Restoration of Inland Valley Ecosystems in West Africa

edited by

Shohei HIROSE · Toshiyuki WAKATSUKI

Association of Agriculture & Forestry Statistics

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◀ Expansion of desertified lowland, Torodi town, Niger , Aug. 1992

▲ Upland rice is apt to be damaged by sever weed, Bida, Nigeria, Sept. 1989

▲ Non-sawah rice cultivation degrades valley bottom soil, at Makeni, Sierra Leone, Jan. 1987

▲ Mixed cropping with Asian rice (*Oryza Sativa*), bending panicle, and African rice (*Oryza Glaberrima*), straight panicle, at Kaduna, Nigeria, Sept. 1990

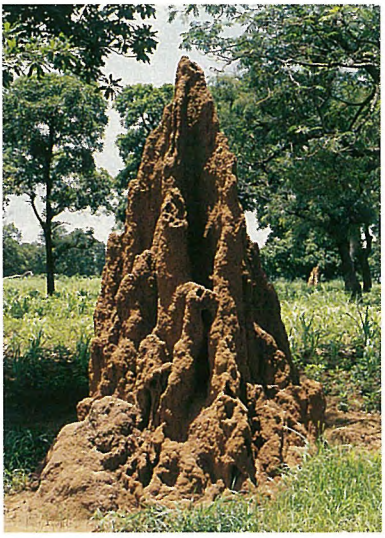
▶ In addition to Azolla, sawah system has various nitrogen fixation mechanisms, Biemso, No. 1 sawah, Ashanti, Ghana, Aug. 2000

◀ Farmer's irrigation canal and small-lot quasi-sawah, at Emitsu Ndadan, Bida, Nigeria, Jan. 1997

▲ After rice, farmers planted ground nuts, maize, cassava, sweet potato, and taro on the mounds, at Makeni, Sierra Leone, Jan. 1998

▲ Borgu Sector, Kainji Lake Park, Niger State, Nigeria, July. 2000

▲ Tree nursery at Biemtetrete, Ashanti, Ghana, May 1998



Trees arranged on a farmland with a rising termite mound, Gadza, Nigeria, Aug. 2000 ▶

▲ Fulbe herd on the harvested sawah field, Gadza, Nigeria, Dec. 1994

▲ Fulbe people and cattle in the Gadza camp, Gadza, Nigeria, Mar. 1993

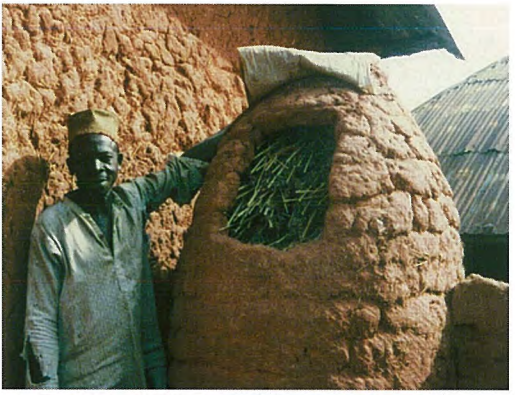
▲ Leveling using power tiller is very efficient for participatory sawah development, Biemso No. 1 sawah, Ashanti, Ghana, Aug. 2000

▼ Fish and rice culture in sawah developed. Small refuge pond is seen at Biemso No. 1 sawah, Ashanti, Ghana, Aug. 2000

▲ Nupe farmers harvesting the rice on the sawah field at Gadza, Nigeria, Jan., 1995

▲ Nupe farmers winnowing the harvested rice at Mochita, Nigeria, Dec. 1994

▲ A Nupe traditional healer explaining the usage of a plant, Emiafa, Nigeria, Aug., 2000



▲ Storage earth house of the cereals, at Gadza, Nigeria, Jan. 1989

Manual canal construction ▶ by participating farmers group, Biemso No. 1, Ashanti, Ghana, Apr. 1999

Restoration of Inland Valley Ecosystems in West Africa

Contents

Contributers

Introduction : Preface and Executive Summary S. Hirose and T. Wakatsuki

Chapter 1 Sustainable Agricultural Development of West Africa during Global Environmental Crises T. Wakatsuki

1. Peoples and history of West Africa 1
1-1. Countries and peoples of West Africa 1
1-2. West Africa's history of constant suffering 5
2. Characteristics of recent agricultural production in West Africa 8
2-1. Crop production that cannot keep up with population growth 8
2-2. Changes in *land use* in the period 1974-1998 in West Africa 16
2-3. Comparison of *historical forest cover changes in Europe, America and Japan* 18
3. Situations of *farmland degradation* and *desertification* in the tropics and West Africa 21
3-1. Agricultural production, farmland, and *soil degradation* 21
3-2. Comparison of human induced soil degradation in three main tropical regions 24
3-3. Estimate of *effective population density* of the *three major tropical regions* 31
3-4. Situations of farmland degradation and desertification in West Africa 37
(1) Desertification : southward movement of the desertification front 37
(2) Decrease in forests 37
4. Directions of *restoration of degraded farmland* and development of *sustainable farming systems* in West Africa 43
4-1. *Traditional farming systems* in West Africa 43
(1) *Shifting cultivation* and *nomadic herding* 43
(2) *Bush fallowing* or *land rotation* 43

