Contents

Dedication	V
Preface	vii
Acknowledgments	хi
Contents	xiii
Contributors	xxxi
About the Editorxx	xvii
PART I INTRODUCTORY PART	
I Introductory Part	3
I.1 Introduction to Part I	3
I.2 Agrometeorology, a Broad Definition (and Other Starting Issues)	4
I.3 Agrometeorology, an "End to End" Information Flow Scheme	7
I.4 Agrometeorology, Applications and Use	15
I.5 Agrometeorological Services	19
I.6 Boundary and Initial Conditions for Solving Problems	
with Agrometeorological Components	31
Annex I.I Postgraduate Syllabi Applied Agrometeorology	34
Annex I.II Conceptual and Diagnostic Framework: Information Flow	44
Annex I.III Syllabi Agrometeorological Extension Intermediaries	45
PART II OPERATIONAL APPLICATIONS OF AGROMETEOROLOGICAL SERVICES	
II.A Introduction to Part II (INSAM Examples)	55
-	xiii

xiv Contents

II.B Introduction to Part II (CMA/CAU/APMP Examples)	75
II.C Agrometeorological Services	101
II.1 Design of sand settlement of wind blown sand using local trees and grasses (Sudan) Nawal K. Nasr Al-Amin, C.J. Stigter, Ahmed Eltayeb Mohammed	102
II.2 Agrometeorological service for irrigation advice (Cuba) Ismabel María Domínguez Hurtado	108
II.3 Frost forecast service for Inner Mongolia in 2007 (China)	114
II.4 Design of protection of sloping land from soil loss and water run off using hedgerow intercropping (Kenya)	118
II.5 Design of multiple shelterbelts to protect crops from hot dry air (Nigeria) Lambert O.Z. Onyewotu, C.J. Stigter, J.J. Owonubi	123
II.6 Seasonal vegetable growing on riverbeds – a farmers' innovation (India)	129
II.7 Agrometeorological information for the prevention of forest and wildland fires (Cuba)	133
II.8 Furrow planting and ridge covering with plastic for drought relief in semi-arid regions (China)	138
II.9 Design of on-station alley cropping trials on flat land in the semi-arid tropics (Kenya)	142
II.10 Early snow melting through surface spread of soil material (India) . Rajendra Prasad, Vijay Singh Thakur	147

II.11 Water use and water waste under traditional and non-traditional	
irrigation practices (Sudan)	151
II.12 Shelterbelt design for protection of irrigation canals and agricultural land from blown sand encroachment (Sudan)	157
II.13 Design of improved underground storage pits (matmura) for sorghum in cracking clays (Sudan)	162
II.14 Improved design of millet based intercropping systems using on-station field research and microclimate manipulation (Nigeria) Tunji Oluwasemire, C.J. Stigter, J.J Owonubi	168
II.15 Design of wind protection agroforestry from experience in a demonstration plot of hedged agroforestry (Kenya)	174
II.16 Applying straw mulch on winter wheat in winter to improve soil moisture conditions (China)	179
II.17 Using shade trees to ameliorate the microclimate, yields and quality of tea (India)	183
II.18 Explaining wind protection of coffee from umbrella shade trees (Tanzania)	187
II.19 Development and establishment of a drought early warning system (Cuba)	190
II.20 Development of a web-based optimal irrigation calendar (Portugal)	195
II.C.I Advisory and service system of crop and variety planning in Xing'an	199

xvi Contents

II.C.11 Sowing advice for spring wheat depending on the frost melting condition in the autumn irrigated top soil in Bayannur	205
II.C.III Improving microclimate for water melon by covering sandy soil with pebbles	210
II.C.IV Forecasting fungus disease conditions for wolfberries	217
II.C.V Refined agroclimatic zoning used for planning of growing navel oranges, and protection advisory services after planting	224
II.C.VI Demonstration and extension of relay intercropping of late rice into lotus, enhanced by climate change	232
II.C.VII Water saving irrigation determined by soil moisture forecasting for wheat farms in the Huang-Huai-Huai Plane, Henan	238
II.C.VIII Forecasting peony flowering periods for various varieties and places in Luoyang city, Henan	245
II.C.IX Winter straw mulching increasing water use efficiency and yields in winter wheat	251
II.C.X Early warning of low temperatures and less sunshine for plastic greenhouse crops in winter	256
II.D Communication Approaches in Applied Agrometeorology	263
PART III FIELDS OF APPLICATION IN AGROMETEOROLOGY	
III.1 Introduction to Part III	289

