution in Liberia (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	0	73	27	0
2000	0	0	0	70	29	1

Table 4.36 Liberia; nutrient balances for LWC s and for country total

		AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL	
		000 HA												(TON) (KG/HA)	
* LOW RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* GOOD RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* PROBLEM AREA															
N	1983	544	399	0	2110	2433	0	5487	1334	1592	5410	4000	218	-12664	-23
	2000	726	1159	0	2604	3058	0	9964	2441	1651	6322	5120	377	-18299	-25
P205	1983	544	249	0	799	0	0	2160	739	0	0	1200	218	-2834	-5
	2000	726	886	0	986	0	0	3964	1415	0	0	1536	377	-4666	-6
K20	1983	544	400	0	1658	0	0	4469	2850	971	0	3000	109	-9124	-17
	2000	726	600	0	2046	0	0	8575	4916	939	0	3840	189	-15434	-21
* NATURALLY FLOODED															
N	1983	198	193	0	676	2246	719	1694	390	564	1187	0	0	0	0
	2000	300	776	0	1064	3524	2132	4142	961	707	1686	0	0	0	0
P205	1983	198	145	0	256	0	923	1123	201	0	0	0	0	0	0
	2000	300	568	0	403	0	2288	2763	495	0	0	0	0	0	0
K20	1983	198	0	0	531	0	1553	598	1483	2	0	0	0	0	0
	2000	300	0	0	836	0	4337	1507	3664	1	0	0	0	0	0
* IRRIGATED AREA															
N	1983	3	9	0	20	66	30	77	12	14	29	0	0	-8	-3
	2000	9	65	0	59	198	90	344	53	35	80	0	0	-100	-11
P205	1983	3	6	0	7	0	9	51	5	0	0	0	0	-33	-11
	2000	9	48	0	22	0	27	232	21	0	0	0	0	-156	-17
K20	1983	3	0	0	15	0	15	27	45	0	0	0	0	-41	-14
	2000	9	0	0	46	0	45	122	202	0	0	0	0	-232	-26
* TOTAL															
N	1983	745	601	0	2806	4745	749	7258	1736	2170	6626	4000	218	-12672	-17
	2000	1035	2001	0	3727	6780	2222	14451	3455	2393	8088	5120	377	-18399	-18
P205	1983	745	401	0	1062	0	932	3334	945	0	0	1200	218	-2867	-4
	2000	1035	1502	0	1411	0	2315	6959	1932	0	0	1536	377	-4822	-5
K20	1983	745	400	0	2204	0	1568	5095	4378	973	0	3000	109	-9165	-12
	2000	1035	600	0	2929	0	4382	10204	8782	939	0	3840	189	-15667	-15

Figure 4.19 Nutrient balance for Madagascar, 1983 (in kg/ha,yr)

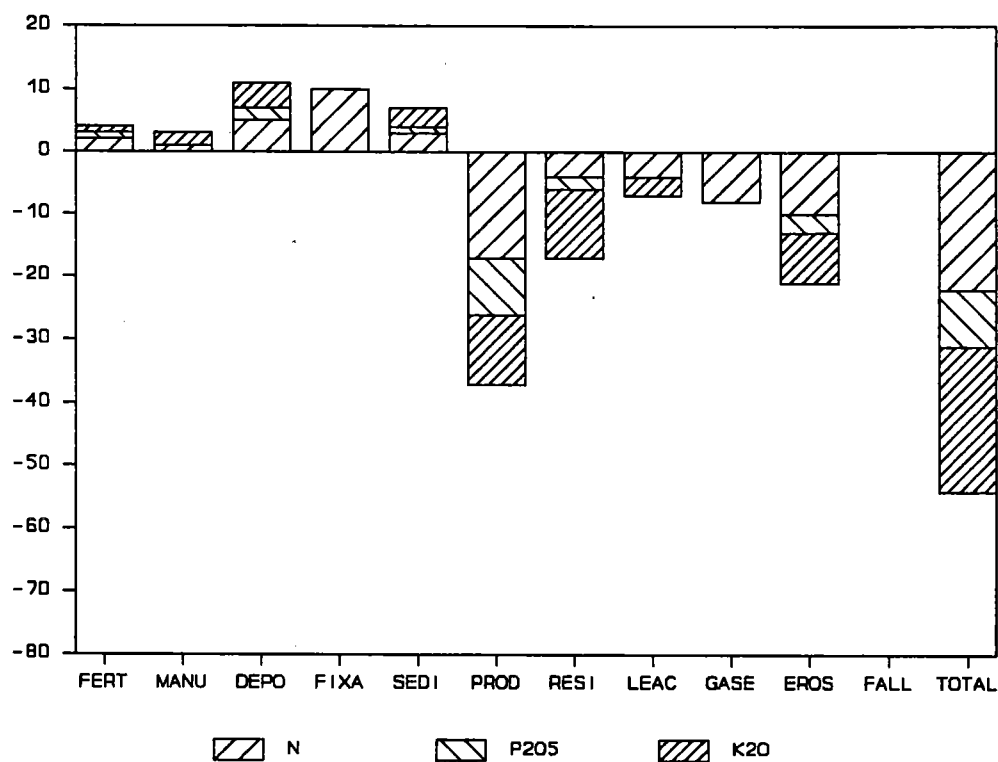


Table 4.37 LWC-distribution in Madagascar (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	3	7	25	31	6	29
2000	3	7	25	29	7	29

Table 4.38 Madagascar; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983 83	7	85	82	209	0	390	189	69	156	480	118	-782 -9
	2000 107	20	112	106	299	0	520	249	91	202	620	152	-993 -9
P205	1983 83	9	43	31	0	0	197	95	0	0	180	118	-271 -3
	2000 107	16	55	40	0	0	256	123	0	0	232	152	-349 -3
K20	1983 83	4	178	65	0	0	127	396	114	0	360	59	-691 -8
	2000 107	17	228	84	0	0	168	506	152	0	465	76	-887 -8
* UNCERTAIN RAINFALL													
N	1983 206	152	647	701	999	0	2969	958	579	1380	5010	78	-8318 -40
	2000 273	402	783	836	1479	0	4410	1339	638	1642	5970	147	-10352 -38
P205	1983 206	119	311	266	0	0	1061	499	0	0	1879	78	-2665 -13
	2000 273	231	369	316	0	0	1635	698	0	0	2239	147	-3507 -13
K20	1983 206	167	1135	551	0	0	2780	1280	1002	0	3757	39	-6927 -34
	2000 273	479	1377	657	0	0	3915	1955	1245	0	4477	74	-9006 -33
* GOOD RAINFALL													
N	1983 776	989	1351	2776	3894	0	11416	2827	2021	4357	10490	528	-21574 -28
	2000 1002	2179	1875	3367	5747	0	20517	5241	2055	5114	12900	761	-31898 -32
P205	1983 776	680	643	1051	0	0	4354	1561	0	0	3147	528	-6160 -8
	2000 1002	1343	880	1275	0	0	8156	2855	0	0	3870	761	-10623 -11
K20	1983 776	1091	2282	2181	0	0	10656	3859	2529	0	7867	264	-19094 -25
	2000 1002	2818	3242	2646	0	0	18694	6886	3372	0	9675	381	-29542 -29
* PROBLEM AREA													
N	1983 961	903	437	4218	3402	0	15756	2880	3557	6860	16615	692	-36014 -37
	2000 1174	2931	633	5315	4441	0	25187	4468	4316	8481	21085	798	-49416 -42
P205	1983 961	426	219	1597	0	0	5010	1676	0	0	4984	692	-8738 -9
	2000 1174	1417	317	2012	0	0	7763	2591	0	0	6325	798	-12135 -10
K20	1983 961	1273	687	3314	0	0	12830	4294	3289	0	12461	346	-27253 -28
	2000 1174	3745	995	4176	0	0	20132	6655	4546	0	15814	399	-37831 -32
* NATURALLY FLOODED													
N	1983 197	245	689	1510	4333	1583	2742	1286	1792	2541	0	0	0 0
	2000 286	1135	1003	2197	6302	2334	4320	2026	2768	3857	0	0	0 0
P205	1983 197	99	345	572	0	1490	1844	662	0	0	0	0	0 0
	2000 286	370	501	832	0	2245	2905	1043	0	0	0	0	0 0
K20	1983 197	107	1083	1187	0	4714	969	4898	1224	0	0	0	0 0
	2000 286	572	1576	1726	0	7198	1527	7716	1828	0	0	0	0 0
* IRRIGATED AREA													
N	1983 908	2904	0	5687	19541	9082	21026	4868	3510	8596	0	0	-785 -1
	2000 1186	12943	0	7425	25369	11859	39298	8938	4844	11576	0	0	-7059 -6
P205	1983 908	1169	0	2153	0	2725	14213	2590	0	0	0	0	-10756 -12
	2000 1186	4322	0	2811	0	3558	26791	4928	0	0	0	0	-21029 -18
K20	1983 908	1356	0	4468	0	4541	8351	18425	86	0	0	0	-16497 -18
	2000 1186	7078	0	5834	0	5929	17488	33596	466	0	0	0	-32709 -28
* TOTAL													
N	1983 3131	5200	3210	14975	32379	10665	54299	13008	11528	23889	32595	1415	-67474 -22
	2000 4028	19610	4407	19246	43638	14193	94252	22259	14712	30872	40575	1859	-99717 -25
P205	1983 3131	2502	1560	5669	0	4214	26678	7083	0	0	10190	1415	-28590 -9
	2000 4028	7699	2121	7286	0	5802	47506	12237	0	0	12667	1859	-47642 -12
K20	1983 3131	3999	5367	11766	0	9255	35713	33152	8244	0	24446	708	-70461 -23
	2000 4028	14710	7417	15122	0	13127	61925	57315	11610	0	30431	929	-109975 -27

Figure 4.20 Nutrient balance for Malawi, 1983 (in kg/ha,yr)

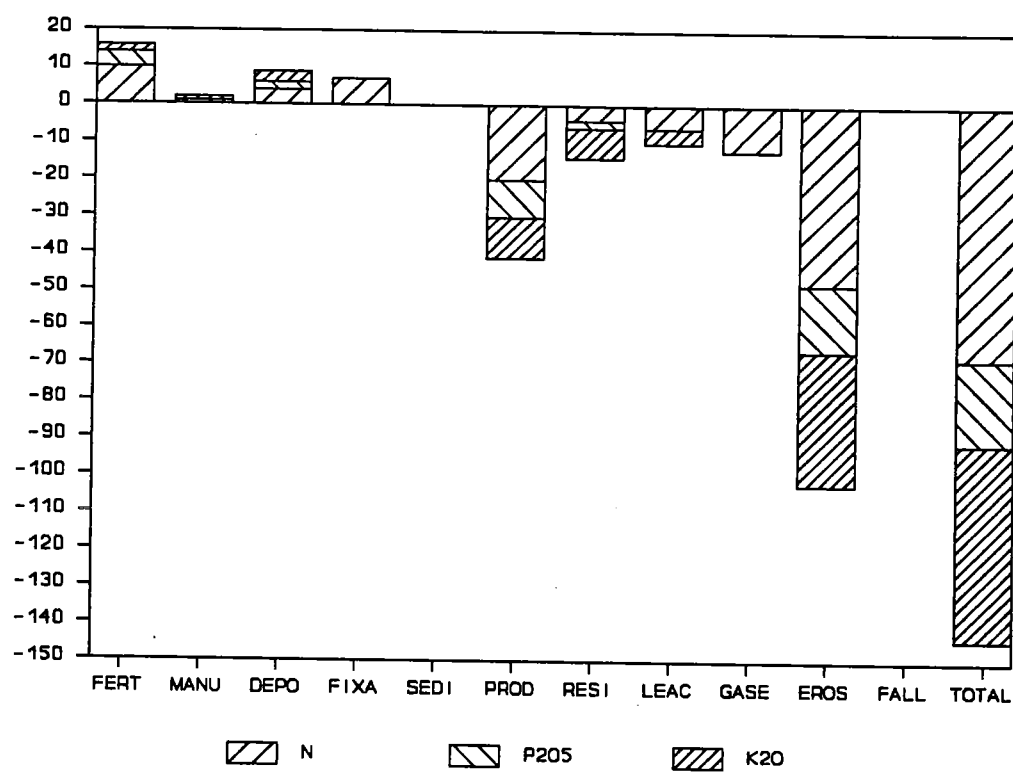


Table 4.39 LWC-distribution in Malawi (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	15	70	12	1	2
2000	0	21	62	14	2	2

Table 4.40 Malawi; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL													
N	1983	377	1123	884	1172	2512	0	4832	2014	1188	1970	6675	196 -10793 -29
	2000	630	4653	1866	2037	5271	0	12664	5150	2360	3930	11160	290 -21148 -34
P205	1983	377	647	458	444	0	0	2407	1054	0	0	2002	196 -3718 -10
	2000	630	2506	963	771	0	0	6043	2679	0	0	3348	290 -7539 -12
K20	1983	377	161	1902	921	0	0	2477	4375	1203	0	5006	98 -9979 -26
	2000	630	812	3939	1600	0	0	8294	9274	2362	0	8370	145 -21803 -35
* GOOD RAINFALL													
N	1983	1768	12446	600	7748	11004	0	37583	6802	8006	20925	99430	35 -140911 -80
	2000	1834	31328	740	8120	14469	0	58025	10522	10898	24596	103873	0 -153257 -84
P205	1983	1768	6513	300	2933	0	0	18962	3435	0	0	37286	35 -49901 -28
	2000	1834	15943	370	3074	0	0	29692	5304	0	0	38953	0 -54561 -30
K20	1983	1768	1859	975	6087	0	0	20461	14349	4908	0	74572	18 -105352 -60
	2000	1834	4645	1203	6380	0	0	31231	22755	3817	0	77905	0 -123480 -67
* PROBLEM AREA													
N	1983	302	7132	0	1475	2046	0	5001	500	3443	6014	15370	60 -19614 -65
	2000	425	13713	0	2028	3630	0	8674	902	5619	9154	20880	102 -25755 -61
P205	1983	302	2147	0	558	0	0	2115	270	0	0	5764	60 -5383 -18
	2000	425	4944	0	768	0	0	3635	485	0	0	7830	102 -6136 -14
K20	1983	302	2199	0	1159	0	0	2925	1437	2409	0	11527	30 -14910 -49
	2000	425	3774	0	1593	0	0	5205	2541	3256	0	15660	51 -21245 -50
* NATURALLY FLOODED													
N	1983	30	131	0	126	452	326	433	89	121	394	0	0 0 0
	2000	45	960	0	145	380	490	815	141	331	646	0	0 43 1
P205	1983	30	35	0	48	0	238	276	45	0	0	0	0 0 0
	2000	45	234	0	55	0	228	439	79	0	0	0	0 0 0
K20	1983	30	2	0	99	0	379	151	314	15	0	0	0 0 0
	2000	45	102	0	114	0	593	284	487	39	0	0	0 0 0
* IRRIGATED AREA													
N	1983	41	4135	0	215	542	410	1771	194	1262	1623	0	0 452 11
	2000	48	6092	0	251	436	480	2739	301	1757	2171	0	0 292 6
P205	1983	41	1687	0	81	0	123	1226	288	0	0	0	0 378 9
	2000	48	2137	0	95	0	144	1777	390	0	0	0	0 209 4
K20	1983	41	1114	0	169	0	205	2647	464	381	0	0	0 -2005 -49
	2000	48	1354	0	198	0	240	3459	800	358	0	0	0 -2826 -59
* TOTAL													
N	1983	2518	24968	1484	10735	16556	737	49620	9597	14020	30925	121475	292 -170866 -68
	2000	2982	56746	2606	12582	24187	970	82916	17015	20966	40497	135913	392 -199825 -67
P205	1983	2518	11030	758	4064	0	361	24986	5092	0	0	45052	292 -58625 -23
	2000	2982	25764	1333	4763	0	372	41585	8937	0	0	50131	392 -68028 -23
K20	1983	2518	5334	2877	8435	0	584	28662	20938	8915	0	91106	146 -132246 -53
	2000	2982	10686	5142	9886	0	833	48472	35856	9832	0	101935	196 -169353 -57

Figure 4.21 Nutrient balance for Mali, 1983 (in kg/ha,yr)

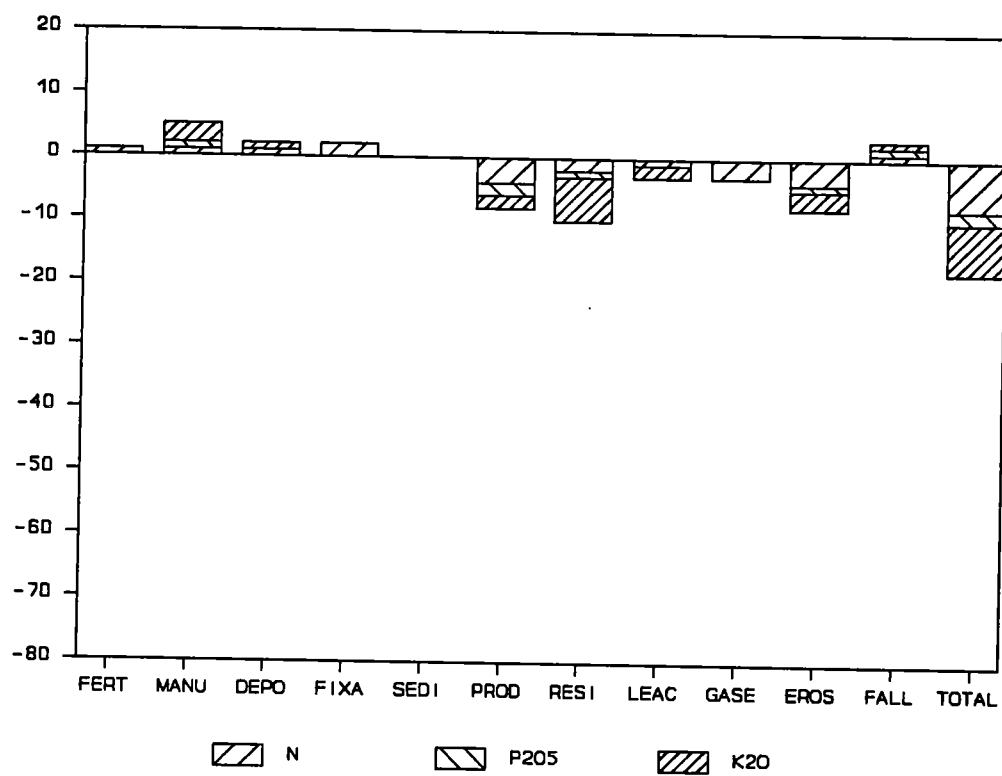


Table 4.41 LWC-distribution in Mali (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	58	25	4	10	1	2
2000	54	27	5	10	1	3

Table 4.42 Mali; nutrient balances for LWC s and for country total

	AREA 000 HA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
* LOW RAINFALL													
N	1983 4648	1265	4656	2367	3541	0	11700	10315	2501	7039	9656	7343	-22038 -5
	2000 4604	1985	5337	2679	4956	0	14332	11903	2894	8016	10922	6998	-26111 -6
P205	1983 4648	433	1870	896	0	0	7749	4235	0	0	3621	7343	-5063 -1
	2000 4604	794	2135	1014	0	0	9027	4925	0	0	4096	6998	-7105 -2
K20	1983 4648	380	14191	1860	0	0	3924	31750	4739	0	7242	3672	-27552 -6
	2000 4604	624	15938	2105	0	0	4863	35921	5359	0	8191	3499	-32168 -7
* UNCERTAIN RAINFALL													
N	1983 2025	3385	3836	3062	4634	0	10364	6232	4176	8161	11480	2592	-22904 -11
	2000 2323	6213	6854	4196	7242	0	19188	12999	5616	10959	16840	2649	-38449 -17
P205	1983 2025	1064	1671	1159	0	0	6377	2754	0	0	4305	2592	-6951 -3
	2000 2323	1887	2889	1588	0	0	11893	5552	0	0	6315	2649	-14747 -6
K20	1983 2025	1141	9380	2406	0	0	4715	17346	6933	0	8610	1296	-23382 -12
	2000 2323	2086	18239	3297	0	0	7493	37317	10438	0	12630	1324	-42933 -18
* GOOD RAINFALL													
N	1983 302	2096	608	717	1280	0	2666	977	1322	2766	2310	320	-5020 -17
	2000 431	3689	1167	1065	1788	0	5442	2299	1923	4099	3580	439	-9194 -21
P205	1983 302	748	253	271	0	0	1990	394	0	0	866	320	-1658 -5
	2000 431	1238	501	403	0	0	3778	1011	0	0	1342	439	-3550 -8
K20	1983 302	547	1393	563	0	0	1504	2533	2119	0	1732	160	-5226 -17
	2000 431	1230	2879	837	0	0	3119	5829	3418	0	2685	220	-9885 -23
* PROBLEM AREA													
N	1983 789	1403	719	667	1806	0	3211	1598	933	2658	8496	1152	-11150 -14
	2000 856	2710	1163	911	2977	0	5414	2585	1384	3741	11616	1130	-15849 -19
P205	1983 789	726	294	252	0	0	1941	653	0	0	3186	1152	-3356 -4
	2000 856	1403	475	345	0	0	3173	1057	0	0	4356	1130	-5232 -6
K20	1983 789	492	2041	524	0	0	1097	4539	1131	0	6372	576	-9506 -12
	2000 856	1085	3222	716	0	0	1832	7161	1744	0	8712	565	-13862 -16
* NATURALLY FLOODED													
N	1983 90	194	0	368	1085	1434	889	440	448	1305	0	0	0 0
	2000 114	703	0	565	1999	2142	1731	918	723	2038	0	0	0 0
P205	1983 90	147	0	139	0	445	535	184	0	0	0	0	12 0
	2000 114	355	0	214	0	1031	1090	423	0	0	0	0	88 1
K20	1983 90	43	0	290	0	1843	384	1363	428	0	0	0	0 0
	2000 114	186	0	444	0	3687	693	3125	500	0	0	0	0 0
* IRRIGATED AREA													
N	1983 161	260	0	311	1975	1110	2124	309	153	1765	0	100	-595 -4
	2000 219	5022	0	577	3884	2060	6944	865	1162	4537	0	26	-1940 -9
P205	1983 161	84	0	118	0	333	1356	150	0	0	0	100	-872 -5
	2000 219	1929	0	218	0	618	4679	443	0	0	0	26	-2331 -11
K20	1983 161	100	0	244	0	555	826	1169	13	0	0	50	-1059 -7
	2000 219	1527	0	453	0	1030	3380	3026	794	0	0	13	-4177 -19
* TOTAL													
N	1983 8015	8603	9819	7491	14322	2544	30955	19871	9532	23693	31942	11507	-61707 -8
	2000 8547	20321	14521	9993	22847	4202	53050	31569	13703	33390	42958	11242	-91543 -11
P205	1983 8015	3200	4088	2836	0	778	19948	8370	0	0	11978	11507	-17888 -2
	2000 8547	7606	6001	3783	0	1649	33639	13411	0	0	16109	11242	-32878 -4
K20	1983 8015	2702	27005	5886	0	2398	12450	58700	15363	0	23956	5754	-66725 -8
	2000 8547	6737	40277	7852	0	4717	21379	92379	22252	0	32218	5621	-103025 -12

Figure 4.22 Nutrient balance for Mauritania, 1983 (in kg/ha,yr)

