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To Helen and Jerome.

Foreword

I think you should always bear in mind that entropy is not on your side.—Elon Musk

This quote is true for all of us. Every person, no matter how diligent or gifted, is doomed to experience a total failure of body processes. No system can be sustained forever. Systems fail, empires fall, and even the universe will succumb to total heat death. Sometimes, we expedite this process ourselves. Human intervention has rapidly deteriorated the sustainability of the environment.

However, there are some who resist.

Adenike Akinsemolu joins the ranks of men and women who fight for environmental sustainability, while others accept the diminishing state of the world. As a person active in promoting and investigating sustainability in my community and the world, who has spent decades focusing on sustainability in the field of energy and engineering, I recognize Akinsemolu's diligence and see its reflection in this work. She understands that the unprecedented and rampant growth in population during the past century presents daunting challenges—but also sees the opportunity in mass cooperation in efforts to move towards sustainability. The work is both informative in its content, a reminder of our relationship to the environment, and a call to action. However, there is still confusion about issues of sustainability and green living despite its importance. That is where this text comes in.

In the book, *The Principles of Green and Sustainability Science*, Akinsemolu provides a comprehensive and step-by-step guide to understanding sustainability. Beginning with the concept of Going Green, the text explores far-reaching implications in the fields of computer science, engineering, physics, and more. The book offers empirical evidence and examines best practices to create a holistic approach to more harmonious living. This understanding of sustainability in the totality of its reach can allow nations and individuals to set, and hopefully to achieve, more appropriate sustainability goals.

Today, we are far from meeting the 17 Sustainable Development Goals[1] (SDGs) set by the United Nations Development Programme (UNDP). Ironically, Akinsemolu first highlights the 17th goal: the need for partnership in turning these goals into our greatest accomplishments. Although some think of humanity as owning the planet, much of humankind has long viewed itself as stewards of the Earth. Yet, we have damaged the ozone layer, destroyed forests, littered the marine world, and threatened the animal kingdom. This text illuminates the path towards repairing this relationship with our environment by working together towards a more sustainable future. Akinsemolu takes an aspirational approach and reminds us that anyone can join the effort.

The book offers immediate actions that the individual can take. Akinsemolu adopts a practical approach which examines how everyday activities affect climate, ecosystems, and more. As such, the book presents both a top-down methodology and a grassroots vision. While covering broad topics, the text offers practices for readers to put into action in their everyday lives. It is an invitation to explore the mindset of sustainability and take action. A consistent source of inspiration and illustration throughout the text is the use of examples of sustainability contributions. Each chapter highlights a prime example of a single person's ability to bring about a greater balance with the environment.

This text is not a stand-alone effort. It is born within a culture of progress towards sustainability. The book enriches a global movement while highlighting efforts in Africa. Africa has seen examples of substantial initiatives towards sustainability and Green living. One such example is the Green Institute in Nigeria, which aims to "build the next generation of sustainability innovators through education, advocacy, and social entrepreneurship." This type of education will prove vital to global sustainability. Indeed, a 2016 Forbes report by Amy Jadesimi stated that Nigeria "lies on the cusp of greatness" as the country has an abundance of resources and an economy which has grown annually. One way this is becoming a reality is through education that challenges traditional forms of education, which at times have thwarted the progress of humanity. This text carries the same spirit of presenting an updated conversation on the topic of sustainability.

Akinsemolu views sustainability as progress. The benefits are manifold when social, economic, and environmental equilibrium is found. Applying sound principles of sustainability science is needed to avoid damaging Earth, our home, and the life and civilization on it. With this in mind, it is my hope that this text becomes a standard choice for inclusion in the education of readers globally on the challenges and threats to sustainability and the best practices to protect the environment and promote a balanced ecosystem.

The material and educational approach in this book are past due. At this stage, we must live in a more green and sustainable manner if we are to thrive. We must

[1] https://www.undp.org/content/dam/undp/library/corporate/brochure/SDGs_Booklet_Web_En.pdf.

change if we are to flourish. For Akinsemolu, sustainability is more than delaying the inevitable—it is the promise of a future.