Contents xvii

III.2 APPLIED AGROMETEOROLOGY OF MONOCROPPING IN THE OPEN

III.2.1 Strategic Use of Climate Information	
III.2.1.(a) Combating Disasters: Monocropping	305
HI.2.1.(b) Selection Processes of (Changes in) Land Use and Cropping Patterns: Monocropping	309
III.2.1.(c) The Selection of Actual Preparedness Strategies for Dealing with Climate as Adopted in Monocropping	315
III.2.1.(d) More Efficient Use of Agricultural Inputs as Part of Adoption of Preparedness Strategies: Monocropping	321
III.2.1.(e) Selection of (Changes in) Livestock Management Patterns: Monocropping	327
III.2.1.(f) The Development of Microclimate Modification Patterns: Monocropping	331
HI.2.1.(g) Designs of (Changes in) Protection Measures Against Extreme Climate: Monocropping	335
III.2.2 Coping with Climate Variability and Climate Change	
III.2.2.(i) Improving the Issuing, Absorption and Use of Climate Forecast Information in Agricultural Production: Monocropping	341
III.2.2.(ii) The Sustainable Development and use of Agro-Ecosystems: Monocropping	347

xviii Contents

III.2.2.(iii) Detection and Awareness of Increasing Climate Variability and the Elevating Climate Risk: Monocropping	355
III.2.2.(iv) (Changes in) Adaptation Strategies to Climate Changes: Monocropping Kees Stigter	359
III.2.3. Coping with Extreme Meteorological Events	
III.2.3.(A) Problems and Solutions in Coping with Extreme Meteorological Events in Agricultural Production, and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in this Context: Monocropping	365
III.2.3.(B) Designing and Selecting Efficient Early Warning Strategies and Increasing Their Efficiencies in Monocropping	371
III.2.4 Tactical Decision Making Based on Weather Information	
III.2.4.(I) Problems and Solutions in Using of and Coping with Weather Phenomena in Need of Tactical Decision Making and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Viable Solutions in this Context: Monocropping	379
III.2.4.(II) Designing and Selecting Weather Related Tactical Applications for Agricultural Management and Increasing Their Efficiencies: Monocropping	385
III.2.5 Developing Risk Management Strategies	
III.2.5.(α) Defining, Managing and Coping with Weather and Climate Related Risks in Agriculture: Monocropping	393
III.2.5.(β) Developing Scales and Tools for Weather and Climate Related Risk Quantifications: Monocropping Kulasekaran Ramesh, Roger E. Rivero Vega, and Kees Stigter	397
range in range on, reper 21 rayore repair and recording to	

Contents xix

III.2.5.(γ) Improving Weather and Climate Related Risk Assessments in Agricultural Production: Monocropping	403
Kulasekaran Ramesh and Kees Stigter (with a Box contributed by Roger E. Rivero Vega)	
III.2.5.(8) Designing and Communicating Improvements in Farm Applications of Risk Information Products: Monocropping	409
III.2.5.(e) Improving Coping Strategies with Weather and Climate Risks in Agricultural Production, Including the Improved Use of Insurance Approaches: Monocropping	413
III.3 APPLIED AGROMETEOROLOGY OF MULTIPLE CROPPING	
III.3.1 Strategic Use of Climate Information	
III.3.1.(a) Combating Disasters: Multiple Cropping	419
HII.3.1.(b) Selection Processes of (Changes in) Land Use and Cropping Patterns: Multiple Cropping	423
III.3.1.(c) The Selection of Actual Preparedness Strategies for Dealing with Climate as Adopted in Multiple Cropping	429
III.3.1.(d) More Efficient Use of Agricultural Inputs as Part of Adoption of Preparedness Strategies: Multiple Cropping	435
III.3.1.(e) Selection of (Changes in) Livestock Management Patterns: Multiple Cropping	441
III.3.1.(f) The Development of Microclimate Modification Patterns: Multiple Cropping Kees Stigter	445