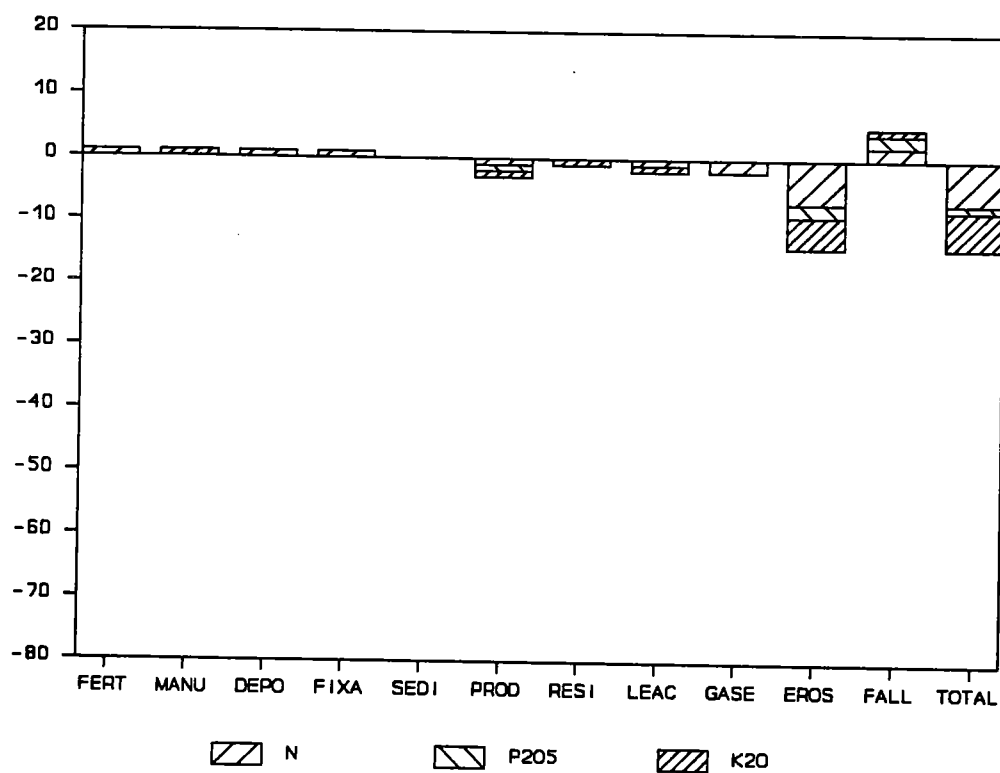


Table 4.43 LWC-distribution in Mauritania (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	58	40	0	0	0	2
2000	65	34	0	0	0	1

Table 4.44 Mauritania; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)	
	000 HA													
* LOW RAINFALL														
N	1983 494	44	99	176	497	0	355	180	250	695	870	811	-723	-1
	2000 660	205	347	261	761	0	1070	732	356	1016	1296	1056	-1840	-3
P205	1983 494	44	34	67	0	0	161	57	0	0	326	811	412	1
	2000 660	68	128	99	0	0	593	273	0	0	486	1056	-1	0
K20	1983 494	0	209	138	0	0	203	403	174	0	652	405	-679	-1
	2000 660	0	936	205	0	0	493	2038	358	0	972	528	-2192	-3
* UNCERTAIN RAINFALL														
N	1983 337	93	105	254	538	0	401	208	347	1004	4760	513	-5217	-15
	2000 346	690	613	423	1052	0	1917	1323	616	1709	7940	422	-10306	-30
P205	1983 337	60	39	96	0	0	188	79	0	0	1785	513	-1344	-4
	2000 346	131	245	160	0	0	1095	539	0	0	2977	422	-3653	-11
K20	1983 337	0	227	199	0	0	228	472	362	0	3570	256	-3949	-12
	2000 346	0	1648	332	0	0	802	3619	820	0	5955	211	-9005	-26
* GOOD RAINFALL														
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
* PROBLEM AREA														
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
* NATURALLY FLOODED														
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0	0
* IRRIGATED AREA														
N	1983 14	292	0	15	112	60	172	27	77	153	0	15	65	5
	2000 7	1187	0	17	114	70	301	45	327	415	0	0	300	43
P205	1983 14	0	0	6	0	18	104	10	0	0	0	15	-76	-6
	2000 7	104	0	6	0	21	182	18	0	0	0	0	-68	-10
K20	1983 14	0	0	11	0	30	84	101	0	0	0	8	-136	-10
	2000 7	0	0	13	0	35	137	171	0	0	0	0	-260	-37
* TOTAL														
N	1983 846	429	204	444	1147	60	929	415	674	1851	5630	1339	-5876	-7
	2000 1013	2082	959	701	1927	70	3288	2100	1299	3141	9236	1478	-11846	-12
P205	1983 846	104	72	168	0	18	453	146	0	0	2111	1339	-1008	-1
	2000 1013	304	373	265	0	21	1870	830	0	0	3463	1478	-3722	-4
K20	1983 846	0	436	349	0	30	515	976	536	0	4222	670	-4765	-6
	2000 1013	0	2584	551	0	35	1432	5828	1178	0	6927	739	-11457	-11

Figure 4.23 Nutrient balance for Mauritius, 1983 (in kg/ha, yr)

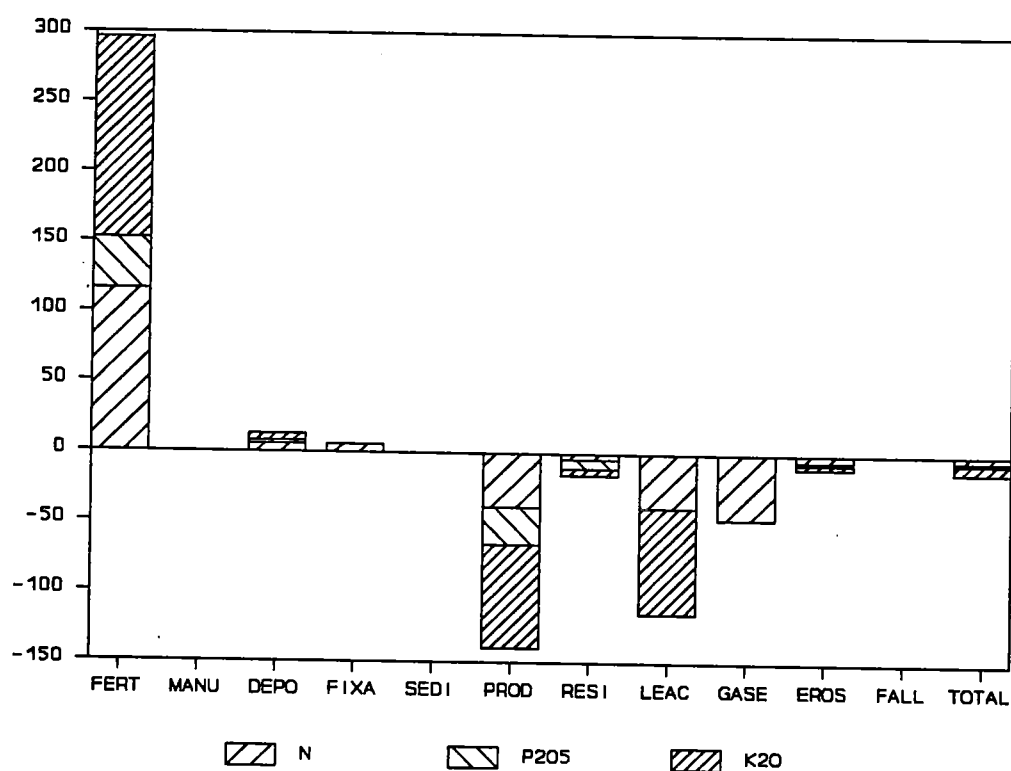


Table 4.45 LWC-distribution in Mauritius (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	0	100	0	0
2000	0	0	0	100	0	0

Table 4.46 Mauritius; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL	
	000 HA												(TON)	(KG/HA)
* LOW RAINFALL														
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL														
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
* GOOD RAINFALL														
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
* PROBLEM AREA														
N	1983	84	9707	14	482	463	0	3243	318	3272	3942	380	13	-477 -6
	2000	83	11861	33	520	572	0	3762	402	3916	4633	680	0	-408 -5
P205	1983	84	3050	4	183	0	0	2294	614	0	0	142	13	199 2
	2000	83	3995	9	197	0	0	2533	672	0	0	255	0	742 9
K20	1983	84	12064	17	379	0	0	6181	450	6346	0	285	7	-796 -10
	2000	83	14457	46	408	0	0	6802	654	7527	0	510	0	-582 -7
* NATURALLY FLOODED														
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
* IRRIGATED AREA														
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
* TOTAL														
N	1983	84	9707	14	482	463	0	3243	318	3272	3942	380	13	-477 -6
	2000	83	11861	33	520	572	0	3762	402	3916	4633	680	0	-408 -5
P205	1983	84	3050	4	183	0	0	2294	614	0	0	142	13	199 2
	2000	83	3995	9	197	0	0	2533	672	0	0	255	0	742 9
K20	1983	84	12064	17	379	0	0	6181	450	6346	0	285	7	-796 -10
	2000	83	14457	46	408	0	0	6802	654	7527	0	510	0	-582 -7

Figure 4.24 Nutrient balance for Mozambique, 1983 (in kg/ha,yr)

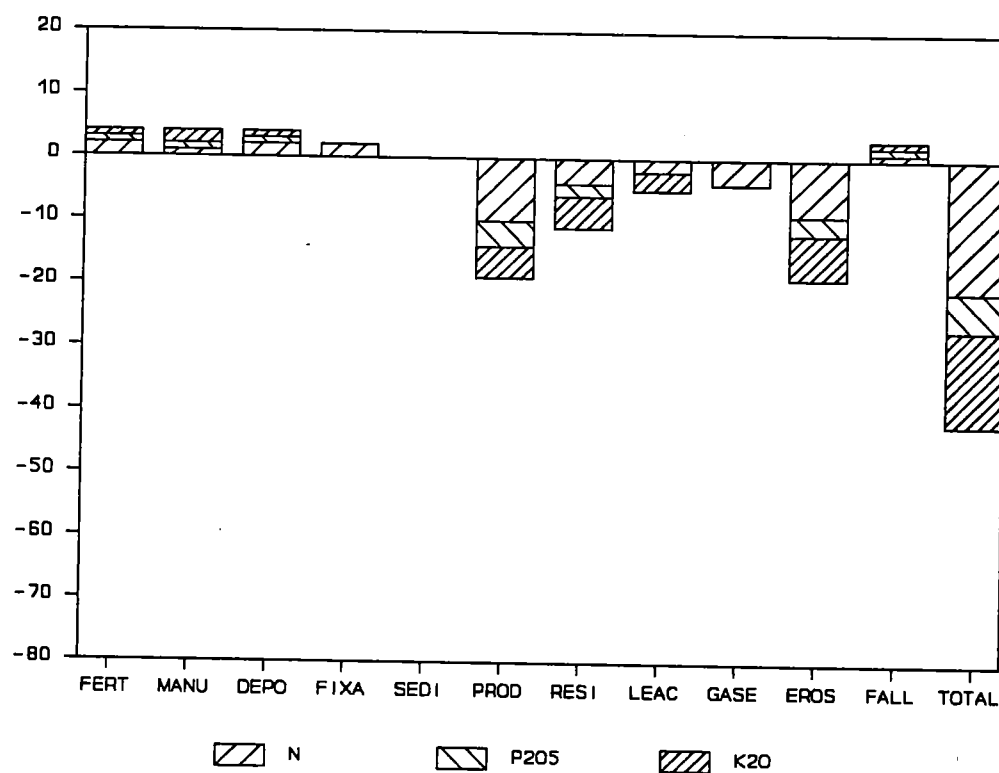


Table 4.47 LWC-distribution in Mozambique (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	15	41	30	11	2	1
2000	13	42	31	10	2	1

Table 4.48 Mozambique; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 841	4160	338	799	1148	0	1578	750	2132	3242	2324	1143	-2438 -3
	2000 921	4418	383	903	1305	0	1743	851	2328	3582	2644	1234	-2906 -3
P205	1983 841	72	184	302	0	0	839	409	0	0	871	1143	-417 0
	2000 921	142	207	342	0	0	932	460	0	0	991	1234	-458 0
K20	1983 841	21	768	628	0	0	717	1707	842	0	1743	572	-3020 -4
	2000 921	39	884	709	0	0	784	1965	967	0	1983	617	-3449 -4
* UNCERTAIN RAINFALL													
N	1983 2292	1497	3926	3449	5129	0	12783	10818	2837	5654	15190	2842	-30438 -13
	2000 3017	2825	6240	4779	7639	0	21209	17850	3678	7449	21015	3621	-46097 -15
P205	1983 2292	1971	2020	1306	0	0	4967	5704	0	0	4557	2842	-7090 -3
	2000 3017	3731	3237	1809	0	0	8168	9431	0	0	6304	3621	-11505 -4
K20	1983 2292	1063	7003	2710	0	0	10938	8372	4769	0	11392	1421	-23275 -10
	2000 3017	2080	11308	3755	0	0	17565	14762	6905	0	15761	1811	-36040 -12
* GOOD RAINFALL													
N	1983 1712	2918	2889	3417	3041	0	11873	6124	4023	9311	18310	1951	-35425 -21
	2000 2235	7980	4903	5293	4973	0	20956	10950	6922	14932	29170	2191	-57589 -26
P205	1983 1712	2667	1602	1294	0	0	5538	3563	0	0	6866	1951	-8454 -5
	2000 2235	7349	2688	2004	0	0	9647	6296	0	0	10939	2191	-12650 -6
K20	1983 1712	1638	5662	2685	0	0	8506	9534	6196	0	13732	976	-27006 -16
	2000 2235	4383	9750	4159	0	0	14912	17384	10222	0	21877	1095	-45009 -20
* PROBLEM AREA													
N	1983 607	906	120	2402	2251	0	29350	6877	834	3220	17230	328	-51504 -85
	2000 749	3245	213	3248	3072	0	57186	13265	1521	5401	23150	300	-90447 -121
P205	1983 607	825	80	909	0	0	8170	3422	0	0	6461	328	-15912 -26
	2000 749	2974	144	1230	0	0	15905	6599	0	0	8681	300	-26538 -35
K20	1983 607	661	336	1887	0	0	9139	7304	1697	0	12922	164	-28014 -46
	2000 749	3201	590	2552	0	0	16547	14338	2455	0	17362	150	-44210 -59
* NATURALLY FLOODED													
N	1983 110	270	0	358	494	1732	822	209	427	1396	0	0	0 0
	2000 151	479	0	562	602	2815	1218	326	696	2218	0	0	0 0
P205	1983 110	260	0	135	0	213	470	139	0	0	0	0	0 0
	2000 151	464	0	213	0	148	622	202	0	0	0	0	0 0
K20	1983 110	90	0	281	0	1013	600	302	482	0	0	0	0 0
	2000 151	199	0	441	0	1571	991	406	815	0	0	0	0 0
* IRRIGATED AREA													
N	1983 60	282	0	257	916	580	1013	124	258	849	0	4	-206 -3
	2000 87	2855	0	314	982	710	2633	304	853	1577	0	31	-475 -5
P205	1983 60	229	0	97	0	174	654	120	0	0	0	4	-270 -5
	2000 87	2423	0	119	0	213	1898	422	0	0	0	31	466 5
K20	1983 60	123	0	202	0	290	996	380	102	0	0	2	-862 -14
	2000 87	1231	0	247	0	355	3893	768	262	0	0	16	-3075 -36
* TOTAL													
N	1983 5621	10034	7273	10682	12979	2312	57419	24902	10511	23672	53054	6268	-120010 -21
	2000 7161	21802	11739	15100	18573	3525	104945	43546	15999	35161	75979	7377	-197514 -28
P205	1983 5621	6023	3886	4044	0	387	20638	13357	0	0	18756	6268	-32143 -6
	2000 7161	17083	6277	5716	0	361	37172	23410	0	0	26916	7377	-50685 -7
K20	1983 5621	3597	13770	8393	0	1303	30896	27598	14088	0	39790	3134	-82177 -15
	2000 7161	11133	22532	11864	0	1926	54693	49623	21626	0	56984	3688	-131783 -18

Figure 4.25 Nutrient balance for Niger, 1983 (in kg/ha,yr)

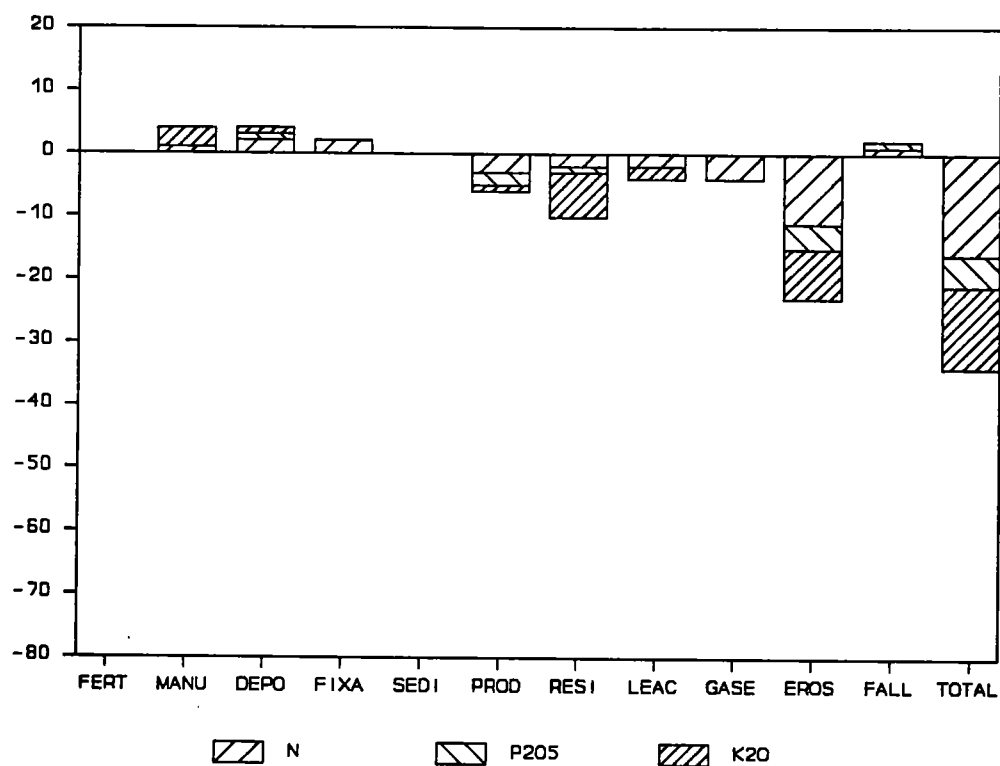


Table 4.49 LWC-distribution in Niger (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	95	5	0	0	0	0
2000	95	5	0	0	0	0

Table 4.50 Niger; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 0430	913	10004	16417	23579	0	29129	22217	18819	41619110560	9804	-161627	-15
	2000 0848	3386	22782	17397	29025	0	62265	50605	17574	41735117160	9980	-206767	-19
P205	1983 0430	271	4617	6215	0	0	18803	10272	0	0 41460	9804	-49628	-5
	2000 0848	1066	10061	6586	0	0	41136	22366	0	0 43935	9980	-79743	-7
K20	1983 0430	180	28732	12899	0	0	11581	63918	20766	0 82920	4902	-132473	-13
	2000 0848	543	67091	13669	0	0	23445149187	28521	0 87870	4990	-202730	-19	
* UNCERTAIN RAINFALL													
N	1983 525	154	1193	1228	2442	0	5420	3820	885	1824 7545	431	-14047	-27
	2000 532	569	2600	1497	4387	0	10348	7133	844	2031 9220	309	-20215	-38
P205	1983 525	29	532	465	0	0	2693	1908	0	0 2263	431	-5408	-10
	2000 532	134	1124	567	0	0	5469	3366	0	0 2766	309	-9468	-18
K20	1983 525	20	3261	964	0	0	2841	8218	1391	0 5659	215	-13648	-26
	2000 532	114	7053	1176	0	0	4926	16920	2273	0 6915	154	-22537	-42
* GOOD RAINFALL													
N	1983 0	0	0	0	0	0	0	0	0	0 0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0 0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0 0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0 0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0 0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0 0	0	0	0
* PROBLEM AREA													
N	1983 0	0	0	0	0	0	0	0	0	0 0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0 0	0	0	0
P205	1983 0	0	0	0	0	0	0	0	0	0 0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0 0	0	0	0
K20	1983 0	0	0	0	0	0	0	0	0	0 0	0	0	0
	2000 0	0	0	0	0	0	0	0	0	0 0	0	0	0
* NATURALLY FLOODED													
N	1983 17	64	0	65	374	109	315	74	25	197 0	0	0	0
	2000 35	191	0	134	770	233	690	162	61	415 0	0	0	0
P205	1983 17	0	0	25	0	226	212	38	0	0 0	0	0	0
	2000 35	64	0	51	0	433	464	83	0	0 0	0	0	0
K20	1983 17	0	0	51	0	342	112	282	0	0 0	0	0	0
	2000 35	0	0	105	0	755	244	616	0	0 0	0	0	0
* IRRIGATED AREA													
N	1983 12	71	0	38	104	120	616	61	3	99 0	0	-446	-37
	2000 23	255	0	72	206	230	1684	162	15	183 0	0	-1281	-56
P205	1983 12	0	0	14	0	36	291	55	0	0 0	0	-295	-25
	2000 23	36	0	27	0	69	812	158	0	0 0	0	-837	-36
K20	1983 12	0	0	30	0	60	388	197	0	0 0	0	-496	-41
	2000 23	46	0	57	0	115	1171	518	0	0 0	0	-1471	-64
* TOTAL													
N	1983 0985	1201	11197	17748	26499	229	35480	26172	19732	43739118105	10235	-176120	-16
	2000 1439	4401	25382	19100	34389	463	74988	58061	18495	44364126380	10289	-228263	-20
P205	1983 0985	300	5148	6719	0	262	21998	12273	0	0 43723	10235	-55331	-5
	2000 1439	1300	11184	7231	0	502	47881	25973	0	0 46701	10289	-90049	-8
K20	1983 0985	200	31993	13945	0	402	14922	72616	22157	0 88579	5118	-146617	-13
	2000 1439	703	74143	15007	0	870	29786167242	30793	0 94785	5145	-226738	-20	

Figure 4.26 Nutrient balance for Nigeria, 1983 (in kg/ha,yr)

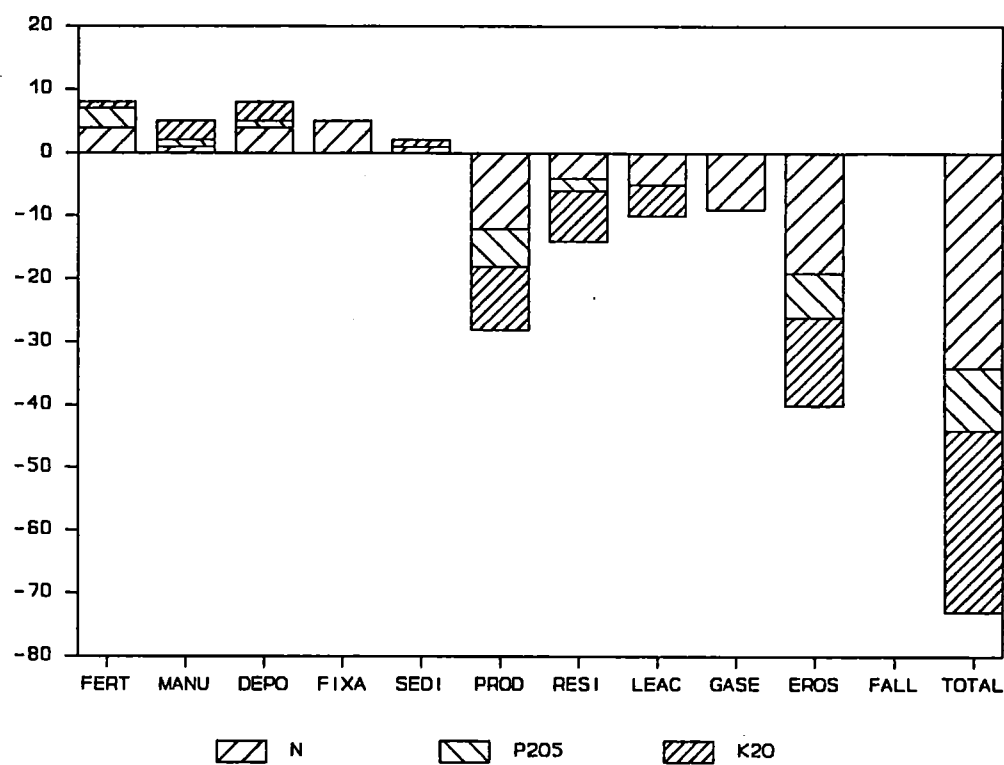


Table 4.51 LWC-distribution in Nigeria (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	10	26	27	32	5	0
2000	8	24	25	36	5	1

