## Contents

Edi	itors	xiii
Lis	st of Contributors	xv
Soi	ils and Food Security: Challenges and Opportunities	1
Pe	ter J. Gregory	
Ab	ostract	1
1	The Role of Soils in Food Security	2
2	Key Soil Constraints to Crop and Fodder Production	4
	2.1 Soil pH	5
	2.2 Saline and Sodic Soils	6
	2.3 Soil Strength and Structure	8
3	Contributions to Recent Increases in Crop Production	10
4	Opportunities for Sustainable Increases of Yield	13
	4.1 Improved Efficiency of Resource Use	16
	4.1.1 Nutrients	16
	4.1.2 Water	18
	4.1.3 Nutrient-Water Interactions	20
	4.2 Improved Tillage	21
	4.3 Improving Root Systems	22
5	Concluding Remarks	24
Re	ferences	25
Glo	obal Soils: Preserving the Capacity for Food Production	31
Lu	ca Montanarella	
Ab	estract	31
1	Introduction	32

Issues in Environmental Science and Technology No. 35
Soils and Food Security
Edited by R.E. Hester and R.M. Harrison
© The Royal Society of Chemistry 2012
Published by the Royal Society of Chemistry, www.rsc.org

vii

• • •	C 44
V111	Contents

2	Glo	bal Dist	tribution of Soil Resources versus Food	
	Proc	duction		33
3	Towards Global Governance of Soil Resources			
4	Towards Zero Net Soil Degradation			38
5	Con	clusion	S	39
Re	feren	ces		39
So	il Nat	ural Ca	pital and Ecosystem Service Delivery in a World of Global	
So	il Cha	nge		41
			son, Bridget A. Emmett, Brian Reynolds, Ed C. Rowe, Dave	
Sp	urgeo	n, Aidai	n M. Keith, Inma Lebron and Neal Hockley	
At	strac	t		41
1	Ove	rview o	of Soil Ecosystem Services	42
	1.1		re's Services	42
	1.2	Review	w of the Ecosystems Approach	43
		1.2.1	Ecosystem Goods and Services	44
		1.2.2	Natural Capital	46
	1.3	Soil N	Natural Capital and Ecosystem Services	46
	1.4	Stock-	-and-flow Ecosystem Service Framework for Soils	48
2	Driv	ers of	Global Soil Change	49
	2.1	Direct	t Drivers of Soil Change	50
		2.1.1	Physical and Biogeochemical Soil Change as a Result of	
			Food Production	50
		2.1.2	Artificial Soil Sealing by Man-made Infrastructure	53
	2.2	Indire	ect Drivers of Soil Change	53
		2.2.1	Changes in the Atmosphere	53
		2.2.2	Changes in the Hydrosphere	54
		2.2.3	Changes to the Lithosphere	54
			Changes to the Biosphere	54
	2.3		oing Global Soil Change	55
3			oil Change, the Countryside Survey of Great Britain	56
	3.1	Carbo	on	57
	3.2	pН		57
		Nitro		59
		Metal		60
	3.5	Biodiv		61
4			s to Ecosystem Service Valuation	63
	Acknowledgements			63
Re	References			64

Contents	ix
Contents	13.

	Eval	uation and Reporting of Soils in Sustainable Agriculture and Food	69
-		Hartemink, Amanda L. Raster and Molly M. Jahn	0)
Abs	tract		69
1	Intro	oduction	70
2	Mea	surement Tools	72
	2.1	Field to Market Initiative for Sustainable Agriculture	72
	2.2	Stewardship Index for Specialty Crops	73
	2.3	Cool Farm Tool	73
3	Susta	ainability Schemes in the USA	74
	3.1	California Almond Board Sustainability Program	74
	3.2	Council on Sustainable Biomass Production Draft Provisional	
		Standard for Sustainable Production of Agricultural Biomass	75
	3.3	Demeter Biodynamic Farm Standard	76
	3.4	Food Alliance Whole Farm/Ranch Inspection Tool	76
	3.5	Wisconsin Vegetable Sustainability Standards/Healthy Farms	
		Whole Farm Self-Assessment	77
	3.6	Lodi Rules for Sustainable Winegrowing	77
	3.7	USDA National Organic Program	78
	3.8	Central Coast Vineyard Sustainability in Practice Certification	
		Program	78
4	Glob	pal Sustainability Schemes	79
	4.1	Basel Criteria for Responsible Soy Production	79
	4.2	Better Cotton Initiative	81
	4.3	European Integrated Farming Framework	81
	4.4	European Union Organic Production and Labelling of Organic	
		Products	82
	4.5	Generic Fairtrade Standards for Small Producers'	
		Organisations	82
	4.6	GlobalG.A.P. Standards	83
	4.7	IFOAM Norms for Organic Production and Processing	83
	4.8	LEAF Marque Global Standard	84
	4.9	RTRS Standard for Responsible Soy Production	85
	4.10		
		Production	85
	4.11	RSPO Principles and Criteria for Sustainable Palm Oil	
		Production	86
	4.12	SAN Sustainable Agriculture Standard	86
5	Disc	ussion and Conclusions	88
Ref	erenc	es	90