(3) Intensive subsistence agriculture 45
(4) Flood plain agriculture 47
4-2. Present situations of research and development (R&D) on sustainable farming systems in tropical Africa 49
(1) Improvement in shifting cultivation and fallowing system 49
(2) R&D on sustainable upland farming systems 50
(3) R&D on sustainable lowland farming systems 54
5. Restoration strategies for West African land : ecotechnology approaches for sustainable development of sawah and afforestation in inland valley watershed 56
5-1. Potential of inland valleys for the development of sawah based agriculture 56
5-2. The concept of geological fertilization and the carrying capacity of a global region 58
5-3. Restoration theories and hypothes for land and agriculture in tropical Africa 64
(1) Sawah hypotheses 64
(2) Basic pedological conditions for the sustainability of the global ecosystem 66
(3) Sawah system in the watershed ecosystem 68
5-4. Conceptual frameworks for ecotechnology approaches for the restoration of degraded watersheds in West Africa 71
(1) The sawah hypothesis and the Green Revolution 71
(2) Geological fertilization theory for the integration of a watershed 73
(3) Sawah and forestry ecotechnology development 75
(4) Participatory approach for ecotechnology research, development and extension 76
(5) Ecotechnology approach for the sustainable sawah development in inland valley bottom in West Africa 77

Chapter 2 Ecological Environment of West Africa

1. Climatic characteristics ..... Y. Kitamura ... 83
1-1. Climatic features 83
(1) Climatic zones 83
(2) Rainfall 85
1-2. Climate and agricultural potential 88

2. Topography, geology, vegetation and soils in West Africa ··· T. Wakatsuki ··· 92
2-1. Topography and geology ··· 92
2-2. Distribution of vegetation ··· 94
2-3. Soil distribution ··· 97
3. Distribution and characteristics of lowland soils in West Africa ··· T. Wakatsuki, R. N. Issaka and Md. M. Buri ··· 105
3-1. Distribution and characteristics of lowlands in tropical Africa ··· 105
3-2. Vertisols in inland basins ··· 106
3-3. Poor soils in inland valleys and more fertile soils in flood plains ··· 110
(1) Inland valleys ··· 110
(2) Soil fertility of inland valleys and flood plains in West Africa ··· 111
(3) Geographic distribution of soil fertility in inland valleys and flood plains ··· 122
(4) Toposequence of inland valley soils ··· 129
(5) Sulfur and zinc deficiency and the other micronutrients in the soils of inland valleys and flood plains ··· 131
(6) Relationship between the configuration, geology and climate of inland valleys and their soil fertility ··· 133
3-4. Acid sulfate soils in coastal swamps ··· 134
3-5. Characteristics of clay minerals ··· T. Kosaki ··· 135
4. Characteristics of the hydrologic environment ··· Y. Kitamura ··· 137
4-1. Hydrologic geography ··· 137
4-2. Outline of water resources ··· 139
4-3. Runoff characteristics ··· 141
(1) River Niger basin ··· 141
(2) Senegal river basin ··· 143
(3) Other river systems ··· 145
5. Characteristics of the water use environment ··· 147
5-1. International water treaties ··· 147
5-2. Water treaties for main rivers ··· 150
(1) River Niger ··· 150
(2) Senegal River ··· 151
5-3. Outline of water resource and irrigation development ··· 151
5-4. Outline of irrigated rice development ··· 155
5-5. Present situation of water resources and irrigation development of West African countries ··· 160
(1) Guinea ··· 160

(2) Mali 162
(3) Niger 163
(4) Nigeria 164
(5) Senegal 165
(6) Ghana 166
(7) Côte d'Ivoire 168
(8) Liberia 170
(9) Sierra Leone 171
(10) Burkina Faso 171
5-6. Problems of irrigation development 172
6. Oxygen isotope composition of natural water in West Africa ..... C. Mizota ... 174
6-1. Introduction 174
6-2. Collection of water samples and measurement of their oxygen isotope composition 175
6-3. Oxygen isotope composition of natural water in West Africa 176
6-4. Oxygen isotope composition of natural water around the City of Bida in central Nigeria 177
(1) Outline of the survey area 177
(2) Analysis and discussion 179
6-5. Summary 180

Chapter 3 Traditional Agriculture and Crop Production —Case studies in the Guinea Savanna Zone

1. Rice and upland farming in the Nupe community ..... S. Hirose ... 183
1-1. Introduction 183
1-2. Nature and diversity of inland valleys 184
(1) Inland valleys 184
(2) Complex hydrological environment and their elements 185
(3) Physical and chemical properties of soil and related factors 185
1-3. Division of cultivated land in inland valleys and its ecology 186
1-4. Farming environment and livelihood in Bida and its environs in central Nigeria 187
1-5. Farming environment of Gadza, the survey site 188
(1) Outline of Gadza 188
(2) Gadza's farmland environment 189

1-6. Traditional farming systems : rice cropping 190
(1) Land preparation methods 191
(2) Traditional rice cultivation methods and cultivars in inland valleys and flood plains 196
1-7. Traditional farming systems : upland farming 198
(1) Plowing methods of fallow land 199
(2) Species of upland crops 199
(3) Cropping systems in upland fields 202
(4) Cultivation management and yield 203
1-8. Toward the realization of sustainable agriculture in inland valleys in West Africa 205
2. Nupe's lowland farming systems ..... F. Ishida ... 212
2-1. Introduction 212
2-2. Nupe's traditional lowland rice cropping systems 212
2-3. Meaning of the Nupe's lowland rice cropping systems 217
(1) Measures against weeds 217
(2) Measures for soil nutrient 218
(3) Microtopography and rice cropping patterns 222
3. Ethnopedological study of Nupe's farming systems ..... F. Ishida ... 225
3-1. Ethnopedology 225
3-2. Lessons learned from failure in the introduction of Asian sawah field system 226
3-3. Survey site and experiment method 227
3-4. Results and discussions 228
(1) Nupe's topographical description and classification 228
(2) Nupe's soil classification 229
(3) Comparison between Nupe's soil texture distinction and analytical data 231
3-5. Conclusion 232