Table 4.52 Nigeria; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983 3120	1031	3700	9523	9841	0	14127	7293	9773	13994	13885	686	-34289 -11
	2000 3198	5977	6179	10528	12314	0	23896	12898	11185	15852	15350	256	-43928 -14
P205	1983 3120	814	1836	3605	0	0	8230	3849	0	0	4165	686	-9303 -3
	2000 3198	4645	3001	3986	0	0	14530	6596	0	0	4605	256	-13843 -4
K20	1983 3120	116	9704	7482	0	0	5320	21201	7474	0	10414	343	-26763 -9
	2000 3198	421	16960	8272	0	0	9276	37924	8586	0	11512	128	-41517 -13
* UNCERTAIN RAINFALL													
N	1983 8483	12634	20990	32249	51845	0	95122	45992	35352	75513	233290	679	-366874 -43
	2000 9274	52469	38923	35254	58924	0	154643	87538	44805	89076	254470	742	-444220 -48
P205	1983 8483	11097	10709	12208	0	0	46478	28343	0	0	87484	679	-127611 -15
	2000 9274	42286	19950	13346	0	0	84479	51333	0	0	95426	742	-154914 -17
K20	1983 8483	3739	50937	25338	0	0	71495	114325	43109	0	174967	339	-323543 -38
	2000 9274	7917	103879	27700	0	0	10720	5234855	56114	0	190852	371	-449159 -48
* GOOD RAINFALL													
N	1983 8982	39466	16823	43558	57477	0	160991	48767	46884	105666	256674	0	-461658 -51
	2000 9609	126696	32326	46603	67974	0	261922	87053	63106	127699	274395	0	-540576 -56
P205	1983 8982	33476	9832	16490	0	0	80314	30730	0	0	96253	0	-147500 -16
	2000 9609	97509	19876	17643	0	0	142782	56138	0	0	102898	0	-166789 -17
K20	1983 8982	13826	46351	34224	0	0	13701	4117924	50981	0	192505	0	-404024 -45
	2000 9609	23939	91153	36617	0	0	19297	6224557	55743	0	205796	0	-527364 -55
* PROBLEM AREA													
N	1983 0506	31930	0	33546	28597	0	76960	15591	44137	85304	128600	10296	-246222 -23
	2000 3969	129829	0	50727	43003	0	199149	36276	76203	138438	202760	11734	-417534 -30
P205	1983 0506	25832	0	12700	0	0	28065	8910	0	0	48225	10296	-36372 -3
	2000 3969	98172	0	19204	0	0	76017	22144	0	0	76035	11734	-45086 -3
K20	1983 0506	27490	0	26358	0	0	82583	13648	55852	0	96450	5148	-189537 -18
	2000 3969	53081	0	39857	0	0	215337	36822	71585	0	152070	5867	-377010 -27
* NATURALLY FLOODED													
N	1983 1662	26005	0	6848	11852	29578	28462	2804	13767	27534	0	0	1716 1
	2000 2092	114835	0	11344	20504	52935	66312	6240	41069	63874	0	0	22123 11
P205	1983 1662	11394	0	2593	0	7131	15957	2107	0	0	0	0	3053 2
	2000 2092	50072	0	4295	0	12025	37133	4673	0	0	0	0	24585 12
K20	1983 1662	1150	0	5381	0	29889	22160	8121	6138	0	0	0	0 0
	2000 2092	3684	0	8913	0	61397	50333	18113	5549	0	0	0	0 0
* IRRIGATED AREA													
N	1983 60	4118	0	265	659	599	2679	275	1177	1789	0	0	-279 -5
	2000 212	21297	0	940	2158	2124	12064	1170	5815	8127	0	0	-657 -3
P205	1983 60	2666	0	100	0	180	1644	255	0	0	0	0	1047 17
	2000 212	11969	0	356	0	637	6193	1071	0	0	0	0	5698 27
K20	1983 60	374	0	208	0	300	2148	986	37	0	0	0	-2290 -38
	2000 212	1365	0	739	0	1062	8060	3879	311	0	0	0	-9085 -43
* TOTAL													
N	1983 2813	115184	41513	125990	160271	30177	378340	120723	151090	309799	632449	11661	-1107605 -34
	2000 8355	451103	77429	155396	204877	55059	717985	231177	242184	443066	746975	12732	-1424791 -37
P205	1983 2813	85278	22377	47696	0	7310	180687	74194	0	0	236127	11661	-316687 -10
	2000 8355	304653	42827	58829	0	12662	361134	141953	0	0	278964	12732	-350349 -9
K20	1983 2813	46696	106992	98992	0	30188	320719	276207	163593	0	474337	5830	-946157 -29
	2000 8355	90406	211993	122097	0	62459	583186	556150	197888	0	560231	6366	-1404135 -37

Figure 4.27 Nutrient balance for Rwanda, 1983 (in kg/ha,yr)

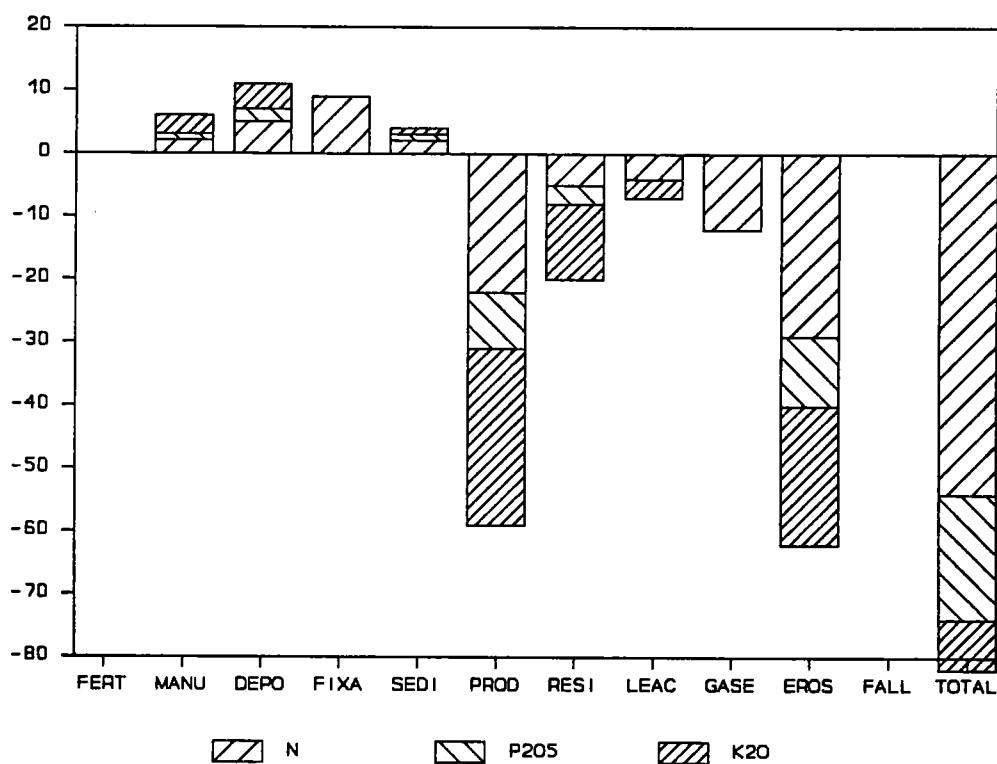


Table 4.53 LWC-distribution in Rwanda (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	34	59	7	0
2000	0	0	36	58	6	0

Table 4.54 Rwanda; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* GOOD RAINFALL													
N	1983	379	127	1258	1678	3309	0	9726	3353	968	2915	4786	0 -15374 -41
	2000	456	692	2153	2019	5423	0	18386	6183	775	2960	5680	0 -23696 -52
P205	1983	379	60	700	635	0	0	4130	2141	0	0	1436	0 -6311 -17
	2000	456	234	1267	764	0	0	8028	4079	0	0	1704	0 -11545 -25
K20	1983	379	30	2578	1319	0	0	10134	6636	1033	0	3590	0 -17466 -46
	2000	456	131	4569	1587	0	0	21435	13058	1388	0	4260	0 -33855 -74
* PROBLEM AREA													
N	1983	652	247	532	3535	6190	0	13225	2302	3023	8994	27012	0 -44053 -68
	2000	735	1202	791	3983	9141	0	22069	3797	2907	9467	29978	0 -53101 -72
P205	1983	652	135	288	1338	0	0	5618	1529	0	0	10130	0 -15516 -24
	2000	735	435	401	1508	0	0	9017	2460	0	0	11242	0 -20375 -28
K20	1983	652	70	1068	2777	0	0	19548	5754	2342	0	20259	0 -43989 -67
	2000	735	251	1557	3130	0	0	30839	8585	2172	0	22484	0 -59142 -81
* NATURALLY FLOODED													
N	1983	74	27	0	359	238	2008	1354	232	215	830	0	0 0 0
	2000	82	108	0	398	314	2996	2480	424	130	783	0	0 0 0
P205	1983	74	5	0	136	0	788	746	183	0	0	0	0 0 0
	2000	82	31	0	151	0	1593	1437	337	0	0	0	0 0 0
K20	1983	74	0	0	282	0	1499	1292	422	67	0	0	0 0 0
	2000	82	18	0	313	0	2684	2165	840	9	0	0	0 0 0
* IRRIGATED AREA													
N	1983	1	0	0	5	22	10	49	11	0	5	0	0 -29 -29
	2000	3	0	0	14	66	30	132	31	0	19	0	0 -73 -24
P205	1983	1	0	0	2	0	3	33	6	0	0	0	0 -34 -34
	2000	3	0	0	5	0	9	89	16	0	0	0	0 -91 -30
K20	1983	1	0	0	4	0	5	17	44	0	0	0	0 -52 -52
	2000	3	0	0	11	0	15	47	118	0	0	0	0 -139 -46
* TOTAL													
N	1983	1106	401	1790	5577	9759	2018	24354	5898	4206	12744	31799	0 -59456 -54
	2000	1276	2003	2944	6415	14944	3026	43067	10434	3811	13230	35658	0 -76869 -60
P205	1983	1106	200	987	2111	0	791	10527	3858	0	0	11566	0 -21861 -20
	2000	1276	700	1668	2428	0	1602	18572	6892	0	0	12946	0 -32011 -25
K20	1983	1106	100	3646	4382	0	1504	30992	12856	3442	0	23849	0 -61507 -56
	2000	1276	399	6125	5040	0	2699	54486	22600	3569	0	26744	0 -93135 -73

Figure 4.28 Nutrient balance for Senegal, 1983 (in kg/ha,yr)

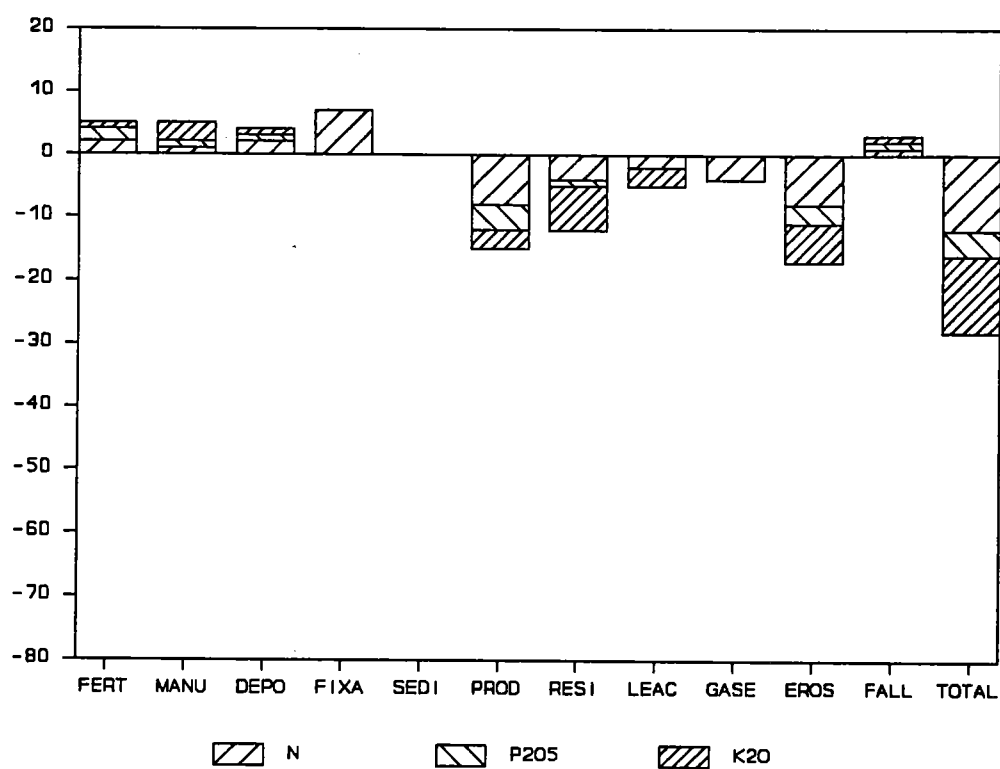


Table 4.55 LWC-distribution in Senegal (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	21	61	6	9	0	3
2000	22	60	6	9	0	3

Table 4.56 Senegal; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 1100	603	1567	1602	5615	0	5903	3482	1582	2771	5720	1056	-9016 -8
	2000 1233	1872	2857	2002	7990	0	9951	6350	2075	3562	7150	1036	-13332 -11
P205	1983 1100	1037	640	606	0	0	2743	1423	0	0	1716	1056	-2543 -2
	2000 1233	2944	1162	758	0	0	4898	2583	0	0	2145	1036	-3726 -3
K20	1983 1100	491	3378	1258	0	0	1679	7507	1881	0	4290	528	-9701 -9
	2000 1233	1266	6657	1573	0	0	2890	14793	3139	0	5362	518	-16170 -13
* UNCERTAIN RAINFALL													
N	1983 3189	3296	5955	6027	26194	0	29271	13330	5654	12725	29130	3508	-45132 -14
	2000 3444	8893	11304	8245	44211	0	54439	25280	7436	17126	39840	2962	-68507 -20
P205	1983 3189	5097	2461	2282	0	0	13327	5524	0	0	10924	3508	-16428 -5
	2000 3444	13847	4667	3121	0	0	25249	10463	0	0	14940	2962	-26055 -8
K20	1983 3189	2475	10578	4735	0	0	8530	23609	9803	0	21847	1754	-44246 -14
	2000 3444	6308	21020	6478	0	0	15920	46902	15176	0	29880	1481	-72591 -21
* GOOD RAINFALL													
N	1983 298	1468	0	737	2150	0	3371	1138	884	1993	4480	292	-7218 -24
	2000 324	2429	0	660	1873	0	4542	1344	884	1834	3960	376	-7228 -22
P205	1983 298	1766	0	279	0	0	1725	490	0	0	1680	292	-1558 -5
	2000 324	2729	0	250	0	0	2313	597	0	0	1485	376	-1041 -3
K20	1983 298	794	0	579	0	0	1102	1933	1025	0	3360	146	-5900 -20
	2000 324	1047	0	518	0	0	1507	2588	742	0	2970	188	-6055 -19
* PROBLEM AREA													
N	1983 489	853	0	739	1913	0	2039	350	725	1197	1745	626	-1925 -4
	2000 517	3407	0	1021	3145	0	4182	748	1401	2053	2410	548	-2672 -5
P205	1983 489	1306	0	280	0	0	1057	145	0	0	523	626	487 1
	2000 517	4608	0	386	0	0	2237	310	0	0	723	548	2272 4
K20	1983 489	2176	0	581	0	0	644	881	1185	0	1309	313	-948 -2
	2000 517	5794	0	802	0	0	1330	1952	2659	0	1807	274	-878 -2
* NATURALLY FLOODED													
N	1983 20	121	0	80	216	226	234	27	90	292	0	0	0 0
	2000 25	371	0	102	246	323	400	47	158	415	0	0	22 1
P205	1983 20	112	0	30	0	33	158	13	0	0	0	0	4 0
	2000 25	342	0	39	0	28	273	21	0	0	0	0	114 5
K20	1983 20	36	0	63	0	99	82	95	20	0	0	0	0 0
	2000 25	127	0	80	0	118	139	159	26	0	0	0	0 0
* IRRIGATED AREA													
N	1983 139	2463	0	353	1247	1030	2556	146	853	2242	0	72	-631 -5
	2000 177	8634	0	545	2141	1590	5650	318	2517	4648	0	35	-188 -1
P205	1983 139	2387	0	134	0	309	1304	71	0	0	0	72	1527 11
	2000 177	8531	0	206	0	477	3126	168	0	0	0	35	5956 34
K20	1983 139	1326	0	278	0	515	1777	345	544	0	0	36	-511 -4
	2000 177	4811	0	428	0	795	4637	749	1725	0	0	18	-1058 -6
* TOTAL													
N	1983 5235	8805	7522	9538	37335	1256	43374	18473	9789	21220	41075	5554	-63922 -12
	2000 5719	25606	14162	12574	59606	1913	79165	34087	14472	29638	53360	4956	-91905 -16
P205	1983 5235	11704	3102	3611	0	342	20313	7665	0	0	14843	5554	-18509 -4
	2000 5719	33001	5829	4760	0	505	38095	14144	0	0	19293	4956	-22480 -4
K20	1983 5235	7298	13957	7494	0	614	13814	34369	14457	0	30806	2777	-61307 -12
	2000 5719	19352	27677	9879	0	913	26423	67143	23466	0	40020	2478	-96752 -17

Figure 4.29 Nutrient balance for Sierra Leone, 1983 (in kg/ha,yr)

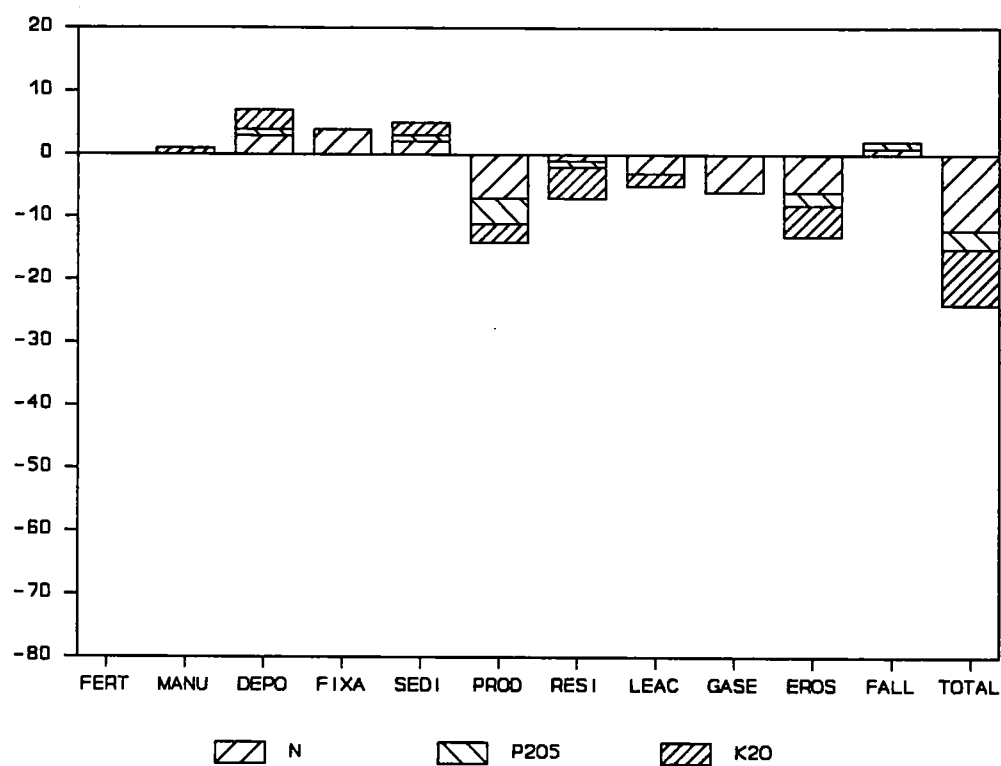


Table 4.57 LWC-distribution in Sierra Leone (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	8	72	20	0
2000	0	0	8	74	17	1

Table 4.58 Sierra Leone; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* GOOD RAINFALL													
N	1983	154	30	339	626	732	0	1214	744	671	931	1945	108 -3669 -24
	2000	167	35	329	657	808	0	1298	753	697	970	2050	123 -3813 -23
P205	1983	154	38	170	237	0	0	637	383	0	0	583	108 -1051 -7
	2000	167	38	163	249	0	0	651	384	0	0	615	123 -1077 -6
K20	1983	154	10	1031	492	0	0	737	2272	781	0	1459	54 -3662 -24
	2000	167	7	984	517	0	0	859	2207	774	0	1537	62 -3809 -23
* PROBLEM AREA													
N	1983	1320	148	0	4067	3735	0	6544	1123	4213	7227	9410	1479 -19089 -14
	2000	1552	278	0	5432	4894	0	10433	1874	5310	9339	12890	1552 -27689 -18
P205	1983	1320	180	0	1540	0	0	3404	582	0	0	2823	1479 -3610 -3
	2000	1552	250	0	2056	0	0	5641	974	0	0	3867	1552 -6624 -4
K20	1983	1320	149	0	3195	0	0	3239	3421	2877	0	7057	739 -12511 -9
	2000	1552	456	0	4268	0	0	5081	5818	3290	0	9667	776 -18357 -12
* NATURALLY FLOODED													
N	1983	360	115	0	1337	3482	3129	4311	850	955	1948	0	0 0 0
	2000	352	158	0	1554	4064	4096	5617	1106	997	2152	0	0 0 0
P205	1983	360	77	0	506	0	2309	2421	470	0	0	0	0 0 0
	2000	352	95	0	588	0	3074	3146	612	0	0	0	0 0 0
K20	1983	360	38	0	1050	0	3762	1598	3104	148	0	0	0 0 0
	2000	352	32	0	1221	0	5013	2093	4031	141	0	0	0 0 0
* IRRIGATED AREA													
N	1983	7	8	0	51	154	70	260	20	25	51	0	0 -73 -10
	2000	22	29	0	160	484	220	995	77	49	129	0	0 -357 -16
P205	1983	7	5	0	19	0	21	175	8	0	0	0	0 -137 -20
	2000	22	17	0	61	0	66	669	31	0	0	0	0 -556 -25
K20	1983	7	3	0	40	0	35	92	76	0	0	0	0 -90 -13
	2000	22	6	0	126	0	110	352	292	0	0	0	0 -402 -18
* TOTAL													
N	1983	1842	300	339	6081	8103	3199	12328	2737	5864	10156	11355	1587 -22831 -12
	2000	2093	500	329	7803	10250	4316	18343	3810	7053	12589	14940	1675 -31860 -15
P205	1983	1842	300	170	2302	0	2330	6637	1444	0	0	3406	1587 -4798 -3
	2000	2093	400	163	2954	0	3140	10107	2001	0	0	4482	1675 -8257 -4
K20	1983	1842	200	1031	4778	0	3797	5667	8873	3807	0	8516	793 -16264 -9
	2000	2093	501	984	6131	0	5123	8385	12348	4205	0	11205	838 -22567 -11