x Contents

	obiodiversity and Potential Use for Enhancing Soil Health in Tropica s of Africa	ıl 94
	drick O. Ayuke, Nancy K. Karanja, Julius J. Okello, Peter M. Wachira ald K. Mutua, David K. Lelei and Charles K. K. Gachene	!,
UEI	ulu K. Muluu, Duviu K. Letel ulu Charles K. K. Guehene	
Ab	stract	94
1	Introduction	95
2	Description of Soils in Sub-Saharan Africa	95
3	Land Degradation in Cropping Systems	97
4	Soil Biology: Role of Soil Biodiversity and Functions (Ecosystem	
	Services)	106
5	Case Studies: Effect of Management and/or Land Use Intensification	n 108
	5.1 Soil Carbon as Fuel for Soil Organisms	108
	5.2 Soil Macrofauna in Tropical Agroecosystems	110
	5.3 Mesofauna	112
	5.4 Beneficial Microorganisms: Soil Fertility Promoters, Plant	
	Growth Regulators and Biocontrols	113
	5.4.1 Legume Nodulating Rhizobia (LNB)	113
	5.4.2 Arbuscular Mycorrhizal Fungi (AMF)	114
	5.4.3 Plant Growth Promoting Rhizobacteria (PGPR)	116
	5.4.4 Trichoderma	116
	5.4.5 Bacillus subtilis	117
	5.4.6 Nematode-destroying Fungi	119
	5.5 Farming Systems and Soil-borne Pests and Diseases	121
6	Mitigation of Soil Degradation through Integrated Soil	
	Fertility Management (ISFM) Approaches: Sustainable Soil-	
	management Practices/Systems	123
7	Biodiversity of Tropical Soils: Socioeconomic,	
	Institutional and Policy Issues	123
	7.1 Approaches to Soil Conservation: A Historical Perspective	124
	7.2 Drivers of Farmers' Use of Sustainable Soil Conservation	
	Practices	126
8	Synthesis	126
Re	erences	127
_		_
	ganic Matter Availability and Management in the Context of Integrate	
	Fertility Management in sub-Saharan Africa	135
В.	Vanlauwe	
	stract	135
1	Introduction	136
2	Organic Matter in Relation to Paradigm Shifts in	
•	Tropical Soil Fertility Management	137
3	Availability and Quality of Organic Resources in	
	African Farming Systems	141

xi

	3.1	The C	Organic Resource Quality Concept	141
	3.2		ability and Production of Organic Resources in African	
			ing Systems	142
4	Orga	anic Ma	atter Production and Use in the Context of	
	ISF			144
	4.1	Organ	ic Matter Production through ISFM	145
	4.2		ctions between Organic Matter and Fertiliser	145
	4.3		nic Matter and Local Adaptation	148
	4.4		nic Matter and Rehabilitation of	
		_	responsive Soils	151
5	Soil		ic Matter Status and Quality as Affected by	
	ISF		, , , , , , , , , , , , , , , , , , , ,	152
6	Con	clusion	S	154
Ac	know	ledgme	nts	155
	ferenc			155
<b>~</b> 1.		<b>CI</b>		4.50
		_	and Forest Dynamics: A Soils Perspective	158
we	nay F	reterma	n and Dominique Bachelet	
Αh	stract			158
1		oductio	n	159
2			rends in Climate Change	160
_			al Climate Trends	160
3			Forest Dynamics	161
_	3.1	_	luction	161
	5.1		Tropical Peat Swamp Forests	162
			Tropical Rainforests	163
		3.1.2	Temperate Forests	164
			Alpine Forests	166
	3.2		ologic Responses	166
	3.3		on Responses	167
	3.4		gen Responses	168
4			rity Implications of Forest and Soil	100
•			to Global Change	170
	4.1		opogenic Soil Degradation	170
	7.1		Mechanisms of Soil Degradation	171
		4.1.2		
		7.1.2	Nitrogen	171
		413	Repairing Soil Degradation	172
			The Agroforestry Alternative	172
5	Soil	Charac	eteristics as Tools for Adaptive Management	172
	deferences			173

••	Content
X11	Content

	nt Nutrients vid A. C. Manning	183
Ab	stract	183
1	Introduction	184
	1.1 Geological Sources of Plant Nutrients	184
	1.2 Minerals in Plants	185
2	Availability of P and K Fertilisers: Supply, Demand and Price	187
3	Nutrient Audits and Fertiliser Use Statistics – Evidence	
	of Need	190
4	Projections of Need to Support a Growing World	
	Population	191
5	Mineral Dissolution Rates in the Soil System	192
6	Possible Alternatives to Conventional Fertiliser	
	Products	194
7	Conclusions	196
Re	ferences	196
	Il Physical Degradation: Threats and Opportunities to Food Security ul D. Hallett, Kenneth W. Loades and Julia Krümmelbein	198
Δh	stract	198
1	Introduction	199
2	Forms and Extent of Soil Physical Degradation	201
2	2.1 Soil Compaction	201
	2.1.1 Extent of Compaction	203
	2.2 Soil Erosion	205
	2.2.1 Extent of Erosion	206
		207
	2.3 Seedbed Instability	207
2	2.3.1 Extent of Seedbed Damage Measuring Soil Physical Constraints	208
3		211
4	Soil Physical Restoration and Food Security 4.1 Soil Cultivation	211
		212
		212
	4.1.2 Shift to Lower Input Systems	212
	4.2 Biological Tillage	
	<ul><li>4.3 Vegetation and Root Reinforcement</li><li>4.4 New Technologies</li></ul>	214
		215
_		216
5	Case Study 1 – Soil Restoration in the Loess Plateau, China	217
6	Case Study 2 – Recultivated Mine Soils, Eastern	010
7	Germany (Lusatia)	218
7	Conclusions	220
Ke	ferences	221

227

**Subject Index**