Chapter 4 People and Forests in Guinea Savanna

1. Land and forest resources in the northern Nigeria ..... M. Masuda ... 233
1-1. Introduction 233
(1) Outline of climate and vegetation 233
(2) Expansion of derived savanna 234
(3) Data collection 236

1-2. Development of forest regimes 238
(1) Creation of forest estate 238
(2) Colonization process until 1914 239
(3) Forest regimes during the colonial period 241
(4) Current situation of forests and forestry 244
1-3. Institutional changes on land and people 248
(1) Native Administration during the colonial period 248
(2) Transition of land regimes 250
(3) Current situation of native authorities 252
1-4. Land system : a case study in Nupeland 255
(1) Pattern of settlements 255
(2) Land tenure in agricultural communities 256
(3) Land use and distribution inside a community 263
1-5. People, land, and forests in Guinea savanna 267
(1) Population and farming system 267
(2) Land system and forests 269
2. Trees on farmland 270
2-1. Introduction 270
(1) Data collection 270
(2) Human impact on forest resources 271
2-2. Distribution of trees outside forest reserves 272
(1) Home garden 272
(2) Farmland 272
(3) Comparison of biomass and floristic biodiversity 274
2-3. Traditional use of medicinal plants 278
(1) Traditional medicine in Africa 278
(2) Native doctors in Niger State 279
(3) Traditional use of medicinal plants
..... K. Shoji, T. Hiramatsu and M. Masuda ... 279
2-4. Importance of trees to improve the quality of life ..... M. Masuda ... 281
3. Climate and growth of trees in savannas ..... N. Okada ... 283
3-1. Growth environment and information of tree rings 283
(1) Method of tree ring analysis 283
(2) Savanna climate and the formation of growth rings 284
(3) Structure of growth rings 285
3-2. Growth process of trees estimated by means of carbon isotope ratios ... 287
(1) Growth of trees and carbon isotope ratios 287

(2) Carbon isotope ratios of sheanut and African mahogany ····· 288
(3) Radial growth rates of sheanut and African mahogany ····· 291
4. Multipurpose use of trees in Bauchi State, Nigeria ····· Y. Hayashi ··· 292
4-1. Characteristics of the survey sites ····· 292
4-2. Uses of trees in Bauchi State ····· 293
4-3. Future directions ····· 299

Chapter 5 Ecological Anthropological Study on Daily Herding Activities of Pastoral Fulbe in Central Nigeria K. Shikano

1. Introduction ····· 303
2. Study area and method ····· 305
2-1. Study area ····· 305
2-2. Study period and method ····· 307
3. Social background of Bida Fulbe ····· 308
3-1. Bida Fulbe's political system ····· 308
3-2. Bida Fulbe patrilineal kin groups ····· 308
(1) Bida Fulbe clans and lineages ····· 308
(2) The family studied ····· 310
3-3. Bida Fulbe's kinship terminology ····· 310
3-4. Bida Fulbe's age-sex classes ····· 312
(1) Age classes of men ····· 312
(2) Age classes of women ····· 313
4. Bida Fulbe settlements ····· 313
4-1. *Baade* and *onde* : components of Fulbe settlements ····· 313
4-2. Spatial structure of Fulbe settlements ····· 314
(1) Fulbe's houses (*hurgooru* and *suudu*) ····· 316
(2) Cattle enclosure (*hoggo*) ····· 317
(3) Other facilities ····· 318
4-3. Social structure of Fulbe settlements ····· 318
(1) Case study of Alhaji Abdullahi's settlement ····· 318
(2) Structural principle of a settlement ····· 319
5. Relationship between Bida Fulbe and cattle ····· 320
5-1. Animals kept by Bida Fulbe ····· 320
5-2. Bida Fulbe's cognitive system of cattle ····· 321
(1) Age and sex classes of cattle ····· 321
(2) Terms for the body color of cattle and shape of their horns (future

subject) 323
5-3. A cattle herd owned by a family 323
(1) Structure of the cattle herd 323
(2) Ownership of cattle 326
(3) Emigration of cattle from a herd 327
(4) Donation of cattle and formation of a family's herd 330
(5) Terms for other animals 330
5-4. Animal products and their use 331
(1) Milk and its use 331
(2) Use of other livestock products 335
6. Bida Fulbe's herding activities 336
6-1. Outline of Bida Fulbe's herding 336
(1) *Baade* and settlement as the units for herding 336
(2) Outline of day-trip herding 336
(3) Fulbe words related to herding 338
(4) Bida Fulbe's classification of seasons 339
6-2. Details of herding activities at the settlement studied : cycle of six herding patterns 339
(1) Herding pattern in *setto luggini* 340
(2) Herding pattern in *dungu* 343
(3) Herding pattern in early *yande* 344
(4) Herding pattern in late *yande* 346
(5) Herding pattern in *sheedu* 348
(6) Herding pattern in *setto* 350
7. Discussion and conclusion 350
7-1. The first conclusion and a proposition of the problem for this section 350
7-2. Background of coexistence : relationship between pastoral Fulbe and agricultural Nupe 352
(1) Nupe's deep-rooted antipathy against Fulbe 352
(2) Cooperative relations between Fulbe and Nupe 353
7-3. Bida Fulbe herding methods 354
(1) Bida Fulbe herding plan : change in main types of herding range 354
(2) Seasonal migration of the settlement 355
(3) Bida Flube's other herding techniques 356
7-4. The second conclusion : careful cattle herding in farming areas 361
7-5. Future of pastoral Fulbe coexistence with agricultural Nupe 367

