

TECHNOLOGY AND GLOBAL CHANGE

Arnulf Grübler

Contents

A	cknowledgments	ix
1	Introduction	1
	1.1. Purpose	1
	1.2. Approach	2
	1.3. Structural Overview	7
P	ART I: WHAT IS TECHNOLOGY?	17
2	Technology: Concepts and Definitions	19
	2.1. From Artifacts to Megamachines	20
	2.2. Technological Change	38
	2.3. Sources of Technological Change	75
3		91
	3.1. Models of Technological Change	91
4		117
	4.1. A Long View of Technology Development: The Last 200 Years	117
	Some Suggestions for Further Reading on Part I	127
P	ART II: TECHNOLOGY AND THE ENVIRONMENT:	
- 000	ATURAL AND HUMAN	129
5	Agriculture	131
	5.1. Introduction	132
	5.2. Technology, Agricultural Land, and People	133
	5.3. Three Clusters of Change in Agricultural Technologies	134
	5.4. Impacts I: Productivity	154
	5.5. Impacts II: Land-Use Changes	161
	5.6. Impacts III: Other Global Changes	170
	5.7. Global Changes in Human Occupations and Residence	181
	5.8. Environmental Problems of Urbanization	186

6 Industry	
6.1. Introduction	195
6.2. Industrialization: Output and Productivity Growth	196
6.3. Clusters	196
6.4. Socioeconomic Impacts of Industrialization	204
6.5. Environmental Impacts of Industrialization	223
6.6. Industrial Metabolism and D	227
6.6. Industrial Metabolism and Dematerialization Strategies 6.7. Energy	229
Zacigy	248
7 Services	
7.1. Introduction: From Work to Pleasure	291
7.2. Measurement: Time Budgets and Consumer Expenditures	291
7.3. Lifestyles, Services, and the Environment	293
7.4. Mobility: Growing Demands and Emissions	312
7.5. Transport and the Environment	316
por one internationment	330
Some Suggestions for Further Reading on Part II	BATT DE
reduing on Part 11	337
PART III: THE BALANCE OF EVIDENCE 8 Conclusion 8.1. The "Paradox" of Technology and the Environment 8.2. Technology, Productivity, and the Environment 8.3. Patterns and Rates of Change	339 341 341 345 352
8.4. Open Issues in Addressing the Technology-Environment	302
1 aradux	355
8.5. A Manifesto	364
9 Postscript: From Date M. 111	15/8/5
9 Postscript: From Data Muddles to Models 9.1. Introduction	367
	367
+connoiogical Change	374
0.4 Ferring	381
9.5. Next Steps	389
9.6. Summary	392
5.0. Summary	392
10 Appendix	395
References	and the second
	409
Index	
	441