Figure 4.30 Nutrient balance for Somalia, 1983 (in kg/ha,yr)

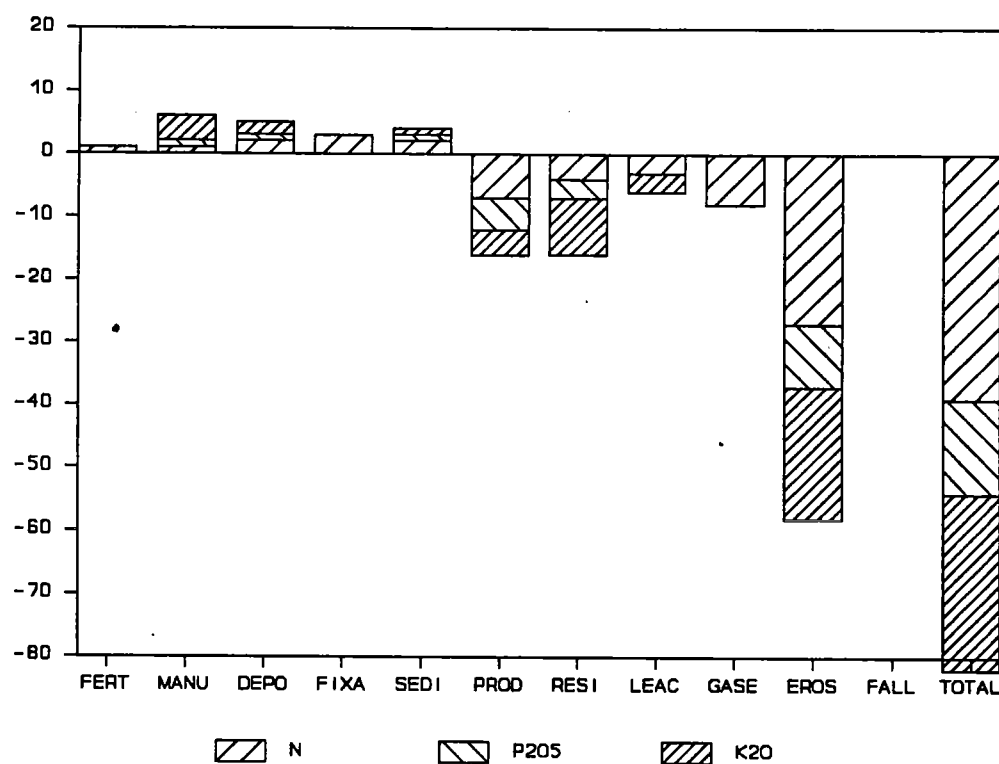


Table 4.59 LWC-distribution in Somalia (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	90	2	0	1	4	4
2000	89	2	0	1	3	6

Table 4.60 Somalia; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 1075	1119	1657	2198	2713	0	6376	3681	2829	7947	31400	581	-43965 -41
	2000 1246	2177	2635	2965	3922	0	10110	5855	3867	10771	42360	374	-60891 -49
P205	1983 1075	266	1364	832	0	0	4279	3032	0	0	11775	581	-16043 -15
	2000 1246	444	1973	1123	0	0	6600	4384	0	0	15885	374	-22956 -18
K20	1983 1075	185	4346	1727	0	0	2289	9658	3449	0	23550	290	-32397 -30
	2000 1246	372	6887	2330	0	0	3745	15305	4857	0	31770	187	-45901 -37
* UNCERTAIN RAINFALL													
N	1983 19	20	72	64	72	0	408	244	53	186	1080	1	-1742 -93
	2000 25	102	136	89	100	0	882	438	55	369	1500	0	-2818 -113
P205	1983 19	0	35	24	0	0	199	122	0	0	405	1	-665 -35
	2000 25	24	67	34	0	0	533	219	0	0	563	0	-1191 -48
K20	1983 19	0	163	50	0	0	263	349	117	0	810	1	-1324 -71
	2000 25	12	314	70	0	0	525	685	289	0	1125	0	-2228 -89
* GOOD RAINFALL													
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 0	0	0	0	0	0	0	0	0	0	0	0	0 0
* PROBLEM AREA													
N	1983 10	71	19	34	50	0	58	43	56	91	100	0	-173 -17
	2000 10	79	19	34	50	0	58	43	58	93	100	0	-170 -17
P205	1983 10	18	19	13	0	0	50	42	0	0	30	0	-73 -7
	2000 10	14	19	13	0	0	50	42	0	0	30	0	-76 -8
K20	1983 10	9	57	27	0	0	18	126	40	0	75	0	-167 -17
	2000 10	7	57	27	0	0	18	126	39	0	75	0	-167 -17
* NATURALLY FLOODED													
N	1983 42	141	0	156	100	1564	1047	146	85	683	0	0	0 0
	2000 43	557	0	159	115	1935	1710	239	102	715	0	0	0 0
P205	1983 42	11	0	59	0	607	593	83	0	0	0	0	0 0
	2000 43	129	0	60	0	897	958	128	0	0	0	0	0 0
K20	1983 42	5	0	122	0	620	358	363	26	0	0	0	0 0
	2000 43	64	0	125	0	1013	588	583	31	0	0	0	0 0
* IRRIGATED AREA													
N	1983 45	166	0	144	144	420	1015	136	103	668	0	5	-1043 -23
	2000 79	1105	0	185	284	540	2900	425	192	895	0	51	-2247 -28
P205	1983 45	11	0	55	0	126	583	134	0	0	0	5	-521 -12
	2000 79	290	0	70	0	162	1634	322	0	0	0	51	-1383 -17
K20	1983 45	5	0	113	0	210	1357	451	17	0	0	3	-1493 -33
	2000 79	245	0	145	0	270	2879	1257	14	0	0	25	-3464 -44
* TOTAL													
N	1983 1191	1518	1748	2596	3079	1984	8904	4251	3125	9576	32580	588	-46923 -39
	2000 1403	4020	2790	3433	4470	2475	15660	7000	4275	12843	43960	425	-66126 -47
P205	1983 1191	305	1419	983	0	733	5704	3415	0	0	12210	588	-17302 -15
	2000 1403	901	2059	1300	0	1059	9776	5096	0	0	16478	425	-25606 -18
K20	1983 1191	205	4566	2040	0	830	4285	10947	3649	0	24435	294	-35381 -30
	2000 1403	701	7258	2698	0	1283	7755	17956	5231	0	32970	212	-51761 -37

Figure 4.31 Nutrient balance for Sudan, 1983 (in kg/ha,yr)

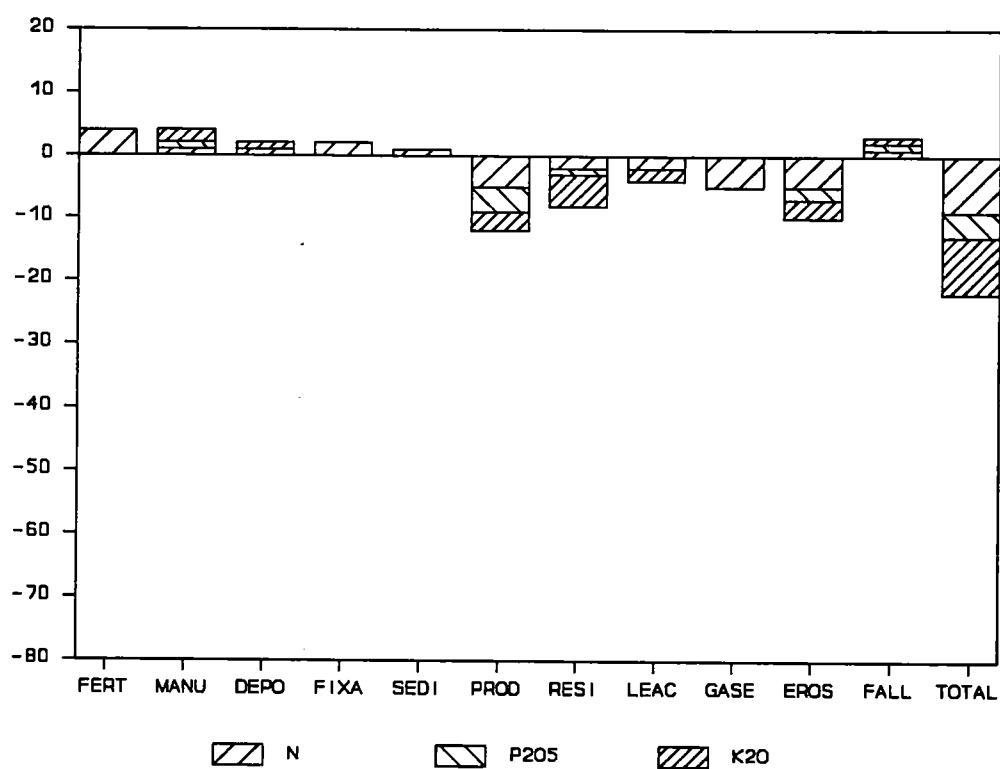


Table 4.61 LWC-distribution in Sudan (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	69	13	3	1	0	13
2000	64	15	4	1	0	15

Table 4.62 Sudan; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL (TON) (KG/HA)
	000 HA												
* LOW RAINFALL													
N	1983 10188	5377	6812	10129	14544	0	23389	15138	13292	32715	41770	12022	-77422 -8
	2000 0142	17738	11699	11067	17412	0	38049	25997	16849	38072	45640	11156	-95536 -9
P205	1983 10188	101	5365	3834	0	0	16704	11923	0	0	15664	12022	-22968 -2
	2000 0142	360	8854	4190	0	0	27855	19676	0	0	17115	11156	-40086 -4
K20	1983 10188	15	18794	7958	0	0	7363	41764	11997	0	31327	6011	-59673 -6
	2000 0142	71	32964	8696	0	0	11982	73254	15273	0	34230	5578	-87430 -9
* UNCERTAIN RAINFALL													
N	1983 1944	4287	2940	4387	7377	0	10786	6379	5821	11890	22160	1672	-36375 -19
	2000 2467	18959	7772	6447	13904	0	27391	17121	11172	20347	32560	1677	-59833 -24
P205	1983 1944	76	2085	1661	0	0	7577	4564	0	0	8310	1672	-14957 -8
	2000 2467	391	5230	2440	0	0	18997	11559	0	0	12210	1677	-33028 -13
K20	1983 1944	0	7611	3447	0	0	3574	16625	7040	0	16620	836	-31965 -16
	2000 2467	72	20615	5065	0	0	8916	45492	12171	0	24420	839	-64409 -26
* GOOD RAINFALL													
N	1983 496	1773	660	1105	1120	0	3319	1334	1403	2671	3480	516	-7033 -14
	2000 613	7175	1439	1537	2536	0	7653	3054	2975	4728	4850	564	-10009 -16
P205	1983 496	31	550	418	0	0	2421	1157	0	0	1044	516	-3107 -6
	2000 613	141	1187	582	0	0	5399	2575	0	0	1455	564	-6954 -11
K20	1983 496	0	1677	868	0	0	1116	3497	1026	0	2610	258	-5446 -11
	2000 613	31	3654	1208	0	0	2541	7841	1398	0	3637	282	-10243 -17
* PROBLEM AREA													
N	1983 184	93	0	309	295	0	943	245	205	694	640	251	-1780 -10
	2000 231	3180	0	435	415	0	1955	382	1130	1817	870	295	-1829 -8
P205	1983 184	1	0	117	0	0	319	172	0	0	192	251	-315 -2
	2000 231	3	0	165	0	0	635	272	0	0	261	295	-705 -3
K20	1983 184	0	0	243	0	0	1403	186	85	0	480	125	-1787 -10
	2000 231	101	0	342	0	0	2347	329	156	0	652	148	-2895 -13
* NATURALLY FLOODED													
N	1983 18	20	0	15	8	89	26	6	22	79	0	0	0 0
	2000 34	275	0	37	140	83	109	25	112	254	0	0	36 1
P205	1983 18	0	0	6	0	19	21	4	0	0	0	0	0 0
	2000 34	2	0	14	0	77	79	14	0	0	0	0	0 0
K20	1983 18	0	0	12	0	14	8	17	0	0	0	0	0 0
	2000 34	0	0	29	0	95	37	87	0	0	0	0	0 0
* IRRIGATED AREA													
N	1983 1894	40935	0	3215	12557	13260	42507	3640	10895	29954	0	1137	-15892 -8
	2000 2451	106572	0	4457	25232	18380	84612	7840	26062	53435	0	1225	-16082 -7
P205	1983 1894	691	0	1217	0	3978	25927	2143	0	0	0	1137	-21048 -11
	2000 2451	2304	0	1687	0	5514	47668	4518	0	0	0	1225	-41455 -17
K20	1983 1894	285	0	2526	0	6630	24109	9481	6327	0	0	568	-29907 -16
	2000 2451	926	0	3502	0	9190	43842	22256	9123	0	0	613	-60990 -25
* TOTAL													
N	1983 14724	52485	10412	19160	35900	13349	80970	26743	31639	78003	68050	15596	-138503 -9
	2000 5938	153899	20909	23979	59639	18463	159769	54419	58300	118654	83920	14918	-183254 -11
P205	1983 14724	900	8000	7254	0	3997	52969	19964	0	0	25210	15596	-62396 -4
	2000 5938	3200	15271	9078	0	5591	100632	38613	0	0	31041	14918	-122228 -8
K20	1983 14724	300	28082	15055	0	6644	37574	71570	26475	0	51037	7798	-128778 -9
	2000 5938	1200	57233	18841	0	9285	69665	149259	38121	0	62940	7459	-225967 -14

Figure 4.32 Nutrient balance for Swaziland, 1983 (in kg/ha,yr)

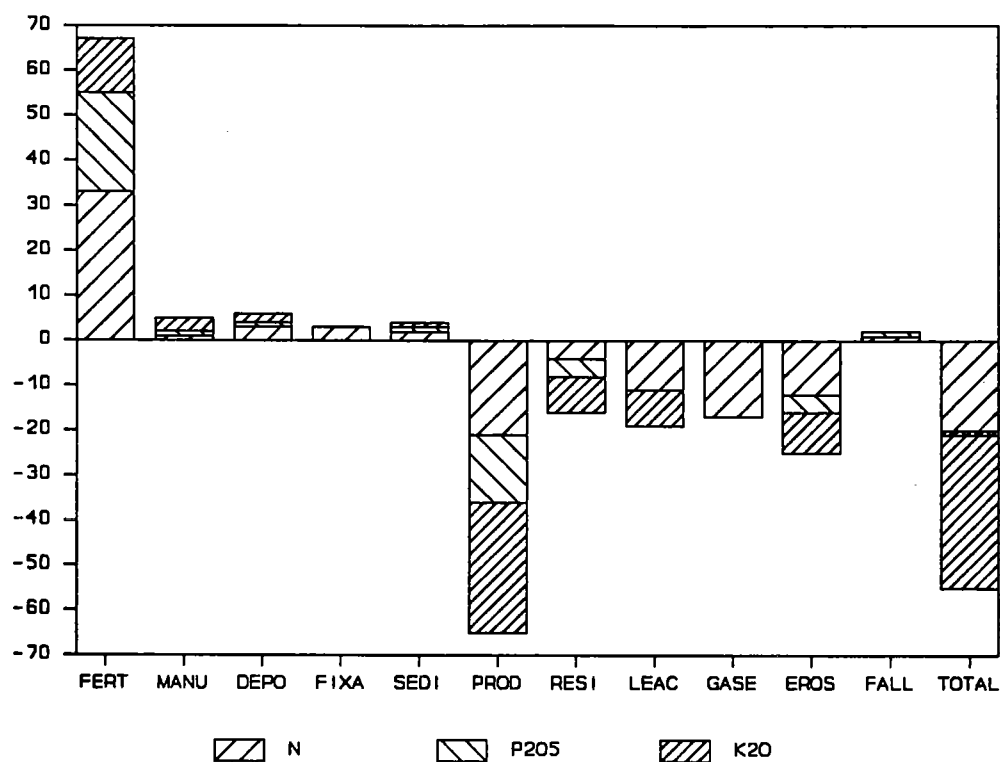


Table 4.63 LWC-distribution in Swaziland (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	13	33	26	5	0	23
2000	12	29	30	4	0	25

Table 4.64 Swaziland; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	29	24	32	41	36	0	127	56	48	107	330	35 -500 -17
	2000	31	174	65	75	66	0	260	130	123	219	630	18 -965 -31
P205	1983	29	16	17	16	0	0	77	32	0	0	124	35 -149 -5
	2000	31	122	39	29	0	0	160	80	0	0	236	18 -269 -9
K20	1983	29	8	69	32	0	0	56	147	73	0	247	17 -397 -14
	2000	31	17	153	59	0	0	101	339	127	0	472	9 -800 -26
* UNCERTAIN RAINFALL													
N	1983	70	212	149	143	154	0	698	331	174	389	1050	70 -1915 -27
	2000	76	933	350	245	332	0	1631	778	429	777	1800	32 -3523 -46
P205	1983	70	124	73	54	0	0	392	161	0	0	394	70 -626 -9
	2000	76	505	176	93	0	0	878	392	0	0	675	32 -1139 -15
K20	1983	70	36	374	112	0	0	328	831	282	0	787	35 -1672 -24
	2000	76	116	849	192	0	0	720	1887	519	0	1350	16 -3303 -43
* GOOD RAINFALL													
N	1983	56	788	68	188	246	0	888	145	368	641	960	36 -1676 -30
	2000	77	2123	211	297	407	0	2456	466	704	1123	1550	34 -3228 -42
P205	1983	56	574	32	71	0	0	430	72	0	0	360	36 -148 -3
	2000	77	1324	103	112	0	0	1235	234	0	0	581	34 -477 -6
K20	1983	56	660	153	148	0	0	605	363	479	0	720	18 -1189 -21
	2000	77	1300	503	233	0	0	1358	1167	792	0	1162	17 -2426 -32
* PROBLEM AREA													
N	1983	10	49	0	23	25	0	101	18	28	47	200	10 -287 -29
	2000	10	210	0	33	35	0	200	35	72	99	280	7 -402 -38
P205	1983	10	24	0	9	0	0	56	9	0	0	75	10 -97 -10
	2000	10	110	0	12	0	0	112	17	0	0	105	7 -105 -10
K20	1983	10	0	0	18	0	0	34	43	11	0	150	5 -214 -21
	2000	10	10	0	26	0	0	68	84	8	0	210	3 -331 -32
* NATURALLY FLOODED													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0 0
* IRRIGATED AREA													
N	1983	50	5988	0	194	98	490	2595	212	1652	2478	0	2 -164 -3
	2000	64	7288	0	226	174	570	3135	253	1996	3029	0	14 -141 -2
P205	1983	50	3903	0	73	0	147	2332	494	0	0	0	2 1300 26
	2000	64	4603	0	85	0	171	2830	552	0	0	0	14 1491 23
K20	1983	50	1919	0	152	0	245	5215	282	848	0	0	1 -4028 -81
	2000	64	2120	0	177	0	285	5874	386	1028	0	0	7 -4699 -73
* TOTAL													
N	1983	215	7062	248	589	558	490	4409	761	2270	3662	2540	152 -4542 -21
	2000	258	10728	626	876	1014	570	7681	1663	3325	5247	4260	105 -8258 -32
P205	1983	215	4642	122	223	0	147	3287	768	0	0	952	152 280 1
	2000	258	6664	318	331	0	171	5216	1276	0	0	1597	105 -499 -2
K20	1983	215	2623	595	463	0	245	6239	1666	1693	0	1905	76 -7500 -35
	2000	258	3564	1506	688	0	285	8121	3864	2474	0	3195	52 -11559 -45

Figure 4.33 Nutrient balance for Tanzania, 1983 (in kg/ha,yr)

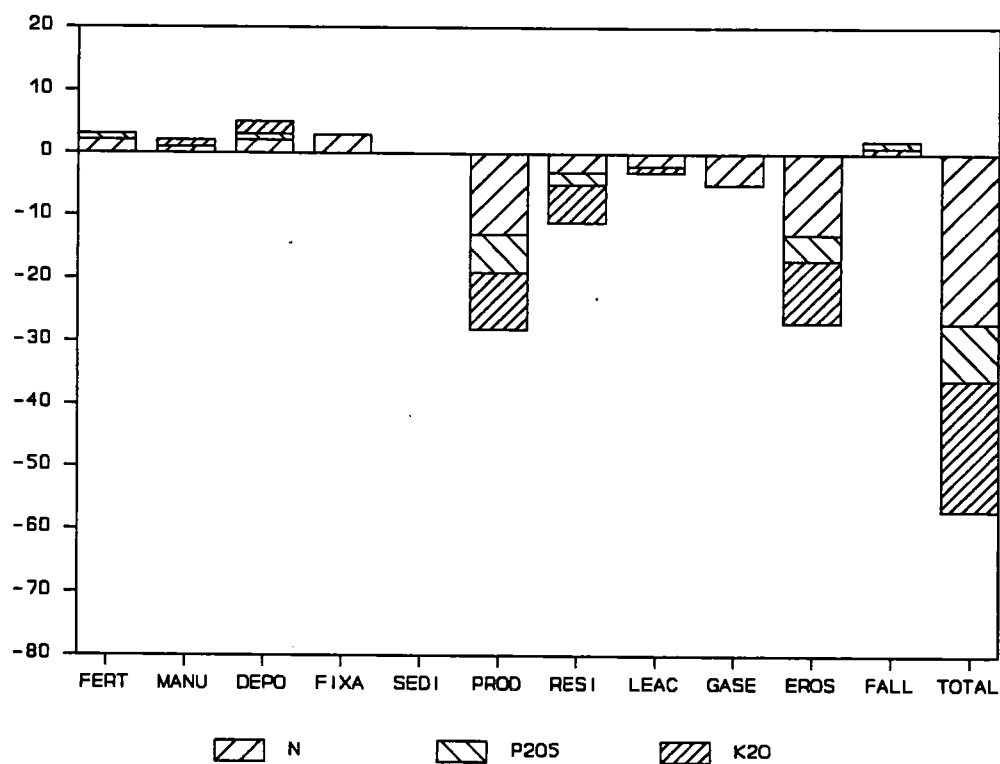


Table 4.65 LWC-distribution in Tanzania (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	14	36	38	8	3	1
2000	14	31	42	8	3	1