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March 9, 2020

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Preface

"**What does it mean to go Green?**" I asked this question to my students in Nigeria. The response was silence and a sea of blank faces. I waited patiently, but not a single hand was raised. Not one student in the group of 250 bright minds was confident enough to talk about the most urgent issue facing our planet and species. I decided that the time for patience was over; I started working on this text which aims to inspire a green movement in the hearts and minds of readers of all ages.

The core purpose of this book is to use the breakthroughs in sustainability science to address the problems afflicting the environment and present measures for improving economies, societies, and human behavior by applying this emerging science through best practices. This book is both informative and prescriptive in its approach to sustainability, a combination missing in previous publications.

Sustainability in science leads to proactive measures geared towards the adoption of knowledge, skills, activities, and attributes necessary for using the existing resources in a way that does not compromise the ability of future generations to meet their own needs. There have been monumental sustainability texts produced prior to the publication of this book and I applaud their contributions. However, sustainability science is unique in its scope and accessibility. It acts as an introductory book for the average reader but can still be used as a condensed knowledge base for the more advanced. It is not just an academic text but a call to action for nations and individuals. It is an easy read filled with hard truths. It provides the basic know-how of sustainability science needed for the reader to start contributing today.

Everyday anthropogenic activities are responsible for the problems of our planet and there is a need to salvage the situation through creativity, innovation, and critical thinking. Now more than ever, there is great potential for sustainability science's incorporation into programs, policies, and cultural norms because of the common consensus on the need to develop proactive measures to protect and preserve the planet's finite resources. This level of common consensus is itself uncommon, and we must not squander this potential. To help accomplish these goals, this book is adapted to present the proposed ideas by using empirical evidence as the basis for achieving sustainability. This is a results-based approach which takes an honest look at unemployment, health, disease, unsustainable production, waste manage-

ment, environmental ethics, and harmful anthropogenic activities. Whereas past literature has mainly examined sustainability as a purely environmental issue, the proposed book expands this conversation into other fields, including mathematics, biology, agriculture, computer science, engineering, and physics. By examining the application of sustainability in all areas of study, it illuminates the path to sustainability as defined by the World Commission on Environment Development in its Our Common Future report. The plethora of information this text offers combines intrigue with practicality and intellect with wisdom.

The text is also authoritative as it moves through each chapter, citing case studies of individuals with notable contributions to sustainability efforts. The achievements in sustainability from the likes of Ken Saro-Wiwa, Wangari Maathai, Jeffrey Sachs, and Elon Musk add an inspirational weight to the text as the reader learns the core concepts of sustainability. Finally, using examples from Africa and the Middle East adds a sense of grounding to the issue. These real-world examples of sustainability efforts show how the applications can lead to real progress and have dire consequences if ignored.

I invite you to view this book as a personal invitation to join the conversation on sustainability and actively engage in saving our planet for all its residents, present and future.

Ondo State, Nigeria Adenike A. Akinsemolu
November 15, 2019

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> None of us, including me, ever do great things. But we can all do small things, with great love, and together we can do something wonderful—Mother Teresa

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Special thanks to my amazing students whose class contributions and ideas served as the seeds that sprouted into this book. I appreciate your support, and I commit this book to the ambition I see in you.

Finally, I would like to thank the Supreme Being for life, strength, and provision to come this far.

The commitment to this book echoes Africa's commitment to sustainability; individual humans might be strong-willed but are ultimately insufficient in the face of goals of such enormity. We must turn to our fellow humans, and, together, a collection of individuals is capable of anything. We are human, and that is our legacy.

"*Dum inter homines sumus, colamus humanitatem.*"

Contents

Acronyms

3Rs	Reduce, reuse, recycle
AAR	African Air Rescue
AI	Artificial intelligence
AIDS	Acquired immune deficiency syndrome
ASAL	Arid and semi-arid land
ATP	Adenosine triphosphate
AU	African Union
BMW	Bayerische Motoren Werke
CEO	Chief executive officer
CGG	Commission on Global Governance
CH_4	Methane
CNN	Cable News Network
CO_2	Carbon dioxide
COD	Chemical oxygen demand
CSR	Corporate social responsibility
DAF	Dissolved air flotation
DC	Direct current
DCM	Direct current motor
DDT	Dichlorodiphenyltrichloroethane
DNA	Deoxyribonucleic acid
EIA	Environmental impact assessment
ELWA	Eternal Love Winning Africa
EMR	Electromagnetic radiation
EPA	Environmental Protection Agency
ERA	Environmental risk assessment
EU	European Union
FCEVs	Fuel cell electric vehicles
FCX	Fuel Cell eXperiment
FEPA	Federal Environment Protection Agency
FORNEWA	The Rwanda Green Fund
GBM	Green Belt Movement