Chapter 6 On-farm Demonstration Studies for the Restoration of Ecological Environment and Rural Life

1. Topography, land use and hydrological characterization of benchmark inland valley watersheds
.....D. Kubota, O.O. Fashola, K.O. Asubonteng, and T. Wakatsuki 371
1-1. Topographical features of inland valleys 371
1-2. Land use and hydrological characteristics of the benchmark inland valleys in the tropical forest zone of Sierra Leone and Guinea Savanna zone of Central Nigeria 373
1-3. Soil, water and land-use characterization of Dwinyan river watershed, forest transition zone of Ashanti region, Ghana 390
(1) Introduction 390
(2) Study area 392
(3) Valley Morphology 397
(4) Soils 397
(5) Water Table Dynamics 401
(6) Interaction of water table and land use 401
2. African Based Sawah Agriculture in Inland Valley —A Case Study at Nupe Land, Guinea Savanna Zone of Central Nigeria 403
2-1. On-farm demonstration study in Gadza village with farmers' partial participation : 1992-1995 .....T. Wakatsuki ... 403
(1) Subsequent situations of the IITA on-farm study fields 403
(2) Sawah field development and repairing and improvement of irrigation facilities in Gadza by farmer participation 406
(3) Economics and theories of large-scale and small-scale development projects 410
(4) Agronomic Evaluation on the Preliminary trials on Sawah farming in Gadza during 1992～1995 ..... S. Hirose ... 413
2-2. Farmers' evaluation of the on-farm trials in Gara and Gadza village : 1992-1995 ..... G.O.Olaniyan ... 424
(1) Historical background on the activities before 1992 424
(2) Farmers' evaluation of the on-farm demonstration trials : 1992 -1995 426
3. African Based Sawah Agriculture in Inland Valley —A Case Study at Ashanti, Ghana 427
3-1. On-farm demonstration study at Adugyama and Biem river watershed
.....D. Kubota, E. Otoo and T. Wakatsuki ... 427

(1) Introduction 427
(2) The main goal of the on-farm trials 429
(3) Comparison of large scale, small scale and traditional systems with eco-technology based systems in Ghana 429
(4) Design, construction and evaluation of various sawah systems 430
3-2. Participatory ecotechnology approach for sustainable sawah development 447
3-3. Farmers' evaluation on the on-farm trial ..... M. Nawano ... 449
(1) Introduction 449
(2) Outline of the survey sites 449
(3) Interview survey on the residents' opinions about sawah fields 450
(4) Farmers' images on sawah fields : "Are sawahs more beautiful than cocoa farms ?" 455
(5) Structure of residents' recognition of different spaces in the villages 462
(6) How do the participating farmers evaluate sawah field development ? : future of sawah fields and a tentative proposal for sawah field development: ecotechnology approach 466
(7) Summary 469
3-4. Development intervention and incentive structure for residents : case study of traditional landownership system and small-scale sawah field development in Central Ghana ..... T. Takane ... 470
(1) Introduction 470
(2) Farmer-land relations in cocoa production 472
(3) Farmer-land relations in traditional rice growing 475
(4) Farmer-land relations in a small-scale sawah field project 476
(5) Conclusion 478
4. Potential for agroforestry as a part of integrated watershed management 479
4-1. Constraints on the introduction of tree crops ..... M. Masuda ... 479
(1) Arrangement of trees in agroforestry 479
(2) Offset mechanism of the *taungya* system 480
(3) Constraints due to the land system : an example of G settlement 481
4-2. Sheanut : traditional agroforestry in savannas ..... M. Masuda and S. Kudu ... 484
(1) Sheanut as an export commodity 484
(2) Current situation of the domestic market 485
(3) Distribution of sheanut in uplands 486

4-3. Cacao : agroforestry in the forest zone ..... A. Ochiai ... 488
(1) Introduction of cacao into Ghana 489
(2) Characteristics of the farming system 490
(3) Multipurpose character of cacao agroforestry 493
(4) Considerations for gender and the existing systems 496
4-4. Introduction of tree crops into the Guinea savanna zone
..... M. Masuda and J. Aliu ... 497

Chapter 7 Conclusion : Integrated watershed management by the ecotechnology approach S. Hirose and T. Wakatsuki

1. Historical and ecological background of non-sawah based rice cultivation in West Africa 501
2. Agronomic and engineering adaptation in rice cultivation 503
3. Road to sustainable rice cultivation in West Africa 505
4. Ecotechnology approach for sawah based agriculture in inland valleys and floodplains in West Africa 508
4-1. Japanese international contribution for sustainable development on sawah based agriculture in Africa 508
4-2. Strategies for developing African based sawah agriculture 510
5. Toward integrated development and management of inland valley watershed in West Africa 512

References 515
Index 547

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Restoration of Inland Valley Ecosystems in West Africa

Introduction : Preface and Executive Summary

S. Hirose and T. Wakatsuki

At the first year of 21st century, there exist regional differences clearly both in the importance of food, agricultural and environmental problems and the urgency for solving them. Thanks to the success in the "Green Revolution," most of the Asian countries achieved food self-sufficiency one after another by the 1980s and their agricultural production exceeded the pace of population growth. This is generally considered to be a basic condition that has brought rapidly expanding economy in Asia now.