xx Contents

Climate: Multiple Cropping	449
III.3.2 Coping with Climate Variability and Climate Change	
III.3.2.(i) Improving the Issuing, Absorption and Use of Climate Forecast Information in Agricultural Production: Multiple Cropping Kees Stigter and Ajit Govind	455
III.3.2.(ii) The Sustainable Development and Use of Agro-Ecosystems:	
Multiple CroppingSue Walker, Emmanuel Ofori, Nicholas Kyei-Baffour, and Kees Stigter	461
III.3.2.(iii) Detection of and Awareness on Increasing Climate Variability and the Elevating Climate Risk: Multiple Cropping	467
III.3.2.(iv) (Changes in) Adaptation Strategies to Climate Changes: Multiple Cropping	471
III.3.3 Coping with Extreme Meteorological Events	
III.3.3.(A) Problems and Solutions in Coping with Extreme Meteorological Events in Agricultural Production, and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in This Context: Multiple Cropping Kees Stigter	477
III.3.3.(B) Designing and Selecting Early Warning Strategies and Increasing Their Efficiencies: Multiple Cropping	485
III.3.4 Tactical Decision Making Based on Weather Information	
III.3.4.(I) Problems and Solutions in Using of and Coping with Weather Phenomena in Need of Tactical Decision Making and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Viable Solutions in This Context: Multiple Cropping Sue Walker, Emmanuel Ofori, Nicholas Kyei-Baffour, and Kees Stigter	493

Contents xxi

III.3.4.(II) Designing and Selecting Weather Related Tactical Applications for Agricultural Management and Increasing Their Efficiencies: Multiple Cropping	499
Emmanuel Ofori, Nicholas Kyei-Baffour, and Kees Stigter (with two Boxes contributed by Kees Stigter)	
III.3.5 Developing Risk Management Strategies	
III.3.5.(α) Defining, Managing and Coping with Weather and Climate Related Risks in Agriculture: Multiple Cropping	509
III.3.5.(β) Developing Scales and Tools for Weather and Climate Related Risk Quantifications: Multiple Cropping	513
Sue Walker, Kees Stigter, and Kulasekaran Ramesh (with Boxes contributed by Kulasekaran Ramesh and Sue Walker)	J13
III.3.5.(y) Improving Weather and Climate Related Risk Assessments in Agricultural Production: Multiple Cropping	519
III.3.5.(8) Designing and Communicating Improvements in Farm Applications of Risk Information Products: Multiple Cropping	527
III.3.5.(e) Improving Coping Strategies with Weather and Climate Risks in Agricultural Production, Including the Improved Use of Insurance Approaches: Multiple Cropping	531
III.4 APPLIED FOREST (AGRO)METEOROLOGY	
III.4.1 Strategic Use of Climate Information	
III.4.1.(a) Combating Disasters in Forestry and Its Protection Functions . Dick Felch	537
III.4.1.(b) Selection Processes of (Changes in) Land Use and Afforestation Patterns	541
Ahmad Ainuddin Nuruddin (with a Box contributed by Kees Stigter)	J71

xxii Contents

III.4.1.(c) The Selection of Actual Preparedness Strategies for Dealing with Climate as Adopted in Forestry	547
III.4.1.(d) More Efficient Use of Forestry and Management Inputs Kulasekaran Ramesh and Kees Stigter (with a Box contributed by Kees Stigter)	553
III.4.1.(e) Selection of (Changes in) Livestock Management Patterns Related to Forests Kees Stigter	559
III.4.1.(f) Development of Microclimate Modification Patterns in Forestry Kees Stigter (with a Box contributed by Kulasekaran Ramesh and Kees Stigter)	563
III.4.1.(g) Designs of (Changes in) Protection Measures Against Extreme Climate in Forestry	567
III.4.2 Coping with Climate Variability and Climate Change	
III.4.2.(i) Improving the Issuing, Absorption and Use of Climate Forecast Information in Forestry	573
III.4.2.(ii) Sustainable Development and Use of Forest Ecosystems Al Riebau	579
III.4.2.(iii) Detection of and Awareness on Increasing Climate Variability and the Elevated Risk to Forestry	585
III.4.2.(iv) (Changes in) Adaptation Strategies to Climate Change in Forestry	589
III.4.3 Coping with Extreme Meteorological Events	
III.4.3.(A) Problems and Solutions in Coping with Extreme Meteorological Events in Forestry, and Challenges Remaining for	