Table 4.66 Tanzania; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 1243	1075	1081	1917	2782	0	4253	1770	2115	3085	11185	1317	-14235 -11
	2000 1948	1446	2193	3326	5056	0	9179	4239	3223	4904	19765	1870	-27418 -14
P205	1983 1243	142	594	726	0	0	2531	1033	0	0	3355	1317	-4141 -3
	2000 1948	346	1127	1259	0	0	5718	2229	0	0	5929	1870	-9274 -5
K20	1983 1243	7	2532	1507	0	0	1942	4913	1462	0	8389	659	-12002 -10
	2000 1948	36	5712	2613	0	0	3766	11957	2467	0	14824	935	-23718 -12
* UNCERTAIN RAINFALL													
N	1983 3304	3387	2594	6334	8884	0	25933	8008	5266	14195	52650	3304	-81550 -25
	2000 4207	8648	5049	9033	11194	0	49283	15259	6432	19194	76070	3702	-128612 -31
P205	1983 3304	1289	1374	2398	0	0	13127	4541	0	0	19744	3304	-29047 -9
	2000 4207	2769	2610	3420	0	0	25307	8427	0	0	28526	3702	-49760 -12
K20	1983 3304	402	5489	4977	0	0	15895	11217	5641	0	39487	1652	-59720 -18
	2000 4207	832	11129	7097	0	0	28477	22691	6509	0	57052	1851	-93821 -22
* GOOD RAINFALL													
N	1983 3521	9382	3332	10647	9594	0	57298	15307	6488	20816	46070	1972	-111052 -32
	2000 5626	23398	5720	17014	17720	0	123888	31195	8007	30573	73112	3150	-199772 -36
P205	1983 3521	3738	1666	4031	0	0	26518	8633	0	0	13821	1972	-37566 -11
	2000 5626	9105	2860	6441	0	0	56864	17466	0	0	21934	3150	-74707 -13
K20	1983 3521	1554	5414	8365	0	0	43036	25713	3634	0	34552	986	-90615 -26
	2000 5626	3048	9295	13368	0	0	84211	53992	4025	0	54834	1575	-169776 -30
* PROBLEM AREA													
N	1983 752	2318	0	2384	3468	0	29066	4421	1296	3087	8850	300	-38250 -51
	2000 1124	6054	0	3338	4639	0	52817	8069	2245	4752	13172	562	-66462 -59
P205	1983 752	836	0	902	0	0	8784	2293	0	0	2655	300	-11694 -16
	2000 1124	2033	0	1264	0	0	16188	4198	0	0	3952	562	-20479 -18
K20	1983 752	547	0	1873	0	0	14318	7028	405	0	6637	150	-25819 -34
	2000 1124	1221	0	2623	0	0	26383	13450	426	0	9879	281	-46013 -41
* NATURALLY FLOODED													
N	1983 282	1213	0	1159	6072	1553	3842	901	1034	4221	0	0	0 0
	2000 424	8642	0	1764	9240	3933	11206	2628	2447	7298	0	0	0 0
P205	1983 282	214	0	439	0	2394	2583	464	0	0	0	0	0 0
	2000 424	1525	0	668	0	6694	7535	1352	0	0	0	0	0 0
K20	1983 282	0	0	911	0	3878	1358	3431	0	0	0	0	0 0
	2000 424	145	0	1386	0	12437	3961	10008	0	0	0	0	0 0
* IRRIGATED AREA													
N	1983 100	862	0	443	920	1000	2478	553	449	1466	0	0	-1720 -17
	2000 148	4370	0	589	1286	1330	5075	1171	1268	2625	0	30	-2535 -17
P205	1983 100	188	0	168	0	300	1704	301	0	0	0	0	-1350 -13
	2000 148	942	0	223	0	399	3500	634	0	0	0	30	-2540 -17
K20	1983 100	2	0	348	0	500	2573	1880	29	0	0	0	-3632 -36
	2000 148	227	0	463	0	665	5285	4055	79	0	0	15	-8049 -54
* TOTAL													
N	1983 9201	18238	7006	22884	31720	2553	122870	30960	16647	46869	118755	6893	-246806 -27
	2000 3477	52558	12962	35064	49135	5263	251448	62559	23622	69347	182120	9314	-424800 -32
P205	1983 9201	6407	3634	8663	0	2694	55247	17266	0	0	39575	6893	-83796 -9
	2000 3477	16720	6597	13274	0	7093	115112	34306	0	0	60341	9314	-156761 -12
K20	1983 9201	2512	13436	17980	0	4378	79122	54183	11170	0	89066	3446	-191788 -21
	2000 3477	5510	26136	27550	0	13102	152084	116153	13505	0	136590	4657	-341377 -25

Figure 4.4 Nutrient balance for Togo, 1983 (in kg/ha,yr)

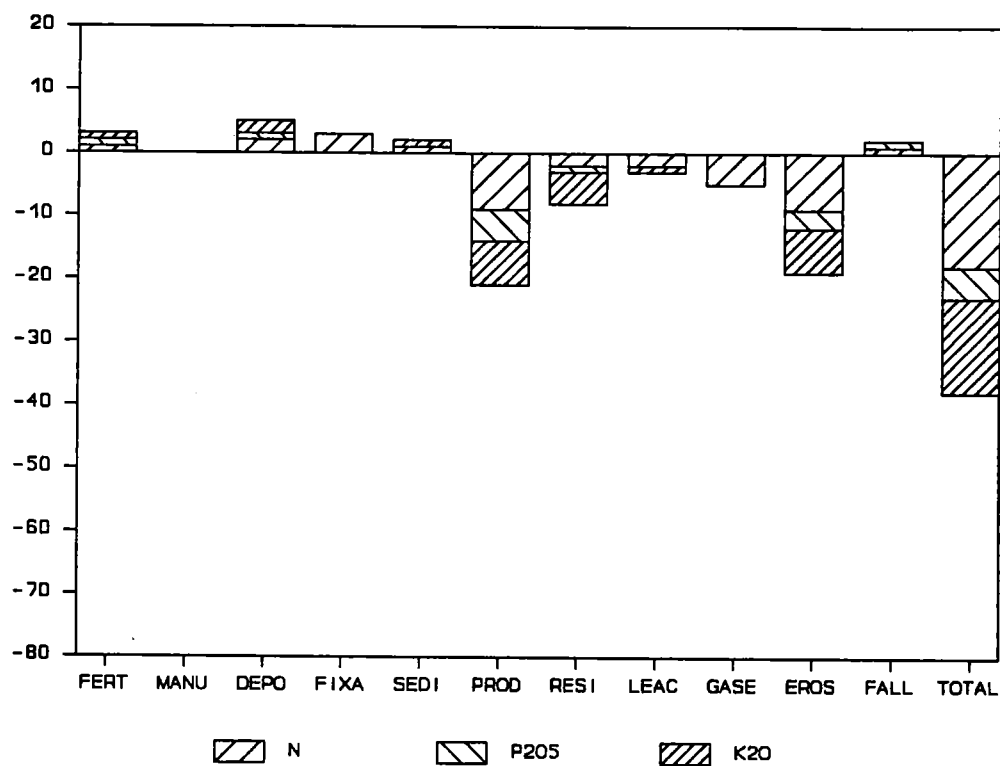


Table 4.67 LWC-distribution in Togo (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	4	42	49	5	0
2000	0	3	36	56	5	0

Table 4.68 Togo; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000	0	0	0	0	0	0	0	0	0	0	0	0 0
* UNCERTAIN RAINFALL													
N	1983	61	49	68	81	97	0	325	143	86	217	360	78 -758 -12
	2000	60	99	111	89	111	0	438	194	104	249	350	72 -853 -14
P205	1983	61	49	33	31	0	0	157	85	0	0	135	78 -186 -3
	2000	60	83	54	34	0	0	219	111	0	0	131	72 -218 -4
K20	1983	61	16	138	64	0	0	269	246	125	0	270	39 -653 -11
	2000	60	28	224	70	0	0	323	374	162	0	262	36 -763 -13
* GOOD RAINFALL													
N	1983	630	1015	0	2473	3747	0	9719	2658	1574	4377	12175	239 -23029 -37
	2000	702	2991	0	3399	6348	0	17551	4911	1890	5730	16727	0 -34071 -49
P205	1983	630	1234	0	936	0	0	5307	1549	0	0	3652	239 -8099 -13
	2000	702	2902	0	1287	0	0	9758	2917	0	0	5018	0 -13504 -19
K20	1983	630	339	0	1943	0	0	6353	5860	1027	0	9131	120 -19969 -32
	2000	702	836	0	2670	0	0	10572	11230	1360	0	12545	0 -32201 -46
* PROBLEM AREA													
N	1983	733	262	0	835	846	0	2695	355	770	1967	600	1159 -3285 -4
	2000	1110	957	0	1204	1134	0	6231	911	1034	2718	1100	1776 -6923 -6
P205	1983	733	320	0	316	0	0	989	214	0	0	180	1159 412 1
	2000	1110	1043	0	456	0	0	2343	565	0	0	330	1776 37 0
K20	1983	733	597	0	656	0	0	1929	532	773	0	450	579 -1852 -3
	2000	1110	1609	0	946	0	0	4529	1330	1186	0	825	888 -4427 -4
* NATURALLY FLOODED													
N	1983	76	28	0	140	190	1076	857	109	103	365	0	0 0 0
	2000	93	94	0	224	380	1537	1235	191	194	613	0	0 2 0
P205	1983	76	50	0	53	0	329	331	101	0	0	0	0 0 0
	2000	93	112	0	85	0	461	500	157	0	0	0	0 1 0
K20	1983	76	44	0	110	0	1623	1376	319	82	0	0	0 0 0
	2000	93	77	0	176	0	2344	1836	603	158	0	0	0 0 0
* IRRIGATED AREA													
N	1983	3	30	0	13	26	30	178	15	2	39	0	0 -135 -45
	2000	7	52	0	21	30	50	287	23	9	68	0	3 -231 -33
P205	1983	3	30	0	5	0	9	52	12	0	0	0	0 -20 -7
	2000	7	54	0	8	0	15	81	21	0	0	0	3 -22 -3
K20	1983	3	0	0	10	0	15	62	46	0	0	0	0 -83 -28
	2000	7	48	0	16	0	25	126	69	13	0	0	2 -117 -17
* TOTAL													
N	1983	1503	1384	68	3542	4906	1106	13774	3280	2535	6965	13135	1476 -27207 -18
	2000	1972	4193	111	4937	8003	1587	25742	6230	3231	9378	18177	1851 -42076 -21
P205	1983	1503	1683	33	1341	0	338	6836	1961	0	0	3967	1476 -7893 -5
	2000	1972	4194	54	1870	0	476	12901	3771	0	0	5479	1851 -13706 -7
K20	1983	1503	996	138	2783	0	1638	9989	7003	2007	0	9851	738 -22557 -15
	2000	1972	2598	224	3878	0	2369	17386	13606	2879	0	13632	926 -37508 -19

Figure 4.35 Nutrient balance for Uganda, 1983 (in kg/ha,yr)

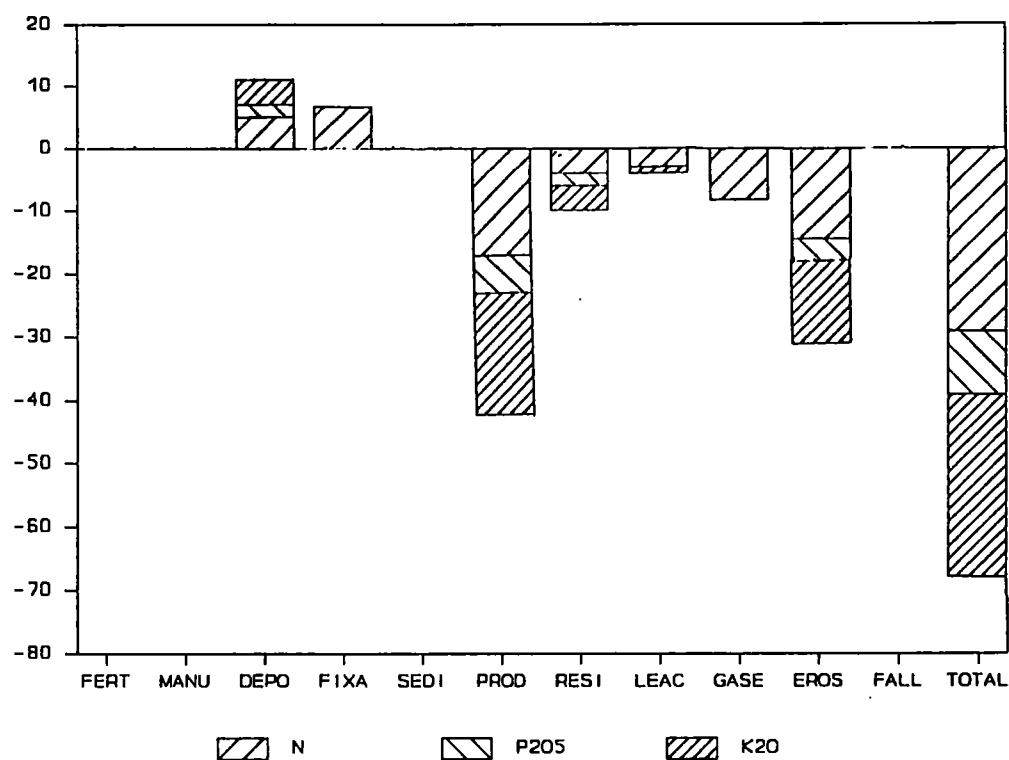


Table 4.69 LWC-distribution in Uganda (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	2	11	58	27	1	0
2000	3	12	57	28	1	0

Table 4.70 Uganda; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 108	2	58	210	244	0	322	130	201	251	1060	110	-1339 -12
	2000 168	7	172	372	509	0	866	382	317	408	1880	148	-2645 -16
P205	1983 108	0	39	79	0	0	201	86	0	0	318	110	-376 -3
	2000 168	1	99	141	0	0	552	221	0	0	564	148	-949 -6
K20	1983 108	0	180	165	0	0	192	400	154	0	795	55	-1141 -11
	2000 168	0	492	292	0	0	405	1094	276	0	1410	74	-2327 -14
* UNCERTAIN RAINFALL													
N	1983 603	13	468	1735	2610	0	5097	1532	1304	2347	5390	422	-10422 -17
	2000 783	37	838	1802	3405	0	8426	2478	907	2067	5495	751	-12540 -16
P205	1983 603	0	238	657	0	0	2416	861	0	0	1617	422	-3576 -6
	2000 783	5	422	682	0	0	4014	1390	0	0	1648	751	-5192 -7
K20	1983 603	0	1096	1364	0	0	3461	2924	1219	0	4042	211	-8976 -15
	2000 783	0	1995	1416	0	0	5193	5247	1181	0	4121	376	-11955 -15
* GOOD RAINFALL													
N	1983 3090	147	0	14089	21131	0	47768	11944	8850	21805	42790	371	-97420 -32
	2000 3789	525	0	17459	31756	0	92314	22992	6720	20784	51940	379	-144631 -38
P205	1983 3090	0	0	5334	0	0	23699	7111	0	0	12837	371	-37943 -12
	2000 3789	63	0	6610	0	0	44610	13491	0	0	15582	379	-66631 -18
K20	1983 3090	0	0	11070	0	0	51275	29757	3079	0	32092	185	-104948 -34
	2000 3789	0	0	13718	0	0	92539	52074	1993	0	38955	189	-171653 -45
* PROBLEM AREA													
N	1983 1424	132	0	6285	7970	0	22881	4259	3897	14260	14395	256	-45048 -32
	2000 1837	324	0	8109	10501	0	35423	6720	3675	17239	19052	331	-62845 -34
P205	1983 1424	0	0	2379	0	0	7766	2331	0	0	4318	256	-11780 -8
	2000 1837	31	0	3070	0	0	13503	3727	0	0	5716	331	-19514 -11
K20	1983 1424	0	0	4938	0	0	30290	7028	793	0	10796	128	-43841 -31
	2000 1837	0	0	6371	0	0	42499	10795	557	0	14289	165	-61605 -34
* NATURALLY FLOODED													
N	1983 48	5	0	213	234	1236	864	122	120	582	0	0	0 0
	2000 52	9	0	252	543	1213	1061	179	115	661	0	0	0 0
P205	1983 48	0	0	81	0	518	529	70	0	0	0	0	0 0
	2000 52	0	0	95	0	740	743	93	0	0	0	0	0 0
K20	1983 48	0	0	168	0	814	555	361	66	0	0	0	0 0
	2000 52	0	0	198	0	812	395	583	32	0	0	0	0 0
* IRRIGATED AREA													
N	1983 11	0	0	53	102	110	202	32	33	138	0	0	-140 -13
	2000 14	0	0	53	82	110	569	52	0	82	0	7	-451 -31
P205	1983 11	0	0	20	0	33	149	24	0	0	0	0	-119 -11
	2000 14	0	0	20	0	33	453	67	0	0	0	7	-460 -32
K20	1983 11	0	0	42	0	55	232	113	23	0	0	0	-271 -25
	2000 14	0	0	42	0	55	1073	144	0	0	0	3	-1117 -77
* TOTAL													
N	1983 5285	300	526	22586	32289	1346	77133	18018	14405	39384	63635	1159	-154369 -29
	2000 6644	901	1010	28048	46796	1323	138659	32804	11734	41241	78367	1616	-223112 -34
P205	1983 5285	0	277	8550	0	551	34759	10482	0	0	19090	1159	-53794 -10
	2000 6644	100	521	10618	0	773	63876	18988	0	0	23510	1616	-92746 -14
K20	1983 5285	0	1277	17746	0	869	86004	40583	5334	0	47726	580	-159177 -30
	2000 6644	0	2487	22037	0	867	142103	69938	4040	0	58776	808	-248656 -37

Figure 4.36 Nutrient balance for Zaire, 1983 (in kg/ha,yr)

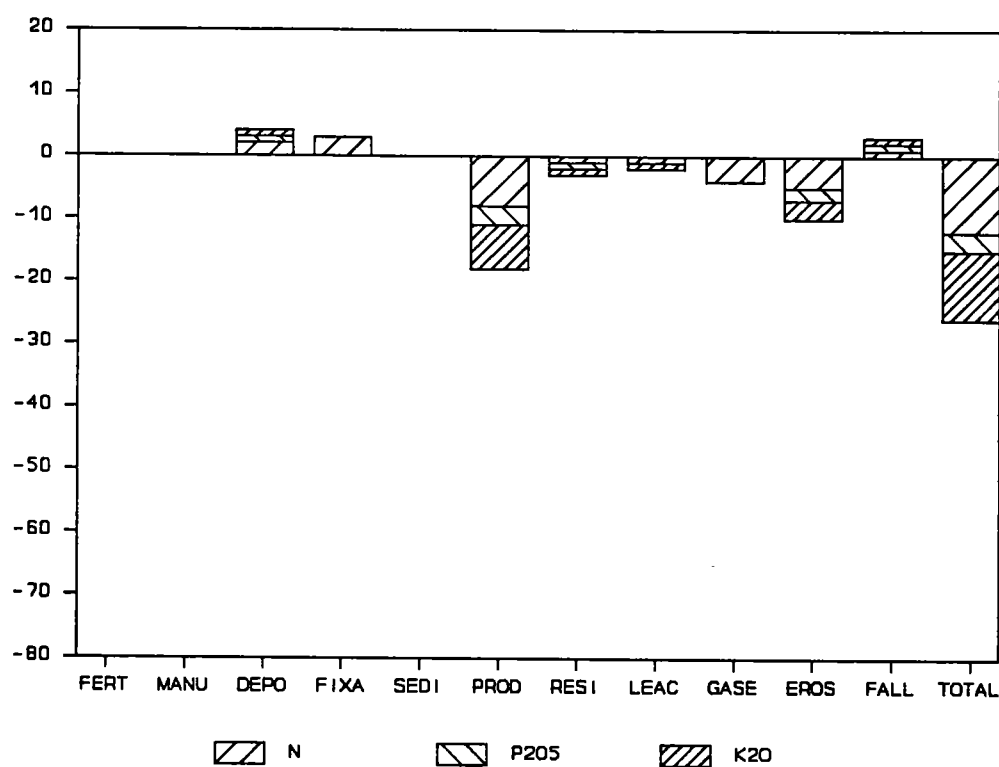


Table 4.71 LWC-distribution in Zaire (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	0	31	67	2	0
2000	0	0	34	63	2	0

Table 4.73 Zaire; nutrient balances for LWC s and for country total

		AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL	
		000 HA												(TON)	(KG/HA)
* LOW RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL															
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
* GOOD RAINFALL															
N	1983 4501	995	131	6770	14080	0	33222	6051	2391	8961	10270	6210	-32709	-7	
	2000 5535	1598	280	7255	16312	0	40826	7317	2531	9398	10885	8079	-37433	-7	
P205	1983 4501	820	66	2563	0	0	12684	3023	0	0	3081	6210	-9129	-2	
	2000 5535	1430	140	2747	0	0	16319	3671	0	0	3265	8079	-10860	-2	
K20	1983 4501	351	206	5319	0	0	27102	7454	2202	0	7702	3105	-35479	-8	
	2000 5535	562	440	5701	0	0	31471	10375	2359	0	8164	4039	-41626	-8	
* PROBLEM AREA															
N	1983 9823	2570	714	20015	28492	0	77480	10478	12329	54321	56388	11393	-147812	-15	
	2000 0277	6318	905	28914	47418	0	142558	19679	14889	72371	81218	8630	-238529	-23	
P205	1983 9823	2156	357	7577	0	0	25900	5550	0	0	21146	11393	-31113	-3	
	2000 0277	5293	452	10946	0	0	47356	10202	0	0	30457	8630	-62694	-6	
K20	1983 9823	1851	1122	15726	0	0	80175	9882	14106	0	42291	5696	-122058	-12	
	2000 0277	3647	1422	22718	0	0	145009	18009	15748	0	60914	4315	-207578	-20	
* NATURALLY FLOODED															
N	1983 306	30	0	238	995	401	709	73	183	698	0	0	0	0	
	2000 400	215	0	621	2629	1433	2541	272	371	1715	0	0	0	0	
P205	1983 306	22	0	90	0	355	429	37	0	0	0	0	0	0	
	2000 400	141	0	235	0	1345	1580	141	0	0	0	0	0	0	
K20	1983 306	0	0	187	0	391	276	267	35	0	0	0	0	0	
	2000 400	27	0	488	0	1510	949	1010	66	0	0	0	0	0	
* IRRIGATED AREA															
N	1983 5	5	0	24	110	50	180	28	2	49	0	0	-70	-14	
	2000 15	274	0	73	130	150	793	66	62	196	0	0	-491	-33	
P205	1983 5	2	0	9	0	15	121	11	0	0	0	0	-106	-21	
	2000 15	137	0	28	0	45	621	79	0	0	0	0	-490	-33	
K20	1983 5	0	0	19	0	25	64	105	0	0	0	0	-125	-25	
	2000 15	67	0	57	0	75	1357	182	0	0	0	0	-1340	-89	
* TOTAL															
N	1983 4636	3600	845	27047	43677	451	111591	16630	14906	64029	66658	17603	-180591	-12	
	2000 6227	8405	1185	36863	66489	1583	186718	27334	17852	83679	92103	16709	-276453	-17	
P205	1983 4636	3000	423	10239	0	370	39134	8622	0	0	24227	17603	-40348	-3	
	2000 6227	7001	592	13955	0	1390	65876	14093	0	0	33722	16709	-74045	-5	
K20	1983 4636	2202	1328	21251	0	416	107616	17709	16342	0	49994	8801	-157662	-11	
	2000 6227	4304	1862	28964	0	1585	178785	29576	18174	0	69078	8354	-250544	-15	

Figure 4.37 Nutrient balance for Zambia, 1983 (in kg/ha,yr)