On the other hand, sub-Saharan African countries, except a few, suffered a decline in the average annual food production in the first half of the 1990s as compared with that in the 1960s and in the 1970s. As a result, according to FAO's estimates, per capita food supply (kcal/day) in developing nations in this region experienced a decrease of 20 kcal every ten years over the 1970-1990 period. In 1990, undernourished people accounted for 37% of the total population, reaching about 175 million. These figures are rapidly increasing in the sub-Saharan region both in absolute numbers and in percentages compared to the world.

In West Africa, population pressure and rest of the deforestation by shifting cultivation followed by timber extraction is turning forests into savannas. The human induced soil degradation, including over grazing is expanding the area of desertification. West Africa is a typical region where food and environmental

crises are becoming increasingly serious and the deteriorating environment is threatening human survival. The major causes for this can be found in the tragedies of many years ago. The slave trade by European countries for as long as 400 years from the 16th to 19th centuries destroyed African communities. Subsequent colonization by the great powers in Europe continued for additional 150 years until the independence of majority of African countries in 1960s. Under the rule of European nations, African people were forced to be involved in the cultivation of commercial crops and trees on the best soils and staple foods on marginal soils, which resulted in the degradation of farmland and ecology as well as in the disruption of Africa's traditional farming systems. This, and the rapid population growth, is probably the main reason for the continuing poverty and crises facing many parts of this continent.

For countries in sub-Saharan tropical Africa with a population growth rate of 3% a year, it is necessary to establish urgently sustainable agricultural systems. Learning from past failures then the direct import of modern farming technology from Europe and USA, researchers have now reassessed their approach through better understanding of traditional agricultures in Africa. However, the revaluation of indigenous farming systems alone is not enough. So far no really effective way has been found to deal with the rapidly increasing population and grave environmental disruption expected in the 21st century.

Agriculture in Africa is basically upland cropping and its traditional methods are bush fallow and shifting cultivation. Excluding some areas with fertile soils, there are only a limited area occupied by farming systems with permanent cultivation. A shift to a cycle of shorter fallowing and longer continuous cultivation has recently been widespread. This new system has invited a vicious circle of farmland degradation and lowering in productivity. F. Jurion and J. Henry, both former directors of L'Institut National pour l'Etude Agronomique du Congo (I.N.E.A.C.) in the Democratic Republic of the Congo (former Zaire) conducted studies in the DRC, Rwanda and Burundi, and published a book entitled "Can "Primitive" Farming Be Modernized?" in 1967 (originally published in French ; English translation in 1969) based on the study results. In this book, they presented the outcome of experiments on how to improve the technology for intensifying African agriculture. High hopes were placed on the non-tillage or minimum-tillage systems studied mainly by IITA (International Institute of Tropical Agriculture ; headquarters in Ibadan, Nigeria) in the 1970s and 1980s and then in the second half of 1980s, on agroforestry investigated chiefly by IITA and newly founded ICRAF (International Center

for Research in Agroforestry ; headquarters in Nairobi, Kenya). But the sustainable intensification of upland farming in the tropics, especially in tropical Africa, still has many technical and socioeconomic difficulties to be cleared up.

For five years from 1984 to 1988, the Japanese survey team headed by Shohei Hirose conducted an investigation project "Agro-ecological Study of the Great Rift Valley in East Africa" in the eastern and western sides of the Great Rift Valley, where soil fertility is especially high in the tropics because of volcanic activities, with a Grant-in-Aid for Scientific Research of the Japanese Ministry of Education, Science, Culture and Sport. This study also showed that crop productivity was low and that there were economic limitations on the introduction of improved technologies. The outcome of this project was published by the following two reports in English:

Hirose, S. (ed) : Agriculture and Soils in Kenya : A Case Study of Farming Systems in the Embu District and Characterization of Volcanogenous Soils, Nihon University, 138 pp., 1987.

Hirose, S. and Mubandu, M. (eds) ; Agriculture and Soils in Zaire : A Case Study of Farming Systems in the Lake Kivu Area and Characterization of Volcanogenous Soils, Nihon University, 147 pp., 1989.

From 1986 to 1990, Toshiyuki Wakatsuki, who participated in the studies in Kenya and Tanzania in East Africa, stayed at IITA as an expert in lowland paddy agriculture of the Japan International Cooperation Agency (JICA). Hereafter we use the term "sawah*" instead of the term "paddy" because of the reason described in the foot note and in Chapter 1. During these years, he conducted studies on various aspects of lowland rice farming and soil fertility in West and Central Africa from countries along the Gulf of Guinea to Mali, Niger, Cameroon and Zaire (present Dem. Rep. of the Congo). Chapters 1 and 2 and part of Chapter 6 are the results of these investigations.

*Sawah : The term sawah refers to leveled rice field surrounded by bund with inlet and outlet for irrigation and drainage. The term originates from Malayo-Indonesian. The English term, Paddy or Paddi, also originates from the Malayo-Indonesian term, Padi, which means rice plant. The term, Paddy, refers to rice grain with husk in West Africa. Most of the paddy fields in the Asian countries correspond to the definition of the term sawah. Paddy field is almost equivalent to sawah for Asian scientists. However, the term paddy field only refers to just a rice field including upland rice field in West Africa. Therefore in order to avoid confusion between the terms rice plant, paddy, and the improved man-made rice

growing environment, the authors propose to use the term *sawah*.