GDP	Gross domestic product
GE	General Electric
GGE	Green growth and economy
GHSs	Greenhouse gases
GMOs	Genetically modified organisms
HEP	Hydroelectric power
HIV	Human immunodeficiency virus
IBM	International Business Machines
IEEE	Institute of Electrical and Electronics Engineers
IFPRI	International Food Policy Research Institute
IKEA	Ingvar Kamprad Elmtaryd Agunnaryd
Inc.	Incorporated
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared ray
ISO	International Organization for Standardization
ITS	Intelligent transportation system
IUCN	International Union for Conservation of Nature
LDCs	Least developed countries
LED	Light-emitting diode
MCED	Ministerial Conference on Environment and Development
MDG	Millennium Development Goal
MEA	Millennium Ecosystem Assessment
MENA	Middle East and North Africa
MFC	Microbial fuel cell
MOSOP	Movement for the Survival of the Ogoni People
MSF	Medecins Sans Frontieres
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCDs	Non-communicable diseases
NESREA	National Environmental Standards and Regulations Enforcement Agency
NGO	Non-government organization
NIDA	National Institute of Drug Abuse
NIST	National Institute of Standards and Technology
NPP	Nobel Peace Prize
OSHA	Occupational Safety and Health Administration
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PAHs	Polycyclic aromatic hydrocarbons
PDA	Personal digital assistant
PP	Precautionary principle
PPE	Personal protective equipment
PPP	Polluter Pays Principle
PV cells	Photovoltaic cells

RNA	Ribonucleic acid
SBSP	Space-based solar power
SDGs	Sustainable Development Goals
SMEs	Small and medium-sized enterprises
TED	Technology, Entertainment, Design
UK	United Kingdom
UPMC	University of Pittsburgh Medical Center
UN	United Nations
UNDP	United Nations Development Programme
UPP	User-pays principle
US	United States
USD	United States Dollars
US EPA	United States Environmental Protection Agency
UV	Ultraviolet radiation
WEMA	Water Efficient Maize for Africa
WHO	World Health Organization
WWF	World Wide Fund

Part I
Introductory Context and Principles of Green

Chapter 1
The Principles of Green

Abstract Going Green has increasingly become a global trend recently because of its potential benefits to the society, environment, economy, and future of life. Using case studies, theories, and various intertwined principles, Chap. 1 demonstrates the way Going Green entails embracing five fundamental principles which are important for making sure that we embrace sustainable lifestyles. Apart from the five principles, the chapter describes the various critical ways of going green at the individual, organizational as well as national level. The case studies of the Maasai in East Africa and Fulani in West Africa are used for bringing out the concept of the Tragedy of the Commons. In addition to the case studies, the first chapter also critically discusses the benefits related to going green, with the major pros identified being cost, environment, reputation, improved health, sustainable development, invention, and innovation. A notable contribution to the green initiative in this chapter is Wangari Maathai's Green Belt Movement. Also, future trends are identified to predict the future of going green.

Keywords Going green · Tragedy of commons · Termite architecture · Wangari Maathai · Conservation of resources

1.1 What Does It Mean to Go Green?

With the world facing a crisis due to scarce resources, there have been numerous attempts to ensure people use resources in a sustainable way. Conceptually, resources in this context refer to materials, energy, or other assets that can be used for benefiting society. This has led to the increased use of the term "Going Green," commonly defined as the adoption of environmentally friendly lifestyles through activities such as recycling, purchasing, reuse, reducing or minimizing, driving, and others. In project management, "Going Green" includes designing projects that meet environmental standards. The two definitions above suggest that Going Green involves engaging in activities that sustainably use resources. However, these definitions are determined by the specific activity. A more comprehensive definition of the term is "pursuing practices and knowledge that can result in ecologically

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responsible and environmentally-friendly lifestyles and decisions, which can be beneficial for protecting the environment and sustaining natural resources for both the current as well as future generations."