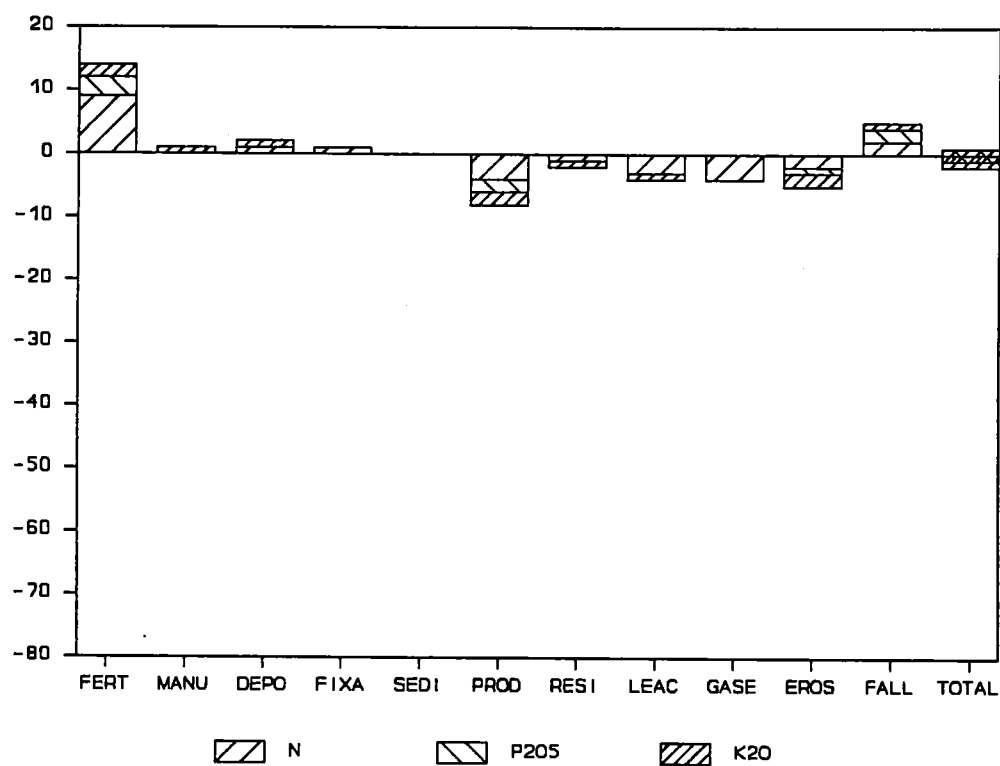


Table 4.74 LWC-distribution in Zambia (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	0	42	54	3	0	0
2000	0	43	53	3	0	1

Table 4.75 Zambia; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL	
	000 HA												(TON)	(KG/HA)
* LOW RAINFALL														
N	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
P205	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
K20	1983	0	0	0	0	0	0	0	0	0	0	0	0	0
	2000	0	0	0	0	0	0	0	0	0	0	0	0	0
* UNCERTAIN RAINFALL														
N	1983 2233	12492	708	1483	1632	0	6998	1711	4841	6396	9420	3797	-9254	-4
	2000 2557	32425	1920	3170	3553	0	16543	4560	11913	15130	20580	3682	-23976	-9
P205	1983 2233	3710	303	561	0	0	3664	760	0	0	3532	3797	414	0
	2000 2557	10040	842	1200	0	0	8890	2051	0	0	7717	3682	-2894	-1
K20	1983 2233	1536	1965	1165	0	0	2681	4564	2606	0	7065	1898	-10351	-5
	2000 2557	3829	5471	2491	0	0	6185	12517	5937	0	15435	1841	-26442	-10
* GOOD RAINFALL														
N	1983 2828	23216	487	2207	3002	0	12440	945	7774	10186	2497	4746	-185	0
	2000 3206	68280	827	4830	6427	0	30961	2155	21625	26677	5397	4420	-2032	-1
P205	1983 2828	7088	240	835	0	0	6351	488	0	0	749	4746	5320	2
	2000 3206	21630	402	1829	0	0	16302	1074	0	0	1619	4420	9286	3
K20	1983 2828	2765	789	1734	0	0	5166	1681	1912	0	1873	2373	-2971	-1
	2000 3206	7875	1567	3795	0	0	12089	4585	3890	0	4048	2210	-9166	-3
* PROBLEM AREA														
N	1983 165	1072	0	160	199	0	519	28	451	798	480	264	-581	-4
	2000 191	3367	0	325	396	0	1200	73	1239	1942	1100	249	-1216	-6
P205	1983 165	311	0	61	0	0	203	17	0	0	180	264	235	1
	2000 191	1026	0	123	0	0	539	39	0	0	412	249	408	2
K20	1983 165	172	0	126	0	0	256	45	222	0	360	132	-452	-3
	2000 191	544	0	255	0	0	613	111	507	0	825	124	-1132	-6
* NATURALLY FLOODED														
N	1983 19	105	0	34	154	0	57	7	71	156	0	0	3	0
	2000 28	1023	0	87	316	109	303	36	373	592	0	0	231	8
P205	1983 19	0	0	13	0	29	38	3	0	0	0	0	0	0
	2000 28	241	0	33	0	30	209	18	0	0	0	0	76	3
K20	1983 19	0	0	27	0	55	20	25	36	0	0	0	0	0
	2000 28	3	0	69	0	189	106	130	25	0	0	0	0	0
* IRRIGATED AREA														
N	1983 18	13013	0	87	36	180	1132	48	3861	4060	0	0	4215	234
	2000 33	25484	0	160	106	330	2153	89	7547	8016	0	0	8273	251
P205	1983 18	4687	0	33	0	54	747	98	0	0	0	0	3928	218
	2000 33	9077	0	61	0	99	1499	175	0	0	0	0	7564	229
K20	1983 18	3613	0	69	0	90	1653	95	1681	0	0	0	342	19
	2000 33	7029	0	126	0	165	2973	185	3400	0	0	0	763	23
* TOTAL														
N	1983 5263	49898	1195	3971	5023	180	21145	2738	16998	21595	12397	8807	-5801	-1
	2000 6016	130578	2747	8572	10798	439	51161	6912	42698	52358	27077	8352	-18720	-3
P205	1983 5263	15795	542	1503	0	83	11004	1366	0	0	4462	8807	9898	2
	2000 6016	42015	1244	3245	0	129	27440	3356	0	0	9749	8352	14440	2
K20	1983 5263	8086	2754	3120	0	145	9776	6411	6457	0	9298	4403	-13432	-3
	2000 6016	19280	7037	6736	0	354	21966	17528	13759	0	20308	4176	-35978	-6

Figure 4.38 Nutrient balance for Zimbabwe, 1983 (in kg/ha,yr)

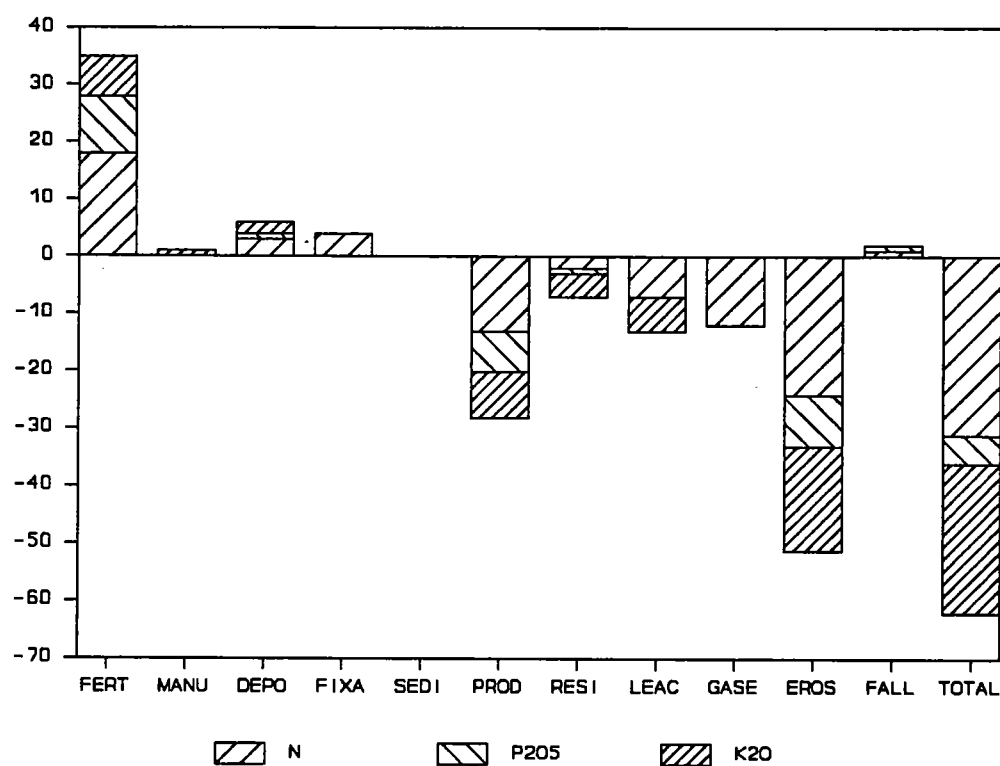


Table 4.76 LWC-distribution in Zimbabwe (in % of total arable area)

	LR	UR	GR	PR	NF	IR
1983	5	21	54	17	0	4
2000	5	22	52	17	0	4

Table 4.76 Zimbabwe; nutrient balances for LWC s and for country total

	AREA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
	000 HA												(TON) (KG/HA)
* LOW RAINFALL													
N	1983 208	135	192	436	592	0	676	428	473	579	1100	195	-1705 -8
	2000 244	523	254	309	489	0	840	565	428	503	780	332	-1209 -5
P205	1983 208	163	109	165	0	0	423	243	0	0	330	195	-364 -2
	2000 244	372	155	117	0	0	556	344	0	0	234	332	-159 -1
K20	1983 208	31	505	342	0	0	301	1122	427	0	825	98	-1699 -8
	2000 244	82	690	243	0	0	319	1533	390	0	585	166	-1646 -7
* UNCERTAIN RAINFALL													
N	1983 857	7397	1238	2391	2638	0	7719	2732	4491	7604	15870	634	-24119 -28
	2000 1116	37196	3827	3161	4675	0	18708	8533	13333	17202	20930	803	-29045 -26
P205	1983 857	3507	635	905	0	0	4870	1417	0	0	5951	634	-6557 -8
	2000 1116	16401	2130	1197	0	0	11216	4772	0	0	7849	803	-3306 -3
K20	1983 857	1977	2925	1878	0	0	4400	6457	5141	0	11902	317	-20804 -24
	2000 1116	5925	9258	2484	0	0	8609	20622	8977	0	15697	402	-35838 -32
* GOOD RAINFALL													
N	1983 2205	22389	168	6416	12980	0	31150	3321	10921	19726	65490	1764	-86890 -39
	2000 2566	124069	283	8337	21437	0	74852	8777	37110	48843	84900	1693	-98662 -38
P205	1983 2205	18877	84	2429	0	0	15250	1594	0	0	24559	1764	-18249 -8
	2000 2566	67194	142	3156	0	0	38203	4292	0	0	31837	1693	-2147 -1
K20	1983 2205	14659	264	5041	0	0	17426	7345	11413	0	49117	882	-64455 -29
	2000 2566	35777	445	6550	0	0	35591	20084	17037	0	63675	847	-92767 -36
* PROBLEM AREA													
N	1983 699	6082	0	1697	2017	0	3910	506	3450	7125	17020	698	-21517 -31
	2000 822	28871	0	1877	2767	0	8707	1169	9712	13775	18570	871	-17548 -21
P205	1983 699	2049	0	643	0	0	2044	277	0	0	6382	698	-5315 -8
	2000 822	11073	0	711	0	0	4701	644	0	0	6964	871	346 0
K20	1983 699	2156	0	1334	0	0	1605	1339	2587	0	12765	349	-14457 -21
	2000 822	6630	0	1475	0	0	3455	3031	4016	0	13927	435	-15889 -19
* NATURALLY FLOODED													
N	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 5	182	0	24	110	0	46	5	81	142	0	0	41 8
P205	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 5	45	0	9	0	0	31	3	0	0	0	0	21 4
K20	1983 0	0	0	0	0	0	0	0	0	0	0	0	0 0
	2000 5	45	0	19	0	19	16	21	46	0	0	0	0 0
* IRRIGATED AREA													
N	1983 149	39309	0	723	298	1490	8851	366	11485	14440	0	0	6678 45
	2000 214	81103	0	1039	509	2142	18213	843	23106	27893	0	0	14737 69
P205	1983 149	17586	0	274	0	447	6764	419	0	0	0	0	11123 75
	2000 214	35965	0	393	0	643	13469	855	0	0	0	0	22677 106
K20	1983 149	10033	0	568	0	745	8209	1369	6155	0	0	0	-4387 -29
	2000 214	20691	0	816	0	1071	15686	3124	11596	0	0	0	-7828 -37
* TOTAL													
N	1983 4118	75312	1598	11663	18525	1490	52305	7353	30821	49474	99480	3291	-127554 -31
	2000 4967	271945	4364	14747	29986	2142	121367	19893	83770	108358	125180	3699	-131685 -27
P205	1983 4118	42182	828	4415	0	447	29352	3951	0	0	37222	3291	-19362 -5
	2000 4967	131051	2427	5583	0	643	68177	10909	0	0	46884	3699	17431 4
K20	1983 4118	28857	3693	9164	0	745	31941	17631	25723	0	74610	1646	-105801 -26
	2000 4967	69150	10394	11587	0	1090	63677	48415	42060	0	93885	1849	-153968 -31

4.2 Nutrient balances per crop and per LUS; an example for N balance, Senegal, 1983

Detailed calculations, which form the basis of the results shown in Section 4.1, are given in Volume II. An example of the detailed results of the N balance for Senegal, 1983 is given in Table 4.77.

Table 4.77 Detailed N-balances for crops, LUS's and LWC's of Senegal, 1983

LWC/LUS	CROP	AREA 000 HA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL
COUNTRY (TON/COUNTRY)	TOTAL	5235	8805	7518	9538	37335	1258	43677	18454	9761	21192	41075	5554	-84157
LR (TON/LWC)	TOTAL	1100	603	1560	1602	5615	0	5649	3487	1577	2767	5720	1056	-8044
LR-L1 (KG/HA)	TOTAL	572	1	3	3	10	0	10	6	3	5	10		-18
	MILL	255	0	3	3	3	0	6	6	3	5	10		-21
	SORG	31	1	2	3	3	0	7	5	3	5	10		-22
	GROU	286	2	3	3	17	0	15	6	2	5	10		-14
FALLOW		528											2	2
UR (TON/LWC)	TOTAL	3189	3298	5956	6027	26194	0	29506	13333	5631	12701	29130	3506	-45321
UR-L1 (KG/HA)	TOTAL	527	1	3	4	4	0	12	7	4	9	20		-40
	MAIZ	25	2	2	4	4	0	15	5	4	9	20		-41
	MILL	447	1	3	4	4	0	12	7	4	9	20		-39
	SORG	53	1	3	4	4	0	16	7	4	8	20		-43
	OTHC	2	0	0	4	4	0	0	0	5	10	20		-27
UR-L2 (KG/HA)	TOTAL	665	2	5	4	28	0	26	11	4	8	20		-29
	PULS	9	0	1	4	8	0	4	2	5	10	20		-28
	GROU	656	2	5	4	28	0	26	11	4	8	20		-29
UR-L3 (KG/HA)	TOTAL	13	3	0	4	4	0	15	7	3	6	30		-52
	SPOT	1	0	0	4	4	0	22	5	2	7	30		-57
	CASS	7	0	0	4	4	0	12	10	2	7	30		-53
	VEGE	2	1	0	4	4	0	25	4	2	7	30		-60
	FRUI	3	10	0	4	4	0	11	5	6	11	30		-45
UR-L4 (KG/HA)	TOTAL	30	25	0	4	4	0	21	0	9	32	30		-58
	COTT	30	25	0	4	4	0	21	0	9	32	30		-58
FALLOW		1754											2	2
GR (TON/LWC)	TOTAL	298	1468	0	737	2150	0	3383	1136	884	1962	4480	292	-7227
GR-L1 (KG/HA)	TOTAL	85	5	0	5	5	0	16	4	5	12	30		-52
	MAIZ	50	7	0	5	5	0	16	4	5	12	30		-53
	MILL	31	2	0	5	5	0	12	4	5	11	30		-49
	SORG	4	3	0	5	5	0	15	4	4	11	30		-52

Table 4.77 (Cont.)

[illegible]

Table 4.77 (Cont.)

LWC/LUS	CROP	AREA 000 HA	FERT	MANU	DEPO	FIXA	SEDI	PROD	RESI	LEAC	GASE	EROS	FALL	TOTAL					
IR	TOTAL	139		2483		0	353	1247	1030		2556	148	853	2242	0		72		-631
IR-H.1 (KG/HA)	TOTAL	70		35		0	3	14	10		34	1	10	24	0				-6
	RICE	43		18		0	3	22	10		24	1	8	20	0				3
	CANE	8		233		0	3	2	10		59	1	66	80	0				43
	VEGE	14		7		0	3	2	10		61	1	0	12	0				-52
	BANA	1		0		0	3	2	10		7	0	3	17	0				-12
	CITR	4		25		0	3	2	10		9	0	11	25	0				-5
	FRUI	2		50		0	3	2	10		29	1	14	28	0				-7
IR-H.2 (KG/HA)	TOTAL	33		0		0	3	7	10		6	2	4	18	0				-9
	PULS	33		0		0	3	7	10		6	2	4	18	0				-9
IR-H.3 (KG/HA)	TOTAL	0		0		0	0	0	0		0	0	0	0	0				0
FALLOW		36															2		2

5 EVALUATION OF THE MODEL

5.1 Assumptions

The model developed for the present study is based on a number of assumptions. In this section, these assumptions are listed and an attempt made to justify them.

General

- Information on specific input and output factors or on Land Use Systems obtained from different literature sources sometimes shows inconsistencies. This adversely affects the reliability of the present exercise. Inconsistencies were also found between various studies, e.g. where studies mention the cultivation of certain crops that are not listed as such in the FAO database.

- Land Water Classes are defined by FAO, mainly on the basis of the length of the growing period (Table 2.3). A further refinement into Land Use Systems proved essential. These LUS's are defined on the basis of an extensive literature review (Tables 3.1 and 3.2). Availability of literature differs greatly between countries.

A LUS is characterized by its general farm management level (L or H). It should be noted that, due to lack of data on a continental scale, the same LUS's apply for 1983 as well as for the year 2000. Improvements in farm management practices, including erosion control are thus ignored in the LUS's. In the sensitivity analysis (Section 5.2) it is shown that the management level does not have a strong impact on the outcome of the model. Erosion, however, can strongly influence the outcome of the model. Improvements in farm management are considered in the projections of fertilizer consumption, cultivated areas and productions for the different crops in the FAO database.

- The dynamics of the nutrients in the soil, as expressed in the various input and output factors, is a thoroughly elaborated part of the model. The stock of nutrients in the soil, however, is regarded as constant and no changes are accounted for between 1983 and 2000. At the scale of the present study it is, however, not possible to consider the soil as a dynamic entity.

IN 1 Mineral fertilizers

- The use of fertilizers is not likely to be evenly distributed within a country. As data on fertilizer use per LWC are not available, weighing factors are used to cater for likely regional differences (Table 3.4 or quantitative information from the literature).

IN 2 Manure

- It is not realistic to use the quantities of manure commonly applied in fertilizer experiments (5-10 ton/ha) as an average for the African farmer. Manure application is assumed to be less than 2000 kg/ha. Classes of 0, 500, 1000 and 1500 kg/ha are used.

- The chemical composition of fresh manure varies widely due to different moisture contents and the different nature of the manures. Fixed concentrations for humid and dry areas were adopted. They are listed in Table 3.5.
- To assess the amount of nutrients which will return to the soil when crop residues are grazed, two assumptions were made. First it was assumed that cattle only spend 12 hours a day on the grazing fields. Second it was assumed that 10 % of the nutrients will remain inside the animals.

IN 3 Deposition

- Information on wet and dry deposition is markedly better available for West Africa than for other parts of the continent. Regression analysis was applied to cover the latter, assuming a high correlation between rainfall and IN 3.

IN 4 Biological N fixation

- Stipulations set for biological N fixation are backed up reasonably well by a good amount of literature and experts' judgement. The expert panel suggested applying a constant contribution from non-symbiotic fixation for every Land/Water Class and a percentual contribution of symbiotic N fixation to the total N uptake of pulses and wetland rice.

IN 5 Sedimentation

- The decision to allow sedimentation bring back the equilibrium to the LWC 'naturally flooded' was taken at an expert's meeting. Data on the nutrient content of irrigation water for the LWC 'irrigated' were difficult to trace. Cross-checking was done using the findings of irrigation specialists.

OUT 2 Crop residues

- Research data on nutrient contents in crop residues, expressed in kg per ton harvested product, vary considerably. This is mainly caused by differences in harvest indices. For some crops the differences were such that ranges are given instead of averages. Part of the range can be explained by the management level, which is the main reason for the differences in the harvest index. For the higher management level (high harvest index) the lower value of the range is used, and for the lower management level the higher value of the range. The range covers the average value plus and minus half the standard deviation. Outliers were excluded from the calculations.
- In many countries it is common practice, or even stipulated by law, to burn cotton residues after harvest and to observe a 'close season', in order to eradicate pests. In this study it was decided to treat cotton residues as such throughout the continent. It is further assumed that, in the process, they lose all their nitrogen through volatilization, and 50% of their potassium through leaching.

OUT 3/OUT 4 Leaching/Gaseous losses

- Due to the limited availability of research data on leaching and gaseous losses, regression analysis was the only way to assess leaching and gaseous losses in the entire study region.

OUT 3/OUT 4/OUT 5 Leaching/Gaseous losses/Erosion

- The factor F (soil fertility) is used in the regression analysis for 'leaching', 'gaseous losses', and also for 'erosion'. The classes (high, moderate and low) are derived from an FAO study (FAO, 1978) that groups soil orders on the basis of inherent soil fertility.

OUT 4 Gaseous losses

- An LWC-specific 'base' denitrification was assumed. These 'base' denitrification estimates reflect the higher denitrification that occurs in more humid climates.

OUT 5 Erosion

- Eroding soil material has a higher nutrient content than the original soil material. The nutrient content of the latter is linked with the three fertility classes mentioned previously. Next, review data by Stocking (1985) were used to set a so-called enrichment factor at 2.0.
- Calculated P and K losses through erosion are partially offset by the downward extension of the root zone. The nutrient contribution by the 'newly explored soil' is set at 25% of the calculated losses for the two elements. Differences in soil depth are not accounted for.

CROPPING INTENSITY

- In case of a cropping intensity of less than 100%, fallow is practised. It is difficult to trace how fallow management differs between and within countries. Therefore, the assumption of a fixed contribution by fallow was applied uniformly to the entire study region.
- Next, double cropping is only accounted for if the harvested acreage exceeds the arable acreage (cropping intensity > 100%).

5.2 Sensitivity analysis

To evaluate the model, a sensitivity analysis was performed. For this sensitivity analysis the LUS Table of Senegal (Table 3.2) was used. All values in this Table were varied within certain accuracy limits (e.g. soil fertility class plus or minus 1 unit; residue removal plus or minus 20%). The effects of these changes on the N depletion in Senegal, 1983 were calculated. The results are given in Table 3.77.

The Table shows that in particular soil fertility and to a lesser extent erosion play an important role in the outcome of the depletion; N depletion may vary plus 10 or minus 16 kg N/ha,yr if the fertility class is changed and up to plus 5 or minus 5 kg N/ha,yr if erosion is manipulated. The effects of the sensitivity analysis are most strongly reflected in the LWC's GR and UR.

