Earth Stewardship Science in Africa - with everyone a stakeholder

Maarten J.de Wit
Nelson Mandela Metropolitan University
Colonization of Nature

Since the beginning of the 19th Century, by its own growing activities, Mankind opened a new geological era: the Anthropocene.

We are clearly affecting climate and can deliberately do so.
4. Humans

Ca. 5 thousand individuals living in South Africa

Colonisation of Africa (ca 100,000 yrs.)

Saturation population throughout Africa

Colonisation of rest of World (ca 30,000 yrs.)

Saturation population throughout World

Agricultural revolution

Invention of writing

Growth of cities

Domestication

Invention of printing press

0.6 billion

Out of Africa

Into Africa

11 billion

1 billion

1.6 billion

6 billion

Scientific revolution

Medical revolution

Industrial revolution

Communication revolution

Human population

Years A.D.

140,000

1454

1800

2000

2100

1 Indiv.

140,000 Years B.P.

Eve

100,000

50,000

5 million

500 million

1 billion

Heavy extinction; industrial civilization, habitat destruction

Heavy extinction; agriculture revolution & civilization, mega-fauna decimated

Moderate – heavy extinction; hunter-gatherers colonising alien territory

Minimal extinction; hunter-gatherers in balance with ecosystem
Looking Back on the Limits of Growth

Forty years after the release of the ground-breaking study, were the concerns about overpopulation and the environment correct?

By Mark Strauss

Smithsonian magazine, April 2012

Turner compared real-world data from 1970 to 2000 with the business-as-usual scenario. He found the predictions nearly matched the facts. “There is a very clear warning bell being rung here,” he says. “We are not on a sustainable trajectory.”

Report for the Club of Rome's Project on the Predicament of Mankind.

Organic farming
It takes 20,000 litres of water to grow 1 kilo of coffee, 11,000 litres of water to make a quarter pounder, and 5000 litres of water to make 1 kilo of cheese.

No wonder the Earth is running dry...
Destruction.
Health

Tensions in societies - mental health

• How do we define it?
• How do they define it
• Japan, Eritrea, Jamaica
Humanity utilises most of Earth’s natural oil in a 100-year peak; Hubert’s Peak

The 100-year period when most of the world’s oil will be produced is known as “Hubbert’s peak.” On this scale, the geologic time needed to form the oil resources can be visualized by extending the line five miles to the left.
What is the forecast....?
Human development index and electricity consumption

Where will our energy come from?
How will this all work out?

- Oil price
- Climate change events
- CCS development
- UCG development
- Renewables cost reduction
- Carbon pricing
- New breakthrough technologies
- Water availability
- Energy efficiency success
- Public acceptance of nuclear
- Shale gas developments
- Geothermal energy

....
We have Mortgaged the future

• Explosion of debt
• Intergenerational debt
• Next generation less well off?
• Cost of education and health
• Borne bankrupt
• What will we do we do for the next ½ century?
Complex systems

• How do things emerge?
• How does collaboration emerge?
• How does inequality emerge?
• How do things fall apart — dissipate?
By the end of this century, the human population is likely to be over ten billion. Just twenty five years ago, it was less than five billion. How are the choices we’re making as a species impacting upon our environment? And how will the sheer force of numbers affect the way we live and interact in the future?
Living systems and the changing Earth

The Changing Earth

- Global processes
  - monitor, quantify & predict
- Geodynamics
- Climate variability
  - understand the impact
- Natural disasters
  - reduce the risk
- GeoEngineering
  - develop the habitat
- Future of Mankind

„How to manage a habitable planet“
Plan A

We can fix it

Geo-Engineer Climate Change

Fertilize the oceans with Iron to decrease CO2
Plan B

Geo-Engineer Climate Change
Inject sulphate aerosols into the atmosphere
‘Spray-paint’ the atmosphere with a cheap layer of ‘sunscreen’

What would be the impact of injecting sulfate aerosols into the middle atmosphere (stratosphere), where they would act to increase the planetary albedo, and thus counter some of the effects of greenhouse gas forcing?

- **Four computer simulations performed**
  - Fixed aerosol and greenhouse forcing at present day values (Control)
  - Doubled CO2 at beginning of simulation (2XCO2)
  - Injection of 1 Tg S/yr as SO2 at 25km between 10N and 10S (Geo-sulfate)
  - Doubled CO2 + Injection of SO2 (2XCO2 + Geo-Sulfate)
Annual Average Surface Temperature

2xCO2 - Control

Geo-SO4/2xCO2 - Control
A jellyfish made of silicone and rat heart cells 'swims' in water when subjected to an electric field.