While the approach to the development of farming technology for Africa, which was strongly affected by that of European countries, attached too much importance to soil-exploiting upland agriculture, there exist numerous small inland valley swamps (IVS) ; in particular in West Africa. Total area of the IVS reaches 10 million hectares, which is capable of being turned into small scale irrigated paddy rice fields, i.e., sawah, in numerous small watersheds of the great plains in West Africa. If floodplains and deltas are added to these small swamps, the total potential of irrigated sawah reaches 20 million ha. Several millions of farmers are actually growing rice in these areas. But rice cultivation in West Africa differs from sawah based rice agriculture commonly observed in Asia in many respects ; it consists of lowland rice growing but with the nature of an extension of upland cropping. This system is probably based on the traditional methods of local farmers who have devised it through their experience. If it is possible to make the most of these unused and poorly used lowland areas by developing them into sawah fields, the potential of sustainable agricultural production in these lowland fields is likely to reach a level equivalent to the existing upland production.

IITA and WARDA (West Africa Rice Development Association ; headquarters in Bouake, Cote d'Ivoire) are the two international organizations supported by the CG group (Consultative Group on International Agricultural Research) that have carried out studies on West Africa's rice cultivation. Since 1990 the latter became a sole body responsible for these studies among the two CG centers. In the past 30 years, research in rice cultivation in West Africa may have yielded many valuable results on the level of institutes or experiment stations but have made no great contribution to productivity in farmers' fields. In fact, the average paddy yield of rice has been stagnant at 1.3-1.6 t/ha (in milled rice 0.8 to 1.0 t/ha) during the past 30 years. This is in distinct contrast to the case of Tropical Southeast Asia where the figure doubled from 1.8 t/ha to 3.6 t/ha in the same period. The main reason cited is that upland rice is grown mostly by shifting cultivation in West Africa. Labor shortage makes it hard to intensify rice cultivation in this region unlike in Asia and that ecological environment and socioeconomic conditions of rice farming in this region differ from those of Asia. Another important reason is that the research and development policies of IITA and WARDA are determined mainly by the strong influences of Europeans and Americans, who little understand the importance of

lowland sawah systems in rice farming. Because of this, almost no efforts have been made to encourage local farmers to introduce sawah based agriculture.

Continued low yield required a larger area for cultivation, which in turn lead to the utilization of a bigger area of forest. The absence of a sawah system means no bunding and leveling even in the traditional lowland rice cultivation in this region, which accelerates soil erosion, even in the valley bottom. As discussed in Chapter 1, since sustainable productivity of 1 ha of lowland sawah is equivalent to more than 10 ha of upland fields, development of 1 ha of sawah open the way for the afforestation of the degraded upland field in West Africa. The total potential area for new sawah development in West Africa is estimated at 20 million ha including floodplain and coastal delta. About half of that figure covers small inland valley bottoms. Thus if we can develop 20 million ha of sawah in the next 50-100 years, we can save an area under natural vegetation of 200 million ha. If we can plant trees with net primary productivity of 2.5 ton-C/ha/year on 200 million ha, the forest can fixed half a billion tons of the carbon dioxide annually in the next 50-100 years, which will roughly reduce the equivalent of 10% of the present human induced global carbon emission.

As already noted, there exist countless inland valley swamps in the water-heads of great plain in West Africa. In 1993, P.N. Windmeijer and W. Andrisse published "Inland Valleys in West Africa : An Agro-Ecological Characterization of Rice-Growing Environments." This book consists of a report on the basic investigation concerning the ecological environment and socioeconomic conditions of rice growing in inland valleys in West Africa. The initial investigation was started in 1982 jointly by IITA and two Dutch institutes, the DLO-Winand Staring Center for Integrated Land, Soil and Water Research (SC-DLO) and Royal Tropical Institute (KIT). This publication contains much useful information about the ecological environment but describes no demonstrative attempts to develop sawah based rice cultivation in inland valleys of West Africa. In 1993, a consortium for sustainable use of inland valley ecosystems (IVS-Consortium) was organized and more comprehensive studies of inland valleys were conducted in Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali, Nigeria and Sierra Leone under the leadership of IITA, WARDA, SC-DLO mentioned above, Wageningen Agricultural University and France's CIRAD (Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement). But in this case too, main emphasis was on the detailed and quantitative characterization of ecological environments and socioeconomic conditions and the construction of models for actual development was defined as a task for 2001 and after.

This means that "research for research's sake" would continue for about 20 years.

One of the motives for publishing this book was this: in view of the foregoing, we considered that if West Africa is to overcome the problem of low farming productivity and to realize a more intensive and sustainable agriculture while conserving and possibly restoring the environment, it would be an urgent task for the region to establish agricultural systems that would include sawah systems to sustain soil fertility and to conserve scarce water resource in lowlands. We also intended to propose strategies for restoring forest environments in uplands, which could be attained by increased production as a result of intensive and sustainable use of lowlands for sawah based agriculture.

It is now evident that over the past 500 years, while Africa was exploited the West was able to globalize itself and accumulate wealth, which then brought the development of Western science and technology and "affluent life." Since the Meiji Restoration in 1868, Japan has received the benefits of the Western science and technology and grew to be an economic power. But the history of past 500 years was the age of the globalization of Western values and at the same time that of deterioration of the global environment. While the conquest of the world by Western countries during these years brought a richer and more convenient life to us, it also caused the destruction of African communities and the disruption of the global environment. If we understand this, we need to consider that Africa, the continent victimized by the West, is the "main battlefield" of global environmental issues. In order to overcome the negative effects of Western civilization and science and technology and also to build a new global community which can solve environmental and North-South problems, Japan and other Asians countries should collaborate not only in Asian region but should also involve themselves more positively in Africa.