Contents xxiii

the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in the Context of Forest (Agro) Meteorology Kees Stigter	595
III.4.3.(B) Designing and Selecting Efficient Early Warning Strategies and Increasing Their Efficiencies in Forestry Al Riebau	601
III.4.4 Tactical Decision Making Based on Weather Information	
III.4.4.(I) Problems and Solutions in Using of and Coping with Weather Phenomena in Need of Tactical Decision Making and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Viable Solutions in This Context: Forest (Agro)Meteorology	609
III.4.4.(II) Designing and Selecting Weather Related Tactical Applications for Forest Management and Increasing Their Efficiencies H.P. Das	615
III.4.5 Developing Risk Management Strategies	
III.4.5.(α) Defining, Managing and Coping with Weather and Climate Related Risks in Forestry	623
III.4.5.(β) Developing Scales and Tools for Weather and Climate Related Risk Quantifications in Forestry	629
III.4.5.(γ) Improving Weather and Climate Related Risk Assessments in Forestry	637
III.4.5.(δ) Designing and Communicating Improvements in Forestry Applications of Risk Information Products	643
III.4.5.(ε) Improving Coping Strategies with Weather and Climate Related Risks in Forestry Including the Improved Use of Insurance Approaches	647

xxiv Contents

III.5 APPLIED AGROMETEOROLOGY OF NON-FOREST TREES

111.5.1 Strategic Use of Climate Information	
III.5.1.(a) Combating Disasters by Using Agroforestry	653
III.5.1.(b) Selection Processes of (Changes in) Cropping Patterns Using Non-forest Trees. Luigi Mariani, Osvaldo Failla, and Kees Stigter	657
III.5.1.(c) Selection of Actual Preparedness Strategies for Dealing with Climate, as Adopted in Using Non-forest Trees	667
III.5.1.(d) More Efficient Use of Inputs in Cropping Systems Using Trees Kees Stigter	675
III.5.1.(e) Selection of (Changes in) Management Patterns in Agroforestry	681
III.5.1.(f) Development of Microclimate Modification Patterns in Agroforestry	685
III.5.1.(g) Designs of (Changes in) Protection Measures Against Extreme Climate in Agroforestry	689
III.5.2 Coping with Climate Variability and Climate Change	
III.5.2.(i) Improving the Issuing, Absorption and Use of Climate Forecast Information In Agroforestry	695
III.5.2.(ii) Sustainable Development and Use of Ecosystems with Non-forest Trees	701
III.5.2.(iii) Detection and Awareness of Increasing Climate Variability and the Elevating Climate Risk in Farming Systems with Non-Forest Trees H.P. Das and C.J. Stigter	707

Contents xxv

III.5.2.(iv) (Changes in) Adaptation Strategies to Climate Changes with Farming Systems Using Non-Forest Trees	711
III.5.3 Coping with Extreme Meteorological Events	
III.5.3.(A) Problems and Solutions in Coping with Extreme Meteorological Events in Agricultural Production, and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in This Context: Non-forest Trees Kees Stigter (with a Box contributed by E. Ofori and N. Kyei-Baffour)	717
III.5.3.(B) Designing and Selecting Efficient Early Warning Strategies and Increasing Their Efficiencies for Agroforestry Farming Systems Simone Orlandini and Francesca Natali	723
III.5.4 Tactical Decision Making Based on Weather Information	
III.5.4.(I) Problems and Solutions in Using of and Coping with Weather Phenomena in Need of Tactical Decision Making and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Viable Solutions in This Context: Non-forest Trees Luigi Mariani, Osvaldo Failla, and Kees Stigter (with a Box contributed by Kees Stigter)	733
III.5.4.(II) Designing and Selecting Weather Related Tactical Applications for Management of Agroforestry and Increasing Their Efficiencies	739
III.5.5 Developing Risk Management Strategies	
III.5.5.(α) Defining, Managing and Coping with Weather and Climate Related Risks in Agroforestry	747
III.5.5.(β) Developing Scales and Tools for Weather and Climate Related Risk Quantifications in Agroforestry	751
III.5.5.(y) Improving Weather and Climate Related Risk Assessments for Non-Forest Trees	757