Bioengineers have made an artificial jellyfish using silicone and muscle cells from a rat’s heart. The synthetic creature, dubbed a medusoid, looks like a flower with eight petals. When placed in an electric field, it pulses and swims exactly like its living counterpart.

“Morphologically, we’ve built a jellyfish. Functionally, we’ve built a jellyfish. Genetically, this thing is a rat,”

Bioengineers have made an artificial jellyfish using silicone and muscle cells from a rat’s heart. The synthetic creature, dubbed a medusoid, looks like a flower with eight petals. When placed in an electric field, it pulses and swims exactly like its living counterpart.
Fig. 4. World of R&D in 2010. Size of circle reflects the relative amount of annual R&D spending by the country noted. [Reproduced by permission of R&D Magazine (28)]
An African project on an African natural resource; no African researchers involved

targely continued to about one-third of the sorghum genome with gene order and density similar to those of rice. Retrotransposon accumulation in recombinationally calcictral heterochromatin explains the ~75% larger genome size of sorghum compared with rice. Although gene and repetitive DNA distributions have been preserved since palaepolyploidization ~70 million years ago, most duplicated gene sets lost one member before the sorghum–rice divergence. Concerted evolution makes one duplicated chromosomal segment appear to be only a few million years old. About 24% of genes are grass-specific and 7% are sorghum-specific. Recent gene and microRNA duplications may contribute to sorghum’s drought tolerance.

43 authors,
20 leading research institutes spread amongst
USA, Germany, India, China, Switzerland

Most cutting edge science
today is done in big teams
Rise and fall of the World Oil Production

Hubbert’s Peak

North America and Europe develop

Africa develops
African Mineral Deposits – a continent of plenty

Known Mineral deposits
- AuAg
- CrNiPgeTi
- CuZnPbBa
- FeVMn
- SnSbF
- UThREEP
- WMo

Pristine Pre Pan African Crust
- Archean
- Meso/Paleo-Proterozoic

Pan African Crust
- Juvenile
- Remobilized Archean
- Remobilized Proterozoic
The most important scientific graph for South Africa in the first decade of the 21st century.

From a major river basin in RSA

- 2\textsuperscript{nd} THRESHOLD:
  - HUMAN CONSUMPTION
- 1\textsuperscript{st} THRESHOLD:
  - AQUATIC ECOSYSTEMS

Dissolved $\text{SO}_4^{2-}$ (mg/L)

Years:
- 1975
- 1985
- 1995
- 2005
GOLD
Acid mine drainage

ACID GENERATION

\[ \text{FeS}_2 + 7\text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{FeSO}_4 + 2\text{H}_2\text{SO}_4 \]

\[ 4\text{FeSO}_4 + \text{O}_2 + 4\text{H}_2\text{O} \rightarrow 2\text{Fe}_2\text{O}_3 + 4\text{H}_2\text{SO}_4 \]
The value of **Stuff, Services and Stewardship**

\[ S^3 \] - The triple bottom line

"Empty World" Model of the Economy

Basic premises:
More is always better
The economy can grow forever
Private property is always best

This has been tried and should now be discarded?
The stark facts of economic inequality

"Hill of Horror" Marikana platinum mine in Rustenburg
Costs of RSA asbestos industry to society

> R100 billion

You - pay for these “externalities” many years later......
Consumption
**Ecological Economics and the War on Externalities**

Inculcating $S^3$ – & the value of nature into our economy and commerce: Earth is a goods and services provider, but NOT a bottomless pit of freebees

![Diagram of ecological economics and the war on externalities]

Materially closed earth system

**NMMU Earth Stewardship Biology, Business & Humanities School**
“Full World” Model of the Ecological Economic System

Materially closed earth system

Stimulation through informed leadership
Technology and innovation – e.g. nano- chemistry and photosynthesis

NMMU Earth Stewardship S&T School
How much does it cost NATURE to form a copper deposit?

~ 20 times what we pay for it on the metal market

Externality costs = Society’s Penalties
The balance of the carbon budget

- Total anthropogenic CO₂
- CO₂ accumulation in sinks
- Atmospheric CO₂
Headed toward extinction
Area is a good predictor of the number of species co-occurring in a given location.

