

---

# Contents

<i>Preface</i>	x
<i>Acknowledgements</i>	xiii
Part I. The ecological fundamentals of the constraints	1
1 Introducing the problem	3
1.1 The theses to be proven	3
1.2 Climatic limitations and characterization of the tropics	7
1.2.1 Radiation conditions	7
1.2.2 Thermal conditions	7
1.2.3 Thermal effects of elevation	8
1.2.4 Soil temperatures	10
1.2.5 Hygro-climatic conditions	11
1.2.6 Hygric effects of elevation	17
1.3 Natural vegetation regions	19
1.4 Population distribution in the context of natural regions	22
1.5 Notorious nutritional problems	26
1.6 High expectations of production capacity	28
1.7 Questioning environmental determinism. The role of interregional exchange	40
1.8 Reasons for an actualistic approach	41
2 Characteristics of traditional rainfed agriculture in the tropics	43
2.1 The areally dominant and representative form of tropical rainfed agriculture	44
2.2 Specific meanings of shifting cultivation and rotational bush fallow	47
2.3 The areal extent of shifting cultivation in its broader connotation	50

2.4	Characteristic procedures of shifting cultivation land-use systems in Africa	52
2.5	Shifting cultivation in South America and South Asia	54
2.6	Critical assessment of shifting cultivation in its broader connotation	57
2.6.1	Why field shifting?	57
2.6.2	The effects of slash-and-burn	59
2.6.3	Nutrient content of forest biomass and ash after burning	60
2.6.4	Impact of shifting fields and dwellings on tropical forests	64
2.6.5	Does rotational bush fallow constitute real progress?	68
2.6.6	The yields obtained from shifting cultivation	69
2.7	Pros and cons of shifting cultivation	70
3	The soils of the tropics and their key role in an ecological context	79
3.1	The problem of classification and taxonomy	79
3.2	Ecologically decisive soil properties	80
3.3	Crystallographic structure of different clay mineral groups	88
3.4	The formation of clay minerals	91
3.5	Properties of clay mineral groups	95
3.6	Climatic dependency of clay mineral formation and soil types	97
3.7	Organic matter in tropical soils	101
3.8	Decomposition of organic matter and the formation of humus	103
3.9	Effects of forest clearing	109
3.10	Manipulating soil chemical properties	110
3.10.1	The effects of phosphorous fixation and aluminium toxicity	110
3.10.2	Liming	112
3.11	The role of topography on the formation of regular microscale soil sequences (toposequences, catenas)	112
3.12	Characteristics of the most important soils of the tropics	116
3.12.1	Ferrallitic soils	118
3.12.2	Ferrisols	119
3.12.3	Fersiallitic soils	120
3.12.4	Eutrophic brown tropical soils	120
3.12.5	Red-brown and brown soils	121
3.12.6	Vertisols	121
3.12.7	Andosols	122

4	The seeming contradiction between lush natural vegetation and poor agricultural crops on nutrient-poor soils of the humid tropics	123
4.1	The stratification of nutrients in tropical soils	123
4.2	Nutrient losses from natural forest ecosystems. The chemistry of natural waters	124
4.3	The closed nutrient cycle in tropical rain forests	129
4.4	Ensuring the nutrient cycle of the tropical rain forests – mycorrhizas	130
4.5	The mutualistic relationship between mycorrhiza and rain-forest trees	131
4.6	Structural adaptations to the closed mineral cycle	133
4.7	The human impact on the mineral cycle	135
4.8	The contrasting conditions in temperate regions	135
5	The ecologically exceptional regions of the humid tropics	137
5.1	Base-rich and base-poor rock groups	138
5.2	Exceptional realms on basaltic parent rocks	141
5.3	Exceptional realms on alluvial accumulations	146
5.4	Ecological advantages of mountainous areas	148
5.5	The special conditions of paddy soils and wet-rice cultivation	149
5.6	The South-east Asian humid tropics compared with the African and South American humid tropics	160
5.7	High population densities on tropical low-base status soils. Counter arguments to the general low carrying capacity?	162
6	The ecological conditions in the seasonally wet-and-dry outer-tropics	167
6.1	The zonal change of soil types	167
6.2	Climatic restrictions and the need for water management	168
6.3	Actual lack of water management	169
6.4	The technical difficulties of dam construction in the ektropical zone of excessive planation: the Deccan Plateau example.	170
Part II. Modern attempts at solving the problems of tropical agriculture; the persistence of the ecological constraints		179
Introduction		181
7	The Green Revolution in the tropical realm	183
7.1	The main characteristics in the Green Revolution technological package	183
7.2	Regional differentiation in the adoption of the new technology	186
7.3	Soil-related constraints on the application of the new technology in the humid tropics	189

7.4	The Green Revolution in the semihumid and semiarid outer tropics	191
8	International attempts at the level of research institutions	196
8.1	The long-term continuous cropping experiments in Yurimaguas (Peru) and their consequences	196
8.1.1	Set-up of the experiments and research strategy	199
8.1.2	The actual performance of the continuous cropping experiments	201
8.1.3	The reality in the countryside beyond the YAES confines	208
8.1.4	General conclusions concerning the ecological frailty of the humid tropical environment	215
8.2	Low-input technology at Yurimaguas	216
8.2.1	Alternatives to continuous cropping	219
8.3	Soil and land-use experiments in the semihumid tropics (IITA, ICRISAT, CIAT)	221
8.3.1	Institutional concepts and geographic location of IITA	221
8.3.2	Soil properties	223
8.3.3	The soil erosion problem and prevention strategies	226
8.3.4	IITA's crop-centred breeding programmes	228
8.3.5	Transferring the innovations	230
8.3.6	Centro Internacional de Agricultura Tropical (CIAT)	232
8.4	Balance of the accomplishments of the international centres of agricultural research in the tropics	233
9	Practical attempts at applying new farming techniques	235
9.1	The ecofarming approach	235
9.2	The Transamazon Colonization Project	238
9.2.1	The general framework of the colonization projects in Amazonia	238
9.2.2	The Transamazon Highway Colonization Scheme	240
9.2.3	Lessons from the colonization programme	243
9.2.4	New concepts for Rondônia	250
9.3	Transmigration in Indonesia	251
9.3.1	Transmigration plans and number of peoples involved	252
9.3.2	Discussion of different transmigration projects	253
9.3.3	Lessons from the transmigration projects	257
9.4	Agroforestry schemes as alternatives in tropical agriculture	259
9.4.1	The general aim of agroforestry	259
9.4.2	Permanent tree-crop farming	261
9.4.3	Taungya farming	262

9.4.4	Basic necessities of a real agroforestry system at smallholder level	264
9.4.5	Feasible agroforestry alternatives at smallholder level	267
9.4.6	Agroforestry in tropical Africa	268
9.4.7	Agroforestry in tropical South America	270
9.4.8	Agroforestry in South-east Asia	271
9.4.9	Facing the obstacles against the spread of agroforestry	272
10	Summary and conclusions	274
	<i>Appendix 1</i>	282
	<i>Appendix 2A Soil types of South America</i>	283
	<i>Appendix 2B Soil types of Africa</i>	284
	<i>Appendix 2C Soil types of South-east Asia</i>	285
	<i>Appendix 3A Dams in West Africa and the Sudan</i>	286
	<i>Appendix 3B Dams in the Deccan states of India</i>	287
	<i>Appendix 4 Soil types of India</i>	290
	<i>Bibliography</i>	292
	<i>Index</i>	314