Hybridization not only rice seeds, such as NERICA, new rice of Africa (Annual report of WARDA 1999 and 2000) but also the farming systems between Africa and Asia would contribute to create new partnership between Asia and Africa. The integration of sawah based agriculture, which is one of the common assets of Asian cultures, to traditional African agriculture will contribute ultimately to build a new global community in the 21st century-this is more important objective of this book than what is mentioned earlier.

This publication is basically a translation of the book published in 1997 written in Japanese edited by S. Hirose and T. Wakatsuki "Nishi-Afurika

Sabanna-no Seitai-Kankyou-no Shyufuku-to Nouson-no Saisei", Restoration of Ecological Environment and Rural Life in Savanna Zone of West Africa, Norin Tokei Kyoukai, Tokyo, pp 504. The book is a collection of reports on our field studies in the past ten years. What started this publishing project directly was the international scientific study supported by the Grant-in-Aid for Scientic Research of the Japanese Ministry of Education, Science and Culture conducted during 1993-1995 period (Study Subject No. 05041041, "Project for Regeneration of Agro-Forest-Ecosystems in sub-Sahalan Africa", Project Leader: Shohei Hirose). Before the project we made preliminary international scientific study supported by Japan Society for the Promotion of Science, JSPS, during 1992 -1993 (Restoration of Agricultural Ecosystems in Savanna Zone of West Africa, conducted by T. Wakatsuki, M. Masuda and T. Kosaki). The Japanese members who took part in this study and the study subjects they took charge of are as follows (their posts are those as of June 1996):

Shohei Hirose (College of Bioresource Sciences, Nihon University): restoration of upland agroecosystems, direction of the study;
Toshiyuki Wakatsuki (Faculty of Life and Environmental Science, Shimane University): soil fertility, restoration of lowland agroecosystems, on-farm demonstration study on sawah systems, coordination of the study;
Chitoshi Mizota (Faculty of Agriculture, Iwate University): investigations on clay minerals, soil genesis, classification, soil erosion and water resources;
Takashi Kosaki (Faculty of Agriculture, Kyoto University): same as above;
Misa Masuda (College of Agriculture and Forestry, University of Tsukuba): on-farm investigations on forest resources, rural communities, land ownership systems and agroforestry in savannas;
Naoki Okada (Forestry and Forest Products Research Institute, Ministry of Agriculture, Forestry and Fisheries): forest ecosystems in savannas and annual ring analysis;
Kazuhiro Shikano (Shimane Prefectural Women's College): traditional coexistence relationship between pastoral Fulbes and Nupe farmers and its changes;
Yukihiro Hayashi (College of Bioresource Sciences, Nihon University): investigations on the multipurpose use of trees in the savanna zone;
Fusako Ishida (Faculty of Life and Environmental, Shimane University): studies on Nupe's ethnopedology and traditional lowland farming systems.

This book, however, is not a direct translation of the book published in

Japanese on 1997. This book also includes some major additional results of following research projects after 1995. During 1996-2001, our group organized various field surveys and advanced on-farm experiments.

(1) "Indigenous farming adaptive SUIDEN, i.e., sawah, and agroforestry systems" supported by the Grant-in-Aid for Scientific Research of the Japanese Ministry of Education, Science and Culture during 1996-1997(Study Subject No. 08041150, conducted by T. Wakatsuki, K. Hayahsi, R. N. Issaka, M. M. Buri, J. Aliu, and G. O. Olaniyan).
(2) Two MOFA-Commissioned Research on Development Assistance through Foundation for Advanced Studies on International Development, Japan (FASID) "Studies on development of sustainable management for rural resources and village life system based on agro-ecological survey in North Guinea savanna of West Africa"(Leader : Shohei Hirose) and "Transfer of Asian Experiences on the African Development in 21 Century : Comparative study and evaluation on the Asian collaborative sawah based rice development projects in West Africa" (Leader : Tsohiyuki Wakatsuki)
(3) "Integrated watershed management of Inland valleys in Ghana-Ecotechnology approach" supported by joint study project between Japan International Cooperation Agency (JICA) and Crops Research Institute of Ghana (CSIR-CRI) during 1997-2001 (conducted by T. Wakatsuki, D. Kubota, M. Masuda, H. Masuda, E. Otoo, A. Ochiai, J. Ofori, and N. Nawano).
(4) "Land and agricultural system in West African small Watershed" supported by the Grant-in-Aid for Scientific Research of the Japanese Ministry of Education, Culture, Sports Science and Technology during 1999-2001(Study Subject No. 11691084, conducted by T. Wakatsuki, Y. Kitamura, T. Takane, M. Nawano, K. Hayashi, K. Shoji and Y. Kitamura).
(5) Interdisciplinary General Joint Research Grant for Nihon University, No. 00-13(2000), No. 01-016(2001) ; "Studies on development of sustainable management for rural resources and village life system in the Guinea savanna of West Africa"(conducted by Shohei Hirose, F. Sugimura, K. Aoki, H. Sumida, K. Ikeda, Y. Hayashi and M. Masuda).

During 1986-2001, the majority of our activities was conducted under the auspices of IITA, International Institute of Tropical Agriculture. Especially the HIROSE project of IITA during 1993-2001 has been a core center of these various projects.