xxvi Contents

III.5.5.(δ) Designing and Communicating Improvements in Farm Applications of Risk Information Products in Agroforestry	763
III.5.5.(e) Improving Coping Strategies with Weather and Climate Related Risks in Agroforestry Including the Improved Use of Insurance Approaches	767
III.6 APPLIED AGROMETEOROLOGY OF OTHER FORMS OF AGRICULTURAL PRODUCTION	
III.6.A Animal Husbandry	
III.6.A.(i) Problems and Solutions in Coping with Extreme Meteorological Events in Agricultural Production, and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in This Context: Animal Husbandry Kees Stigter	773
III.6.A.(ii) Selection of Actual Preparedness Strategies for Dealing with Climate, as Adopted in Animal Husbandry	779
III.6.A.(iii) Designing and Selecting Efficient Early Warning Strategies and Increasing Their Efficiencies for Animal Husbandry	785
III.6.A.(iv) More Efficient Use of Inputs in Animal Husbandry John Gaughan, Silvia Valtorta, and Nicola Lacetera	791
III.6.A.(v) Selection Processes of (Changes in) Animal Husbandry	797
Combined with	
III. 6.A.(vi) Combating Disasters in Animal Husbandry	797
III.6.A.(vii) Development of Microclimate Modification Patterns in Animal Husbandry	803
III.6.A.(viii) Improving the Issuing, Absorption and Use of Climate Forecast Information in Animal Husbandry John Gaughan and Hesham Khalifa	807

Contents xxvii

III.6.B Cropping Under Cove	III.6.B	Cropp	ing	Under	Cover
-----------------------------	---------	-------	-----	-------	-------

Meteorological Events in Agricultural Production, and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in This Context: Cropping Under Cover	R15
Kees Stigter	015
III.6.B.(ii) Combating Disasters in Covered Cropping Systems Zheng Dawei and Kees Stigter (with a Box contributed by Zheng Dawei)	821
III.6.B.(iii) Covering Crops to Improve Growth: Some Essential Experience Kees Stigter (mainly choosing and editing material collected by Ernst Van	825
Heurn and Kees Van der Post)	
III.6.B.(iv) Selection Processes of (Changes in) Covered Cropping Patterns	829
III.6.C Other Aspects: Fisheries and Aquaculture, Urban Agricult Precision Farming	ure,
III.6.C.(i) Problems and Solutions in Coping with Extreme Meteorological Events in Fisheries and Aquacultute, and Challenges Remaining for the Use of Science to Contribute to Problem Analyses and Designing Valuable Solutions in This Context of Fisheries	
and Aquaculture	837
III.6.C.(ii) Agrometeorology and Urban Agriculture	843
III.6.C.(iii) "Paleez Khoursheed": Agrometeorology for Precision Farming in Iran	849
PART IV METHODS AS TOOLS AND APPROACHES SUCCESSFULLY USED IN APPLICATIONS LEADING TO AGROMETEOROLOGICAL SERVICES	
IV.1 Introduction to Part IV	857

xxviii Contents

IV.2 Ethics and Policies	869
IV.3 A Basic View on Models of Nature and the Concept of "Sustainability"	877
IV.4 Expert Systems	885
IV.5 Education, Training and Extension	893
IV.6 Meteorological Data to Support Farming Needs	901
IV.7 Agricultural Physics	909
IV.8 Agricultural Chemistry in Agrometeorology: Relations with Groundwater Contamination	919
IV.9 Field Quantification	929
IV.10 Statistics and Agrometeorology: Introductory Issues and Cases Roger Stern	939
IV.11 Agrometeorological Statistics: More Introductory Issues and Cases	949
IV.12 Climate Prediction and Weather Forecasting	959
IV.13 Examples of Agrometeorological Decision Support Developed and Used in South America	965
IV.14 Global Potentials for Greenhouse Gas Mitigation in Agriculture Julian Dumanski, Raymond L. Desjardins, Rattan Lal, Pedro Luiz De Freitas, Pierre Gerber, Henning Steinfeld, Louis Verchot, Gerald E. Schuman, Justin D. Derner, and Mark Rosegrant (with a Box contributed by R. Lal)	977

Contents xxix

IV.15 Strategies and Economies for Greenhouse Gas Mitigation	
in Agriculture Julian Dumanski, Raymond L. Desjardins, Rattan Lal, Pedro Luiz De Freitas, Pierre Gerber, Henning Steinfeld, Louis Verchot, Gerald E. Schuman, Justin D. Derner, and Mark Rosegrant (Box by all)	983
IV.16 Supporting Evidence for Greenhouse Gas Mitigation in Agriculture	989
IV.17 Modeling and Simulation	997
IV.18 Monitoring and Early Warning	005
IV.19 Remote Sensing	013
IV.20 Geoinformatics for Evaluating Erosive Rainfall Hazards in Uplands Crops: Preliminary Decision Making	.025
Index1	033