Table 5.1 Results of the sensitivity analysis for Senegal, 1983
(kg/ha,yr)

Factor and variation	Nutrient	LR	UR	GR	PR	IR
Rainfall: +/- 100 mm/yr	N	0	0	0	0	0
	P ₂ O ₅	0	0	0	0	0
	K ₂ O	0	0	0	0	0
Soil fertility class: +1 unit	N	-7	-11	-16	-5	-
	P ₂ O ₅	-3	-3	-5	-2	-
	K ₂ O	-4	-7	-13	-3	-
Soil fertility class: -1 unit	N	-	+6	+10	-	+2
	P ₂ O ₅	-	+2	+4	-	0
	K ₂ O	-	+4	+7	-	0
Residue removal: +20% ¹	N	-1	-1	-1	-1	-3
	P ₂ O ₅	0	0	0	0	-2
	K ₂ O	-1	-2	-2	-2	-7
Residue removal: -20% ²	N	0	+1	+2	+1	+1
	P ₂ O ₅	0	0	+1	0	+1
	K ₂ O	+2	+2	+3	+2	+2
Erosion: +5 ton/ha	N	-3	-5	-2	-2	-
	P ₂ O ₅	-1	-2	0	0	-
	K ₂ O	-2	-4	-1	-1	-
Erosion: -5 ton/ha	N	+2	+4	+5	+2	-
	P ₂ O ₅	+1	+2	+2	+1	-
	K ₂ O	+2	+4	+4	+1	-
Management level: All levels are changed	N	0	0	0	0	+1
	P ₂ O ₅	0	0	+1	0	0
	K ₂ O	+1	+2	+2	0	0

¹ up to maximum of 100%

² up to minimum of 0%

6.1 Present and future nutrient losses at the country level

The results of this study as summarized in Chapter 4 show that loss rates of the three nutrients are strongly correlated. The nutrient losses vary between 0 and 60 kg/ha,yr for N, between 0 and 25 kg/ha,yr for P_2O_5 and between 0 and 60 kg/ha,yr for K_2O . In order to compare the rates of nutrient depletion of the various countries a classification is adopted with regard to N, P, and K losses (Table 6.1).

Table 6.1 Classes of nutrient loss rates (in kg/ha)

Class	N	P_2O_5	K_2O
Low	<10	<4	<10
Moderate	10-20	4-7	10-20
High	21-40	8-15	21-40
Very high	>40	>15	>40

The individual classifications can be combined by taking the highest class as representative of the total nutrient loss in a country. For example if for a certain country nutrient loss rates are 15 (moderate), 12 (high) and 17 (moderate) for N, P_2O_5 and K_2O respectively, the total nutrient loss rate is classified as high. Differences between countries are visualized in Table 6.2 and Figure 6.1.

The highest nutrient depletion rates are found in East Africa (>30 kg N/ha,yr, >10 kg P_2O_5 and >30 kg K_2O). West Africa has moderate to high depletion rates and Central Africa and the Sahelian Region moderate to low.

Countries with the highest depletion rates are in most cases also countries with high erosion (e.g. Kenya and Ethiopia). The sensitivity of the model to differences in erosion rates was mentioned in Section 5.2.

The differences between nutrient losses in 1983 and the year 2000 are classified in a similar way, according to Table 6.3. In this case, however, the correlation between the three nutrients is much lower. Therefore, the nutrient with the highest 'loss increase' classification in Table 6.3 is mentioned in Table 6.4 as well. This table and Figure 6.2 show the aggravation of nutrient depletion between 1983 and 2000.

Table 6.2 Countries classified by nutrient depletion rate in 1983.

LOW	MODERATE	HIGH	VERY HIGH
Angola, Botswana, Central African Republic, Chad, Congo, Guinea, Mali, Mauritania, Mauritius, Zambia.	Benin, Burkina Faso, Cameroon, Gabon, Gambia, Liberia, Niger, Senegal, Sierra Leone, Sudan, Togo, Zaire.	Côte d'Ivoire, Ghana, Madagascar, Mozambique, Nigeria, Somalia, Swaziland, Tanzania, Uganda, Zimbabwe.	Burundi, Ethiopia, Kenya, Lesotho, Malawi, Rwanda.

Table 6.3 Classification for total nutrient loss increase rates between 1983 and 2000 (in kg/ha).

Class	N	P ₂ O ₅	K ₂ O
Low	<4	<3	<4
Moderate	4-6	3-4	4-6
High	7-11	>4	7-11
Very high	>11		>11

The distribution of the loss rate increase (Figure 6.2) is very similar to that of the loss rate in 1983 (Figure 6.1), implying that countries with the most serious nutrient depletion will have the highest increase of nutrient depletion over the years 1983-2000.

The increase in nutrient depletion is most clear for N and K, because of increased crop production. A possible explanation for the discrepancy between N and K on the one hand and P on the other is the increase in fertilizer use for the year 2000. All P fertilizer is a 100% input in the system. Whereas more than half of the N and K fertilizer applied is lost through gaseous losses and leaching. The increase of fertilizer use does not reduce the nutrient depletion for N and K, because of increased crop production.

Table 6.4 Countries classified to their increase in nutrient loss rate between 1983 and 2000

LOW	MODERATE	SEVERE	VERY SEVERE
Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic Congo, Gabon, Guinea, Liberia, Mauritius, Sierra Leone, Zambia,	Chad, Ghana (N+K), Madagascar, Malawi (K), Mali (K), Mauritania, Senegal, Sudan (K), Tanzania, Togo, Zaire, Zimbabwe (K).	Côte d'Ivoire (N), Ethiopia (N+K), Kenya (K), Mozambique (N), Niger (K), Nigeria (K), Somalia (N+K), Swaziland (N+K), Uganda.	Burundi (K), Gambia (K), Lesotho (N+K) Rwanda.

The country Tables show that increased application of fertilizers and manure in the year 2000 will not reduce the nutrient losses. Losses through residue removal, leaching, denitrification and erosion are also higher, although they can be combatted by sound management practices. Lack of data on likely developments in this respect on a continental scale makes predictions less valuable. Therefore, the assumption that each 1983-LUS still stands in 2000, is made because nothing better is available. An attempt to do this at country level would be a useful follow-up to the present study. The sensitivity analysis shows that improvements in the LUS input must be concentrated on soil fertility and erosion.

Especially the combination of soil fertility and nutrient loss rate deserves attention. It is the amount of nutrients in the soil which determines the seriousness of the nutrient depletion. For a soil low in nutrients the effect of a low nutrient depletion can be more serious than a high nutrient depletion rate in a rich soil.

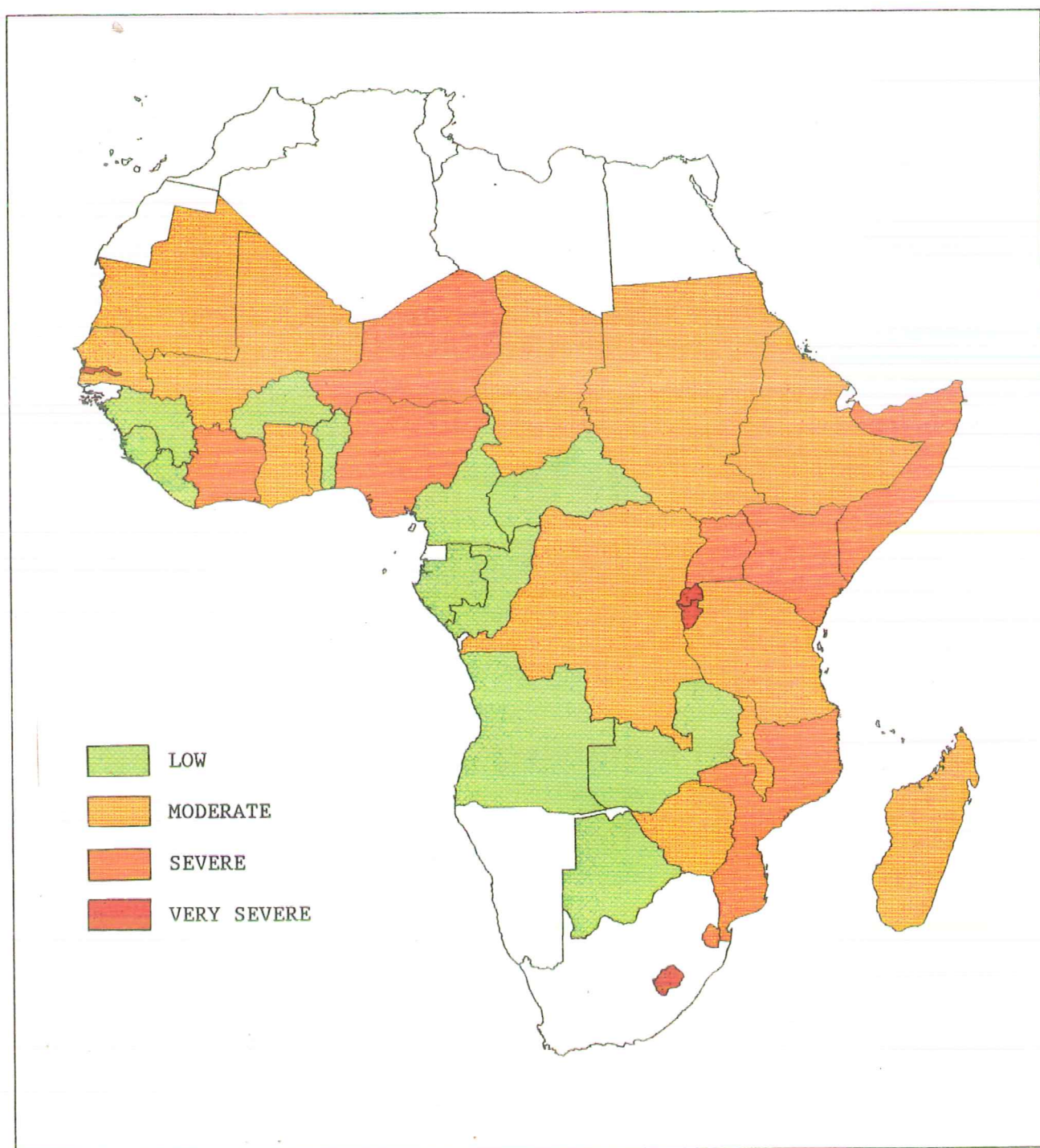


Figure 6.2 Increase in nutrient depletion between 1983 and 2000 for Sub-Saharan Africa.

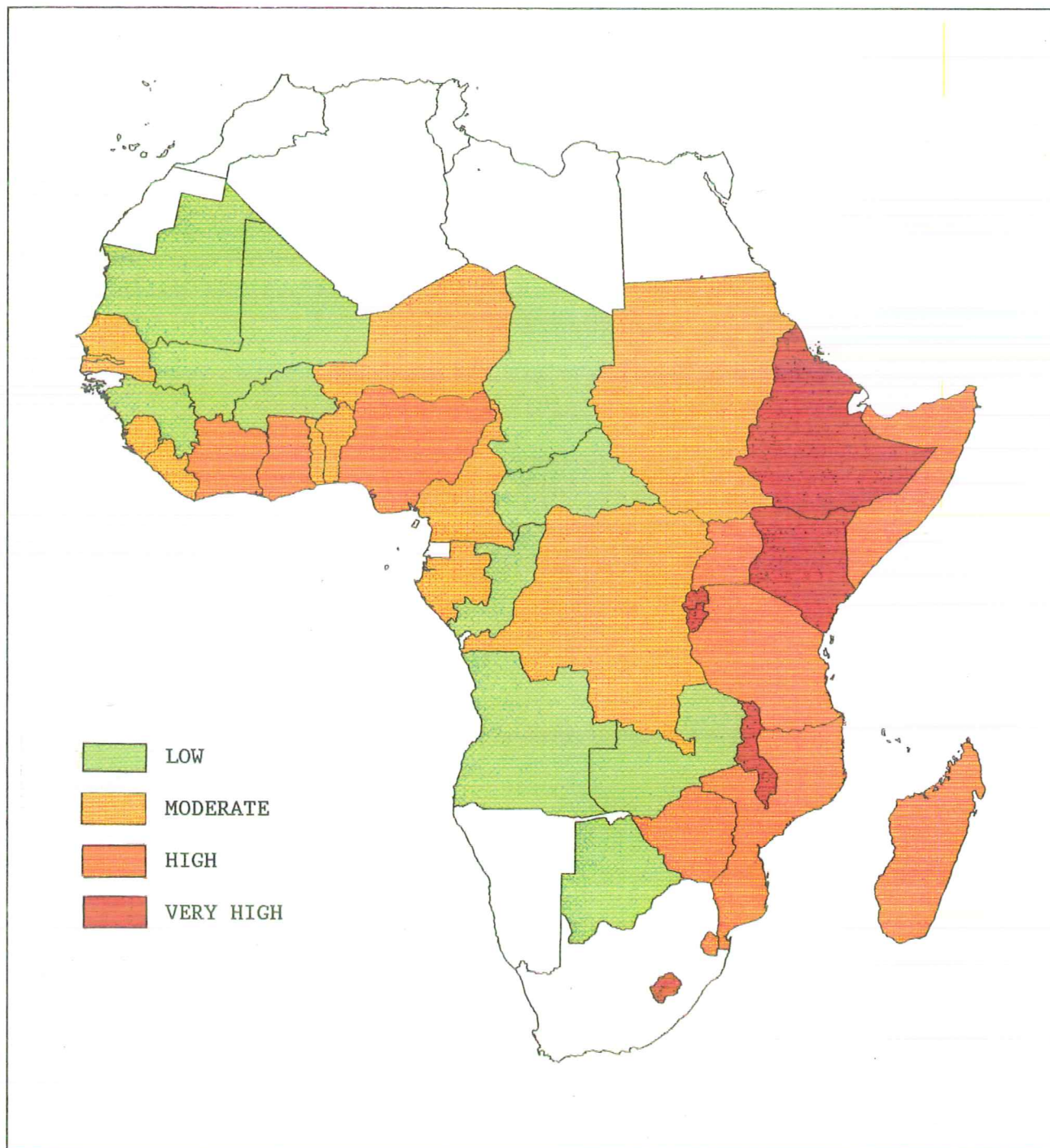


Figure 6.1 Nutrient depletion rate in Sub-Saharan Africa, 1983.

6.2 Evaluation of N, P and K

The nutrient depletion problem discussed in this text has been limited to the three macronutrients.

Nitrogen loss seems to be the most serious problem. A decline in the organic matter content of the soil is difficult to stave off if no proper management is practised. Unlike P and K, organic matter is the only source of soil N to plants. Through mineralization, part of the organic N is liberated. As soil fertility deteriorates, the organic matter content in the topsoil decreases, and so does the soil N content.

Phosphorus and potassium are present in the soil in both organic and inorganic forms. The availability of these two elements to plants is a complex matter, which is beyond the scope of the present study. From the data in Chapter 4 (country totals), loss of phosphorus does not seem too serious, but it should be noted that very little of the 'total P' is actually available to plants, due to processes like retention and precipitation.

Potassium losses are mainly the result of poor crop residue management, leaching and erosion. The content of K in residues largely exceeds the content in harvested products (Table 3.7). Provided that residues remain on the arable field, the K losses diminish considerably. In poor soils, K-availability decreases rapidly, as the amount of weatherable minerals is too low to replenish the annual losses.

6.3 Cross-check with long-term fertilizer experiments

The rather alarming findings of this study, particularly on N and K losses, are supported by long-term trial results, documented by various authors. Qureshi (1987) conducted a long-term maize trial on a Nitisol in Kenya. The data are summarized in Table 6.5. Haule et al. (1989) reported on fertility and yield trends in Tanzania (Table 6.6).

Table 6.5 Yield and soil fertility decline on a Kenyan Nitisol (after Qureshi, 1987)

YEAR	MAIZE YIELDS (KG/HA)				
	control	+crop residues (5 t/ha)	+manure (60 kg/ha)	+NP	+NP+ manure
1976-1980	3214	3205	4024	4074	4568
1981-1985	1953	2410	3368	3863	5108
change (%)	-39	-25	-16	-5	+12

	SOIL PROPERTIES		
	organic C (%)	P-Mehlich (mg/kg)	exch. K (mg/kg)
1976-1980	1.9	14	560
1982-1986	1.5	12	400
change (%)	-21	-14	-29

Table 6.6 Yield and soil fertility decline on Tanzanian soils (after Haule et al, 1989)

YEAR	UNFERTILIZED MAIZE YIELDS (KG/HA)		
	rhodic Ferralsol (F)	intergrade soils (I)	chromic Luvisol (L)
1981-1984	724	2253	4174
1985-1988	677	1245	2625
change (%)	-6	-45	-37

	SOIL PROPERTIES								
	organic C (%)			pH-H ₂ O			exch. K (mg/kg)		
	F	I	L	F	I	L	F	I	L
1981-1984	2.3	2.5	3.6	5.9	5.7	6.4	168	416	308
1985-1988	1.6	1.5	2.2	5.3	5.2	6.0	140	264	184
change (%)	-30	-40	-39	-10	-9	-7	-17	-37	-40

Tables 6.5 and 6.6 show that, broadly speaking, unfertilized yields of 2-4 ton/ha, obtained in the early years of cultivation, coincide with organic carbon contents of 2.0-4.0% and exchangeable K levels of 300-500 mg/kg. Declined yields of 1-2.5 ton/ha, obtained after 5 to 10 years of cultivation, coincide with organic carbon contents of 1.5-2.0% and exchangeable K of 180-400 mg/kg. Hence, an N decline (C/N = 10) of approximately 1 g/kg in 5 years seems to coincide with an approximate yield decline of 1000 kg/ha.

Yields of maize that received fertilizer, manure or crop residues also decreased, but less dramatically. Applying of N+P+manure increased yields. The amount of manure (5 ton/ha), however, is hardly ever available on farms in Africa.

The declining trends, even with increased fertilizer application, are in line with the calculations made in this study. Tanzania and Kenya are in the loss groups "severe" and "very severe" respectively. For the year 2000, aggravation of the nutrient losses is calculated to be "moderate" in Tanzania, but still "severe" in Kenya (Tables 6.2 and 6.3).

6.4 Present and future nutrient losses in LWC UR in Senegal

The LWC used as an example in Section 3.1 (Senegal, UR, 1983) has an average N depletion of 14 kg N/ha,yr (Table 4.56). If it is assumed that the topsoil in this LUS has a weight of 3×10^8 kg/ha (thickness 20 cm, bulk density 1.5 g/cm³), and an N content of 0.1%, the soil contains a total amount of 3000 kg N/ha. Senegal has had a nitrogen loss rate increase of $20-14 = 6$ kg/ha in 17 years (Table 4.56). Assuming linearity this would cause complete removal of the N source in 95 years.

Calculation

N depletion rate after T years: $14 + (T/17) \times 6$ (kg/ha,yr)
(reference is 1983)

Average N depletion between 1983 and (1983+T):
 $14 + (T/17) \times 6 \times 0.5$ (kg/ha,yr)

Total amount of N depleted in T years:

$T \times (14 + (T/17) \times 6 \times 0.5)$ (kg/ha)

For complete removal, 3000 kg N must be depleted:

$T \times (14 + (T/17) \times 6 \times 0.5) = 3000$ (kg/ha) hence $T \approx 95$ years

Assuming linearity, however, is not realistic, as crop production will decline once the mineralization of soil N can no longer make up for the annual losses. The projected yields for the year 2000 are nevertheless higher in all cases, even those with a stable fertilizer consumption and a high nutrient depletion. In such cases, the yields are probably overestimated.

REFERENCES

- ABDULLAHI, Y.A., P. HEKSTRA, M.A. IBRAHIM, A.E. ICKOWICZ, S. PLEUMPANYA and M.R. WICKSTEAD, 1986. The farming system in the coffee area, Kyeni South location, Embu district, Kenya. ICRA Bulletin 22. ICRA, Wageningen. pp 46.
- ABELLA, J.C., P.B. ATENGDEM, N.J. BEUN, J.F. MONDAIN-MONVAL, D. RAY, B.P. del ROSARIO and S.A. WINTON, 1984. The farming system in Tharaka: strategies for subsistence in a marginal area of Kenya. ICRA Bulletin 15. ICRA, Wageningen. pp 78.
- ABU SIN, M.E., 1982. A change in strategy of animal herding among the nomads of the Butana - Eastern Sudan. In: G. Heinritz (Ed.), Problems of agricultural development in the Sudan. Selected papers of a seminar. Edition Herodot, Goettingen. pp 87-104.
- AHN, P.M., 1977. Erosion hazard and farming systems in East Africa. In: Greenland, D.J. and R. Lal (Eds). Soil conservation & management in the humid tropics. John Wiley and Sons, Chichester. pp 165-187.
- AJIBOLA TAYLOR, T., H.O. ADEMEHIN, A. AJANI and I.A. AKINBODE, 1980(?). A consultancy report on agricultural research delivery systems in West Africa (with special reference to food production). pp 49.
- ALBRECHT, D., M. DIAGAYETE, D. MILLAR, R.J. SCHEER and O. SERRANT, 1983. Farming systems in the Kalounayes region in the Lower Casamance, Senegal. ICRA Bulletin 11. pp 48.
- ALEXANDRATOS, N. (ed.), 1988. World Agriculture: Toward 2000, An FAO Study. Belhaven Press, London. pp 338.
- ALLARD, J.L., Y. BERTHEAU, J.J. DREVON, O. SEZE and F. GANRY, 1983. Ressources en résidus de récolte et potentialités pour le biogaz au Sénégal. *l'Agron. Trop.*, 38(3) : 213-221.
- AMBÜHL, H.J., J.C. CASSAGRANDE, W.G. JAYASENA, J.D. SYKES and C.T. REUS, 1985. Smallholders farming systems in the south east Mulanje area of Mulanje rural development project, Malawi. ICRA Bulletin 18. ICRA, Wageningen. pp 44.
- ATAYI, E.A. and H.C. KNIPSCHEER, 1980. Survey of food crop farming systems in the "Zapi-Est" East Cameroon. IITA/Onarest. pp 94.
- AYANABA, A. and P.J. DART (EDS.), 1977. Biological nitrogen fixation in farming systems of the tropics. Papers presented at a symposium held at the International Institute of Tropical Agriculture, Ibadan, Nigeria, in October 1975. John Wiley & Sons, Ltd., Chichester. pp 377.

- BAJWA, M.A., F.M. CHAUDHRY, G.A. HADDAD, I. HAQUE and M.Y. SHAKIR, 1981. Evaluation of nitrogen, phosphorus and potassium requirement for Briggs barley in the Kufra oasis. In: E. Welte (Ed.). Proceedings 3rd CIEC symposium. Centre International des Engrais Chimiques, Göttingen. pp 279-283.
- BALIGAR, V.C., and O.L. BENNETT, 1986. Outlook on fertilizer use efficiency in the tropics. *Fertilizer Research* 10: 83-96.
- BALASUBRAMANIAN, V., J.O. BRAIDE and E.A. ATAYI, 1982. An appraisal of the present farming systems of the Atebubu district of Ghana. IITA, Ibadan, Nigeria. pp 88.
- BILLE, J.C., 1977. Etude de la production primaire nette d'un écosystème Sahélien. Travaux et documents de l'ORSTOM no. 65, ORSTOM, Paris. pp 82.
- BISWAS, A.K., Y.F.O. MASAKHALIA, L.A. ODERO-OGWEL and E.P. PALLANGYO, 1987. Land use and farming systems in the Horn of Africa. *Land Use Policy* 4(1987) 4: 419-443.
- BOXEM, H.W., T. DE MEESTER and E.M.A. SMALING (EDS), 1987. Soils of the Kilifi area, Kenya. *Agricultural Research Reports* 929, Pudoc Wageningen. pp 249.
- BOUGHTON, D., M. FALL, H. MÄHL, O. SERRANT, B. DE TOLLENAERE and J. VUURMANS, 1986. The farming systems in the Serer area of Senegal. *ICRA Bulletin* 6, ICRA Wageningen. pp 79.
- BRAUN, H., 1974. Shifting cultivation in Africa (evaluation of questionnaires). In: FAO. Shifting cultivation and soil conservation in Africa. Papers presented at the FAO/SIDA/ARC regional seminar on shifting cultivation in Africa, Ibadan, Nigeria, 2-21 July 1973. *Soils Bulletin* 24. FAO, Rome. pp 21-36.
- BROWN, P., and A. YOUNG, 1967. The physical environment of central Malawi. Zomba. pp 93.
- BRUBACHER, D., J.T. ARNASON and J.D.H. LAMBERT, 1989. Woody species and nutrient accumulation during the fallow period of milpa farming in Belize, C.A.. *Plant and Soil* 114, 165-172.
- BRUIN B. DE, F.W.T. PENNING DE VRIES, L.W. VAN BROEKHOVEN, N. VERTREGT and S.C. VAN DE GEIJN, 1989. Net nitrogen mineralization, nitrification and CO₂ production in alternating moisture conditions in an unfertilized low-humus sandy soil from the Sahel. *Plant and Soil* 113, 69-78.
- BRUINSMA, J., J. HRABOVSKY, N. ALEXANDRATOS and P. PETRI, 1983. Crop production and input requirements in developing countries. *European Review of Agricultural Economics*, 1983 : 197-222.