The book covers a wide range of subjects and topics. What is dealt with is not limited to studies on the respective fields by the members referred to above. The themes pursued also included the identification of problems of agriculture, forestry and livestock raising. Possible systems for integrating these areas were conducted. Workable strategies for restoring savannas, on-farm demonstration, participatory trials and evaluation at the benchmark villages in benchmark watershed were conducted (i.e. on-farm trials of sawah system development and sawah based agriculture through farmer participation) ; agroforestry trials and the establishment and management of village nursery fields ; construction of fish ponds and pisciculture ; and coexistence systems for Nupe farmers and pastoral Fulbe.

The subjects discussed in this book are as shown in the table of contents and are outlined below. Chapter 1 described the present situation of West Africa, where global environmental problems are posing direct threats to the survival of the human beings, and proposes strategies for restoring the quality of land in this region by sawah and forestry ecotechnology development. The lowland sawah hypothesis for sustainable and intensive agriculture to recover forest in this region, the geological fertilization theory to integrate upland forest and lowland sawah in a watershed, participatory ecotechnology research, development and extension are the conceptual framework. Chapter 2 presents a general survey of West Africa's ecological environment, i.e. geology, topography and hydrology as well as the classification, distribution, and physical and chemical characteristics of lowland soils in the region. Although very diverse and heterogeneous, generally very low soil fertility, even in lowlands, both of major nutrients and minor elements, such as sulfur and zinc, was clearly demonstrated. Based on the results of investigations on traditional agriculture and crop production in Nupe and in the Guinea savanna zone, we pointed out in Chapter 3 that many characteristics of farming systems are well adapted to the environment. Such adaptation can be observed in the cropping of millets and tubers in uplands, in rice growing and alternate planting of rice and upland crops in inland valley fringes and in rice monoculture in floodplains. By analyzing Nupe's recognition and awareness of farmland soils, it also examines traditional and efficient soil-conserving farming techniques using neither animals nor machines. Chapter 4 discussed, first of all, Nupe community's land ownership system, land use system and arrangement of trees as the basic data needed to devise measures for forest conservation and ecosystem restoration in the Guinea savanna zone. This reveals the complex land systems that reflect historical

backgrounds for several centuries. The study of farming in the Bauchi State conducted to compare the situation of tree use by farmers shows that native useful trees are introduced into the farming system and that traditional agroforestry of the scattered type is practiced. The annual ring analysis using carbon isotope ratios is expected to provide clues for estimating the growth rate of trees in savannas. Chapter 5 reported the outcome of an ecologic anthropological study of pastoral Fulbe people, who coexist with farming people of Nupe sharing the same land with them. Fulbe's sphere of activity extends to uplands, swamps and even floodplains (only during the dry season) where Nupe do farming and their activities are sometimes in conflict with Fulbe's. The traditional symbiotic relationship between the two races and its changing process were utilized, and the possibility of coexistence of farming and pastoral people and that of mixed farming and livestock raising is also discussed. Chapter 6 outlined the on-farm studies the results mentioned above. Researchers experimented the sawah technology adaptable to various types of lowland fields of local farmers as well as the on-farm trials carried out by farmer's participation, and points out the possibilities and problems of these attempts. Two benchmark sites were selected, the Emikpata river watershed, Guniea savanna zone of Central Nigeria, and the Dwinyan/Biem river watershed, forest transitional zone, Ashanti of Ghana. Finally, Chapter 7 summarized the findings presented in the preceding chapters and presents the conclusion of this book.

In West Africa, especially in savannas, agricultural activities are mostly carried out in uplands, which is essentially disadvantageous from the viewpoint of intensive and sustainable cropping. Therefore, it is evident that introducing sustainable and highly productive lowland sawah based agriculture into inland valley watersheds in West Africa, together with efforts to promote forestry, agroforestry, mixed farming and livestock raising, is an effective strategy for restoring and reviving the region's agroforestry ecosystems. If forestry, livestock farming, upland cropping, lowland sawah fields and reservoirs/pisciculture can be integrated into an each unit of watersheds, the intensive sustainability of agriculture in West African savannas will increase further. It is evident that the road to the restoration of African land exposed to the risk of degradation and desertification is the introduction and spread of a system of integrated agriculture, forestry and fishery in various watersheds. Realizing such integrated system would be possible only when it is undertaken in harmony with traditional agriculture in Africa.

Of the authors of this book, Wakatsuki's investigation activities have already been presented. Kosaki (1982-1985) and Hayashi (1994-1995) were also on the staff of IITA. Ms. Fusako Ishida joined IITA since 1998. Another study project relating to this book is the "Study for Formulation of Sustainable Agriculture Development Plans for Africa : Preliminary Study on Valley Bottom Rice Farming in West Africa" conducted by AICAF (Association for International Cooperation of Agriculture and Forestry) in the 1992-2000 period. Parts of the results in Chapters 1, 2 and 6 were based on the achievements of the "Technical Cooperation Projects in Agriculture for Global Environmental Conservation," West Africa and Cote d'Ivoire, carried out by the Japan Agricultural Development and Extension Association (JADEA) in the 1993-1995 period. These achievements furnish a basis for the sections on the climatic, hydrologic and irrigation environment of West Africa (Chapter 2, Sections 1, 4 and 5) written by Yoshinobu Kitamura (Faculty of Agriculture Tottori University), too. A special request was made to him to write about these subjects for this book.

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The authors wish to thank all of the people mentioned above and hope that this book will help them and others overcome the crises of agriculture and ecological environments in West Africa. Africa and Japan are quite a long way from each other even today. But Japanese agriculture is faced with crises, too, though in a different sense, and the authors would like to expect that Japan's traditional ecotechnology of sawah and forestry will contribute to the revitalization of Africa and that this will in turn trigger the restoration of Japanese agriculture and forestry.

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