Global trade-offs in Extinction Debts - Like Credit Derivatives’ Trading - can get out of hand.
Earth Stewardship needs Disruptive Innovation

6 habits of mind that characterize disruptive innovators:

• Associating
• Questioning
• Observing
• Networking
• Experimenting
• Multi-tasking
Innovation — Can it be learned?
*Innovators excel at connecting seemingly unconnected things*
Creative associations come from broadening your experiences

The best innovators are T-Shaped: they need to have depth in one area and breath in lots

The taste for questions is linked to a talent for observation
Why aren’t things done differently?

Language and SMS
Physics for Poets/DNA for the Arts
The complexity of sound/music
The economics of nature
The business of waste
The ethics of living
Ill-being and environmental decay
The communication revolution & mobile learning
The networking society
Experiments and self-assembly

Think different
Some questions

• How do societies fail or survive?
• Where do we come from; how did everything begin?
• How resilient is Earth to impacts of human activities?
• What are the boundaries of a safe operating space for humanity?
• Does social stability depend on natural resources?
• What can we learn from the past?
• Is intergenerational equity attainable/desirable?
• How might democracy evolve in a system that also votes for other species?
• Can technology provide sustainable solutions for an ailing planet?
• How can we distil reliable scientific information out of social noise?
• Is something profoundly wrong with the way we live today?
• How do we know where the end begins? (‘borrowed’ from Ben Okri)
Africa Alive Corridors and Imizila

Imizila – finding a new way forward
The Game
1. Corridor Problem/ challenge
2. Impact – take on a role
   - People
   - Flora and Fauna
3. Solution
4. Scores
5. Moves
1. Challenge results in a team putting in a new power station

1. Impact
   - People - electricity
   - Water – pollution
   - Birds –
   - Animals -

Water team moves back

People team moves forward

Animal team moves back

Suprise impact may be ...
Africa Alive Corridors  [strategic game] live-competition Arusha
Earth Stewardship
001
What counts in Earth Stewardship?

- Is not what you cover, but what you uncover
- Emergence of infectious curiosity & discovery
- Measurements, precision, and uncertainty
- Understanding the degree of accuracy
- Questions never thought to ask before
- An engaging sense of wonder and responsibility
- Sharing the joy of learning
- Transcend cultural and intellectual boundaries between science and the arts: artscience
- Consilience
Earth Stewardship Science
Rooted in Iphakade
We’re an intimate part of it
Make it a way of life

Something will emerge in Africa
Iphakade

‘observe the present and consider the past to ponder the future’
help to ensure that these kids can walk the ‘Corridors of Africa’
“Before humans existed, the species extinction rate was (very roughly) one species per million species per year. Estimates for current species extinction rates range from 100 to 10,000 times that, but most hover close to 1,000 times prehuman levels“

(≈ 10% per century)
Humans have done so much damage to the atmosphere that even if they stop burning all fossil fuels immediately, they risk leaving an impoverished Earth for their descendants, an eminent scientist said this week.

Professor James Lovelock, who detected the build-up of ozone-destroying CFCs and formulated the Gaia theory now widely adopted by environmentalists and biologists, told a conference in London this week: "We have been awakened to the seriousness of global warming."

The Gaia hypothesis — the name was suggested by the novelist William Golding — is that life itself regulates the chemistry of the atmosphere, the oceans and the bedrock for life's collective benefit.

Any disturbance of the process could have dramatic consequences.

Lovelock says that recently groups of researchers have begun to point to such dramatic effects:

- A Swiss team examined the heatwave that killed 20,000 people in Western Europe last summer, and decided that it was mainly a consequence of global warming.
- A British, Italian and German scientist reported that the entire European ice cap would begin to melt irreversibly if average temperatures rose by 2.7°C.
- This melting would take 1,000 years to complete, but would raise sea levels by seven metres.
- A team from the United States National Ocean and Atmosphere Administration reported that sea-level rises in recent years have been a consequence of the accelerated melting of glaciers.

Lovelock (84) told the conference, on the science of Gaia, that there were people in Europe and the US who denied the reality of climate change and wanted business as usual. However, there were others who recognised the threat and embraced organic food, renewable energy and alternative medicine.

"If we follow either of these responses, it will allow Gaia eventually to return to her normal state of health — but by eliminating the majority of humans and probably civilisation as well," he said.

Better science and more advanced technology offered the greatest hope, he added.

"We need a portfolio of energy sources, with nuclear power playing a major part, at least until fusion power becomes a practical option."