- CENTRE FOR WORLD FOOD STUDIES (SOW), 1985. Potential food production increases from fertilizer aid: a case study of Burkina Faso, Ghana, and Kenya. Volume I. Centre for World Food Studies, Wageningen.
- CHABALIER, P. F., 1985. Etude comparative de deux engrais azotés marqués par ^{15}N : urée et nitrate, sur une culture de maïs en Côte d'Ivoire. *l'Agron. Trop.* 40(2) : 107 - 114.
- CHANDELE, A., M. CONTEH, J. GOODRICH, B. MONNEY, J. SYKES, WU HOU-JIU, 1987. A study of the smallholder farming system in West Mulanje, Malawi. *ICRA Bulletin* 24. ICRA, Wageningen. pp 55.
- CHARREAU, C., 1972. Problèmes posés par l'utilisation agricole des sols tropicaux Fig 3.3 par des cultures annuelles. *l'Agron. Trop.* 27(9) : 905-929.
- COOKE, G.W., 1982. Fertilizing for maximum yield. English Language Book Society/Collins, London. pp 465.
- DATIRI, B.T., 1974. Soil and water conservation practices particularly in areas of shifting cultivation. In: FAO. Shifting cultivation and soil conservation in Africa. Papers presented at the FAO/SIDA/ARCN regional seminar on shifting cultivation in Africa, Ibadan, Nigeria, 2-21 July 1973. *Soils Bulletin* 24. FAO, Rome. pp 237-241.
- DIDIER, D., 1986. Etude de l'amélioration de la fertilisation des cultures vivrières au Burkina Faso. Université Libre de Bruxelles, Bruxelles. pp
- DUCKHAM, A.N., and G.B. MASEFIELD, 1970. Farming systems of the world. Chatto & Windus, London. pp 542.
- FAO, 1976. A framework for land evaluation. *FAO Soils Bulletin* 32. FAO, Rome. pp 72.
- FAO, 1977a. Guidelines for soil profile description. FAO, Rome. pp 66.
- FAO, 1977b. FAO/Unesco soil map of the world, 1: 5 000 000. Vol. VI. Africa. Unesco, Paris. pp 299.
- FAO, 1978. Report on the Agro-ecological Zones Project. Vol. I, Methodology and results for Africa. *World Soil Resources Report* 48. FAO, Rome. pp 158.
- FAO, 1980. Report on the second FAO/UNFPA expert consultation on land resources for populations of the future. FAO, Rome. pp 369.
- FAO, 1986. Status report on plant nutrition in fertilizer programme countries in Africa. FAO, Rome. pp 170.
- FAO, 1987a. 1986, FAO fertilizer yearbook. Vol.36. FAO Statistics Series No.77. FAO, Rome. pp 124.

- FAO, 1987b. Feasibility study on expanding Aid-in-Kind, country case study on Zambia. FAO, Rome. pp 26.
- FAO, 1988. FAO fertilizer yearbook, Vol. 37, 1987. FAO Statistics Series No. 83. FAO, Rome. pp 123.
- FAO, 1989. FAO production yearbook, Vol. 42, 1988. FAO Statistics Series No. 88. FAO, Rome. pp 350.
- FLAIG, W., B. NAGAR, H. SÖCHTIG and C. TIETJEN, 1977. Organic materials and soil productivity. FAO Soils Bulletin 35. FAO, 1977. pp 119.
- FOURNIER, F., 1967. Research on soil erosion and soil conservation in Africa. African Soils, 12. pp 53-96.
- GAUR, A.C., S. NEELAKANTAN and K.S. DARGAN, 1984. Organic manures. Indian Council of Agricultural Research, New Delhi. pp 159.
- GEUS, J.G. DE, 1973. Fertilizer guide for the tropics and subtropics. Centre d'étude de l'azote, Zürich. pp 774.
- GIGOU, J., 1986a. La fertilisation raisonnée du sorgho en Afrique de l'Ouest. l'Agron. Trop., 41 (3-4) : 192-202.
- GIGOU, J., 1986b. Bilan des éléments minéraux sous une rotation sorgho-cotonnier en lysimètres. l'Agron. Trop., 41 (2) : 149-153.
- GIGOU, J., 1987. L'adaption des cultures dans le centre de la Côte d'Ivoire. l'Agron. Trop., 42 (1) : 1-12.
- GIGOU, J., F. GANRY and J. PICHOT, 1985. Nitrogen balance in some tropical farming systems. Proc. Symp. on Nitrogen Management in the Farming Systems in the Humid and Subhumid tropics. IITA Ibadan: pp 247-268.
- GOLDSWORTHY, R.P. and N.M. FISHER (EDS.), 1984. The physiology of tropical field crops. John Wiley & Sons, Chichester. pp 664.
- GREENLAND, 1977. Contribution of microorganisms to the nitrogen status of tropical soils. In: Ayanaba and Dart, 1977.
- GREENLAND, 1985. Nitrogen and food production in the tropics: contributions from fertilizer nitrogen and biological nitrogen fixation. Proc. Symp. on Nitrogen Management in the Farming Systems in the Humid and Subhumid tropics. IITA, Ibadan: pp 9-38.
- GRIMME, H., 1989. Changes of nutrient concentration in the soil solution and of nutrient status under different cropping systems in southern Nigeria. Proc. Symp. on nutrient management for food crop production in tropical farming systems. Institute for Soil Fertility and Universitas Brawijaya, Haren: pp 171-176.

- GRIMME, H., and A.S.R. JUO, 1985. Inorganic nitrogen lossess through leaching and denitrification in soils of the humid tropics. Proc. Symp. on Nitrogen Management in the Farming Systems in the Humid and Subhumid tropics. IITA Ibadan: pp 57-72.
- GRIST, D.H. 1975. Rice. Longman Group Ltd. London. pp 601.
- GWYNNE-JONES, D.R.G., P.K. MITCHELL, M.E. HARVEY and K. SWINDELL, 1978. A new geography of Sierra Leone. Longman Group Ltd., London. pp 212.
- HADAS, A., A. FEIGIN, S. FEIGENBAUM and R. PORTNOY, 1989. Nitrogen mineralization in the field at various depths. In: Journal of Soil Science 40, 131-137.
- HAKKELING, R.T.A., 1989. Global assessment of soil degradation - Eastern and Southern Africa. Volume I + II. Report no. 2082. Netherlands Soil Survey Institute (STIBOKA), Wageningen. pp 54 + 205.
- HARTLEY, C.W.S., 1977. The Oil Palm (*Elaeis guineensis* Jacq.). Longman Group Ltd., London. pp 806.
- HAULE, K.L., E.I. KIMAMBO and J. FLOOR, 1989. Effect of continuous cultivation and fertilizer applications on yield of maize and soil characteristics of a Ferralsol-Luvisol catena on gneiss in N.E. Tanzania. National Soil Service, Tanga. pp 10.
- HEKSTRA, P., I. KHALU-DEEN, F. MWALYEGO, E. PENOT, U. SABEL KOSCHELLA, T.S. SAHOTA and H. XIAOHUI, 1988. Analysis of the cassava based farming system of the Nkhata Bay Lowlands, Malawi. ICRA Bulletin 28. ICRA, Wageningen. pp 81.
- HOUGHAM, D.A. and F. STURROCK, 1973. The farms - present day organisation. In: Richards, A.I., F. Sturrock and J.M. Fortt [Eds]. Subsistence to commercial farming in present-day Buganda. African studies series. Cambridge University Press, Cambridge. pp 150-178.
- HUSSAIN, S.A., W LANDSTRA, D.R.B. MANDA, J. MEDLAND, E.G.S. PARAICO and J. SCHNABEL, 1982. The farming system in Makueni location, Machakos, Kenya. ICRA Bulletin 8. ICRA, Wageningen. pp 59.
- ILOEJE, N.P., 1980. A new geography of West Africa. Longman Group Ltd., London. pp 169.
- INSTITUTE OF TROPICAL AGRICULTURE KARL MARX UNIVERSITY, 1983. Problems of an optimum nutrient supply to tropical crops. 6th International scientific conference (June 6-12, 1983). Institute of Tropical Agriculture Karl Marx University, Leipzig, pp 519.
- ISTITUTO GEOGRAFICO DE AGOSTINI, 1976. World Atlas of Agriculture vol.4, Africa. Istituto Geografico De Agostini, Novara, Italy. pp 761.

- JAHNKE, H.E., 1976. Tsetse flies and livestock development in East Africa. A study in environmental economics. Afrika-Studien 87. Weltforum Verlag, München. pp 180.
- JESKE, J., 1977. Botswana - Lesotho - Swaziland. Agrargeographische struktur und wirtschaftliche verflechtung im südlichen Afrika. Afrika-Studien 97. Weltforum Verlag, München. pp 396.
- JONES, M.J., and A.R. BROMFIELD, 1970. Nitrogen in the rainfall at Samaru, Nigeria. Nature Vol. 227: 86.
- KALMS, J.M., 1977. Studies of cultivation techniques at Bouaké, Ivory Coast. In: Greenland, D.J. and R. Lal (Eds). Soil conservation & management in the humid tropics. John Wiley & Sons, Chichester. pp 195-200.
- KALU, A.E., 1979. The African dust plume: its characteristics and propagation across West Africa in winter. In: Morales, C. Shara dust. Mobilization, transport, deposition. Scope 14. John Wiley & Sons, Chichester. pp 119-132.
- KANG, B.T., and J. VAN DER HEIDE, 1985. Nitrogen management in farming systems in humid and subhumid tropics. Proceedings of Symposium on "Nitrogen Management in Farming Systems in Humid and Subhumid Tropics" held at the IITA, Ibadan, Nigeria, October 23-26, 1984. Institute for Soil Fertility and International Institute of Tropical Agriculture, Haren (Gr.), The Netherlands. pp 362.
- KASSAM, A.H., 1976. Crops of the West African semi-arid tropics. International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India. pp 154.
- KEULEN, H. VAN, and J. WOLF (EDS.), 1986. Modelling of agricultural production: weather, soils and crops. Pudoc, Wageningen. pp 479.
- KLAUW, E VAN DER, 1989. 'Vee wordt als het grote kwaad gezien'. Vice Versa 23(3): 1-6.
- KNICKEL, K.W., 1988. Farming systems development - smallholder swamp rice schemes in Sierra Leone. Studien zur integrierten ländlichen entwicklung 27. Verlag Weltarchiv GmbH, Hamburg. pp 217.
- LAGEMAN, J., 1977. Traditional african farming systems in Eastern Nigeria. An analysis of reaction to increasing population density. Afrika-Studien 98. Weltforum Verlag, München. pp 269.
- LAL, R., 1976. Soil erosion on Alfisols in Western Nigeria. Geoderma 16: 363-431.

- LAL, R., 1977. The soil and water conservation problem in Africa: ecological differences and management problems. In: Greenland, D.J. and R. Lal (Eds). Soil conservation & management in the humid tropics. John Wiley & Sons, Chichester. pp 143-163.
- LAL, R., 1985. Soil erosion and sediment transport research in tropical Africa. *J. Hydrol.* 30: 239-256.
- LAL, R. (ED.), 1988. Soil erosion research methods. Soil and Water Conservation Society, Ankeney, Iowa. pp 244.
- LAL, R., G.F. HALL and F.P. MILLER, 1989. Soil degradation: 1. Basic processes. Land degradation and rehabilitation, Vol. 1: 51-69.
- LANDON, J.R. (ED.), 1984. Booker tropical soil manual. A handbook for soil survey and agricultural land evaluation in the tropics and subtropics. Booker Agriculture International Limited, London, pp 450.
- LLANO-ALCOBER, D., J. CORNELIS, J. MEDLAND, G.C. MREMA, S. PRAYAG, and G. O'GRADY SHARROCK, 1983. Agricultural development and research priorities for a semi-arid area of Machakos district, Kenya. ICRA bulletin 10. ICRA, Wageningen. pp 71.
- MACDONALD, I., and J. LOW, 1984. Tropical field crops, Evans Brothers Limited, London, pp 112.
- MINISTERIE VAN LANDBOUW EN VISSERIJ, 1988. Landbouwontwikkeling in de Sahellanden. Themawerkgroeperapport, ministerie van Landbouw en Visserij, Wageningen. pp 32.
- MEYER, J., and E. PAMPFER, 1959. Nitrogen content of rainwater collected in the humid Central Congo Basin. *Nature* 184: 714-718.
- MINISTÉRIO DA EDUCAÇÃO, 1986. Atlas geográfico. Ministério da educação, república popular de mocambique. pp 49.
- MIRACLE, M.P., 1967. Agriculture in the Congo basin. Tradition and changes in African rural economies. The University of Wisconsin Press, Madison. pp 355.
- MORTIMORE, M., 1989. The causes, nature and rate of soil degradation in the northernmost states of Nigeria and an assessment of the role of fertilizer in counteracting the processes of degradation. Environment Department Working Paper No. 17. The World Bank, policy planning and research staff.
- MUNYINDA, K., R.E. KARAMANOS, J.O. LEGG and S. SANOGHO, 1988. Nitrogen fixation by soybeans (*Glycine max* L.) in Zambia. *Plant and Soil* 109: 57-63.

- NGATUNGA, E.L.N., R. LAL and A.P. URIYO, 1984. Effects of surface management on runoff and soil erosion from some plots at Mlingano, Tanzania. *Geoderma* 33: 1-12.
- NGUYEN VAN NGUU, 1987. Effect of nitrogen, phosphorus and soil and crop residues management practices on maize (*Zea mays* L.) yield in ultisol of eastern Cameroon. *Fertilizer Research* 14: 135-142.
- NOLL, I.E. VAN DER, and B.H. JANSSEN, 1983. Cow dung slurry as an organic manure for fodder crops in Kilifi, Coast Province, Kenya. Training project in pedology, Kilifi, Kenya. Preliminary report No. 5. Internal Bulletin No. 62, Dept. Soil Science and Plant Nutrition, Agricultural University Wageningen, The Netherlands. pp 69.
- NYE, P.H., 1961. Organic matter and nutrient cycles under moist tropical forest. *Plant & Soil* 13 (4): 333-346.
- NYE, P.H., and D.J. GREENLAND, 1960. The soil under shifting cultivation. Technical Communication No. 51. Commonwealth Agricultural Bureaux, Bucks, England. pp 156.
- OKIGBO, B.N., 1977. Farming systems and soil erosion in West Africa. In: Greenland, D.J. and R. Lal (Eds). *Soil conservation & management in the humid tropics*. John Wiley & Sons, Chichester. pp 151-163.
- PAGEL, H., J. ENZMANN and H. MUTSCHER, 1982. *Pflanzennährstoffe in tropischen Böden*. VEB Deutscher Landwirtschaftsverlag, Berlin. pp 272.
- PAYR, G., 1977. Förderung und Beratung traditioneller Kleinbauern in Salima/Malawi. *Afrika-studien* 96. Weltforum Verlag, München. pp 302.
- PENNING DE VRIES, F.W.T. and M.A. DJITÈYE (EDS.), 1982. La productivité des pâturages sahéliens. Une étude des sols, des végétations et de l'exploitation de cette ressource naturelle. Centre for Agricultural Publishing and Documentation, Wageningen. pp 525.
- PERON, Y., and V. ZALACAIN, 1975. *Atlas de la Haute-Volta. Les atlas Afrique*. Editions Jeunes Afrique, Paris. pp 49.
- PICHOT, J., M.P. SEDOGO, J.F. POULAIN and J. ARRIVETS, 1981. Evolution de la fertilité d'un sol ferrugineux tropical sous l'influence de fumures minérales et organiques. *l'Agron. Trop.* 36(2): 122-133.
- PIERI, C., 1985. Bilans minéraux des systèmes de cultures pluviales en zones arides et semi-arides. *l'Agron. Trop.* 40(1): 1-20.
- PIERI, C., 1986. Fertilisation des cultures vivrières et fertilité des sols en agriculture paysanne subsaharienne. *l'Agron. Trop.* 41(1): 1-20.

- PIERI, C., 1989. Fertilité des terres de savannes. Ministère de la Coopération and CIRAD-IRAT, Paris. pp 444.
- POELS, R.L.H., 1987. Soils, water and nutrients in a forest ecosystem in Suriname. Agricultural University, Wageningen. pp 253.
- PÖSSINGER, H., 1968. Landwirtschaftliche entwicklung in Angola und Moçambique. Afrika-Studien 31. Weltforum Verlag, München. pp 284.
- POWELL, J.M., 1985. Yields of sorghum and millet and stover consumption by livestock in the Subhumid Zone of Nigeria. Trop. Agric. (Trinidad), 62(1): 77-81.
- POWELL, J.M., and W. BAYER, 1985. Crop residue grazing by Bunaji cattle in central Nigeria. Trop. Agric. (Trinidad) 62(4): 302-304.
- PURSEGLOVE, J.W., 1972. Tropical crops. Monocotyledons 1 and 2. Longman Group Ltd., London. pp 607.
- QURESHI, J.N., 1987. The cumulative effects of N-P fertilizers, manure and crop residues on maize grain yields, leaf nutrient contents and some soil chemical properties at Kabete. National Agricultural Laboratories, Nairobi. Paper presented at the National Maize Agronomy Workshop, organized by CIMMYT, Nairobi, February 17-19, 1987. pp 12.
- RHODES, E.R., 1988. Africa - how much fertilizer needed: case study of Sierra Leone. Fertilizer Research 17: 101-118.
- RICHARD, C., 1963. Pluviométrie et étude phisico-chimique des eaux de pluie. l'Agron. Trop. 19(12): 1073-1080.
- RUTHENBERG, H. [ED.], 1968. Smallholder farming and smallholder development in Tanzania. Afrika-Studien 24. Weltforum Verlag, München. pp 360.
- SANCHEZ, P.A., 1976. Properties and management of soils in the tropics. John Wiley & Sons, New York. pp 618.
- SCHULTZ, J., 1971. Agrarlandschaftliche veränderungen in Tanzania. Afrika-Studien 64. Weltforum Verlag, München. pp 294.
- SCOTT, J.S., 1988. Potatoes in Central Africa: A study of Burundi, Rwanda and Zaire. International Potato Center (CIP), Lima. pp 159.
- SINGH, L., and V. BALASUBRAMANIAN, 1983. Direct and residual effect on P and K on crop yield, nutrient uptake and soil properties at Kadawa, Nigeria. Fertilizers and Agriculture, 84: 39-47.
- SINGH, L., U.R. PAL and Y. ARORA, 1987. Direct and residual effect of liming on yield and nutrient uptake of maize (*Zea mays* L.) in moderately acid soils in the savanne zone of Nigeria. Fertilizer Research 12: 11-20.

- SIPKENS, L., 1989. The development of legume - cereal cropping patterns for food crop production in on - farm research in northern Ghana. In: J. van der Heide. Proc. Symp. on nutrient management for food crop production in tropical farming systems. Institute for Soil Fertility and Universitas Brawijaya, Haren. pp 317-326.
- SÖDERLUND, R., 1981. Dry and wet deposition of nitrogen compounds. In: Clark, F.E. and T. Rosswall (Eds). Terrestrial Nitrogen Cycles. Ecol. Bull. (Stockholm) 33: 123-130.
- SSALI, H. (ED.), 1985. Biological nitrogen fixation in Africa. Proceedings of the first conference of the African Association for Biological Nitrogen Fixation, Nairobi, Kenya, 23 - 27 July 1984. Mircen, Nairobi. pp 540.
- STOCKING, M., 1984. Erosion and soil productivity: a review. Consultants' Working Paper No.1. AGLS, FAO, Rome. pp 102.
- STOCKING, M., 1986. The cost of soil erosion in Zimbabwe in terms of the loss of three major nutrients. Consultants' Working Paper No.3. AGLS, FAO, Rome. pp 164.
- STYCZEN, M., 1989. Nutrient and water balance on some eroded soils in Nigeria. (?)
- TANDON, H.L.S. (COMPL. & ED.), 1988. Management in Plantation crops - A guidebook. Fertiliser Development and Consultation Organisation, New Delhi. pp 83.
- TAYLOR, T.A., H.O. ADEMEHIN, A. AJANI and AKINBODE, 1980 (?). A consultancy report on agricultural research delivery systems in West Africa. IITA, Nigeria.(?)
- TISDALE, S.L., W.L. NELSON and J.D. BEATON, 1985. Soil fertility and fertilizers. Macmillan Publishing Company, New York. pp 754.
- TRUDGILL, S.T., 1979. Soil and vegetation systems (contemporary problems in geography). Clarendon Press, Oxford. pp 180.
- TWYFORD, I.T., 1988. Development of smallholder fertilizer use in Malawi. A paper for FAO/FIAC meeting, Rome, 26-29th April, 1988. pp 16.
- VELLY, J., C. EGOUMENIDES and J. PICHOT, 1980. l'Azote extractible par une solution de KCl et la fourniture d'azote a la plante dans 40 sols tropicaux. l'Agron. Trop. 35(4): 374- 380.
- VILLECOURT, P., 1975. Apports d'azote minéral (nitrique et ammoniacal) par la pluie dans la savane de Lamto. Rev. Écol. Biol. Sol 12 (4): 667 - 680.
- WESTPHAL, E., 1981. l'Agriculture autochtone au Cameroun. Miscellaneous papers 20, Landbouwhogeschool Wageningen, the Netherlands. H. Veenman & zonen B.V., Wageningen. pp 175.

- WESTPHAL, E., 1985. Cultures vivrières tropicales avec référence spéciale au Cameroun. Pudoc, Wageningen. pp 514.
- WIELEMAKER, W.G. and H.W. BOXEM (EDS), 1982. Soils of the Kisii area, Kenya. Agric. Res. Rep. 922, Pudoc, Wageningen. pp 208.
- WILLIAMS, C.N., 1975. The agronomy of the major tropical crops. Oxford University Press, Kuala Lumpur. pp 228.
- WOLF, J., C.T. DE WIT and H. VAN KEULEN, 1989. Modeling long-term crop response to fertilizer and soil nitrogen. I. Model description and application. Plant and Soil 120, 11-22.
- WORLD BANK, 1988. Cotton development programs in Burkina Faso, Côte d'Ivoire, and Togo. A World Bank operations evaluation study. Operations Evaluation Department, The World Bank, Washington, D.C. pp 126.