Going Green emphasizes the need for countries and corporations to consider sustainable development in their activities. Sustainable development is defined as development that caters to the "needs of current generations without compromising the ability of future generations to meet their own needs" (Gardner and Abraham 2010). Through efficient production and deployment of Green technologies, organizations can reduce their carbon emissions and promote the protection of the ozone layer. They can also emit less hazardous waste through the 3Rs (reduce, reuse, and recycle), thus ensuring that the ecosystem continues providing its services efficiently. From an individual perspective, Going Green could be beneficial for encouraging people to develop positive ideas and use alternative resources (Cock 1991). This is crucial for avoiding the aspect of Tragedy of the Commons. Conceptually, this describes a situation where individual users of a resource act independently out of self-interest. This behavior contradicts that of common good users since it depletes and spoils that resource. Examples of Tragedy of the Commons are mining in South Africa and overgrazing among the Maasai of Kenya.

Going Green involves more than recycling alone and extends to living life in a way that is respectful and sustainable for the natural environment and the planet. It implies contributing positively towards the maintenance of the natural ecological balance as well as the preservation of the earth and its natural resources. It entails taking steps to reduce the harm ones does to the environment. This includes the carbon footprints that we leave behind because of living on this planet. Green also means (1) *Growth*, (2) *Renewable*, (3) *Efficient*, (4) *Economically Sustainable*, and (5) *Natural*. From these definitions and descriptions, Going Green involves the adoption of five fundamental principles in one's daily life to protect the environment and ensure sustainability: *Reduction of pollution, conservation of resources, conservation of energy, reduction of waste,* and *protection of the ecological balance of the Earth*. Consequently, it is crucial for us to adopt Green practices using these principles in order to make a difference. The five principles are further explained to enhance our understanding.

What steps have you taken in your life that can qualify as part of the "Going Green" initiative?

According to the first principle, Going Green means reducing pollution. Conceptually, pollution is the release of contaminants or toxic substances into the environment. Think about the cleaning detergent, soap, or shampoo that you like to use. Many of these products have chemicals that are washed down sinks and travel into rivers and the water table. Along these lines, think about the fast food lunch you consumed. During the production process of bread, burgers, salad, or pizza, there is the release of human-made fertilizers into the natural environment.

The wrappers that we use for packaging meals are disposed of in incinerators and landfills because they are difficult to be recycled. When the wrappers are burnt or buried, they release harmful gases and other wastes.

What are some of the wrappers that you use for packaging meals? List four effects of these wrappers on the ecosystem.

In addition, think about the car that you drive or the bus that you board while going to work. They emit greenhouse gases (GHG) that contribute to global warming and release toxic substances, including lead, into the atmosphere (Ashuri and Durmus-Pedini 2010). We have only scratched the surface with the forms of pollution produced by industries during the manufacturing of items we use daily.

In life today, it is difficult to leave no carbon footprint of toxic substances or have zero pollution. Consequently, we should understand that many of the things that we utilize every day create some form of a chemical by-product that could contribute to pollution. Going Green implies that we should do something about these activities. There are various things that people can do to minimize the effect of our activities on the planet. We should consider using more natural cleaners as well as personal products, including natural detergents and organic shampoos. These are made from natural substances, are biodegradable,, and impose minimal harm when produced or released into the environment (Eyraud et al. 2011). To support the Green initiatives, you could consider switching to organically grown food. This is the food that is produced without using synthetic fertilizers and pesticides that cause harm to the environment. Other suggestions that can reduce pollution include driving less, carpooling, using eco-friendly vehicles, and adopting Green driving practices.

Identify some organically grown food that you know.

The second principle suggests that Going Green entails conserving resources. While there are limited resources on the planet, our expanding human population is used to modern conveniences from technological advancements that increase the quantity of globally available goods. Therefore, many of us increase our consumption of goods that are eventually discarded as well as the natural resources used in manufacturing. This is an obvious problem in developing nations.

List some of the eco-friendly products that you use every week.

Deforestation, high energy use, over-mining, and intensive farming contribute to the depletion of our natural resources. Certain flora and fauna are becoming