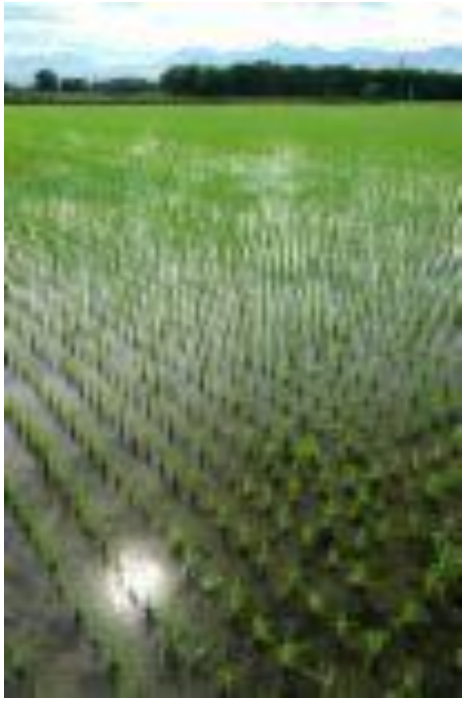
Present day challenges

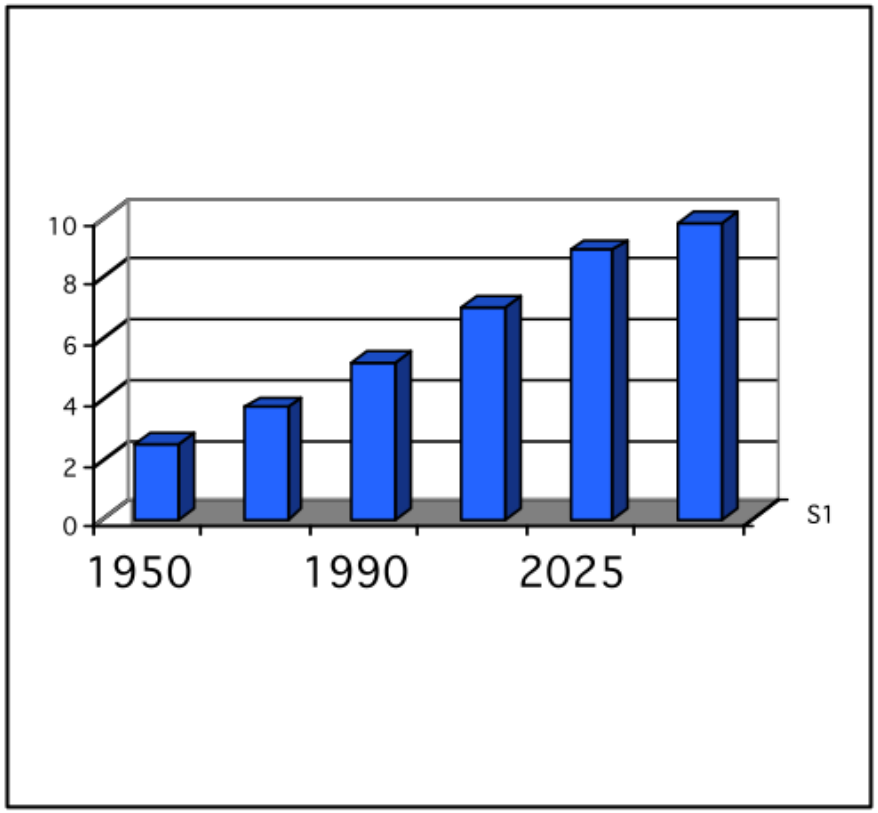
Food



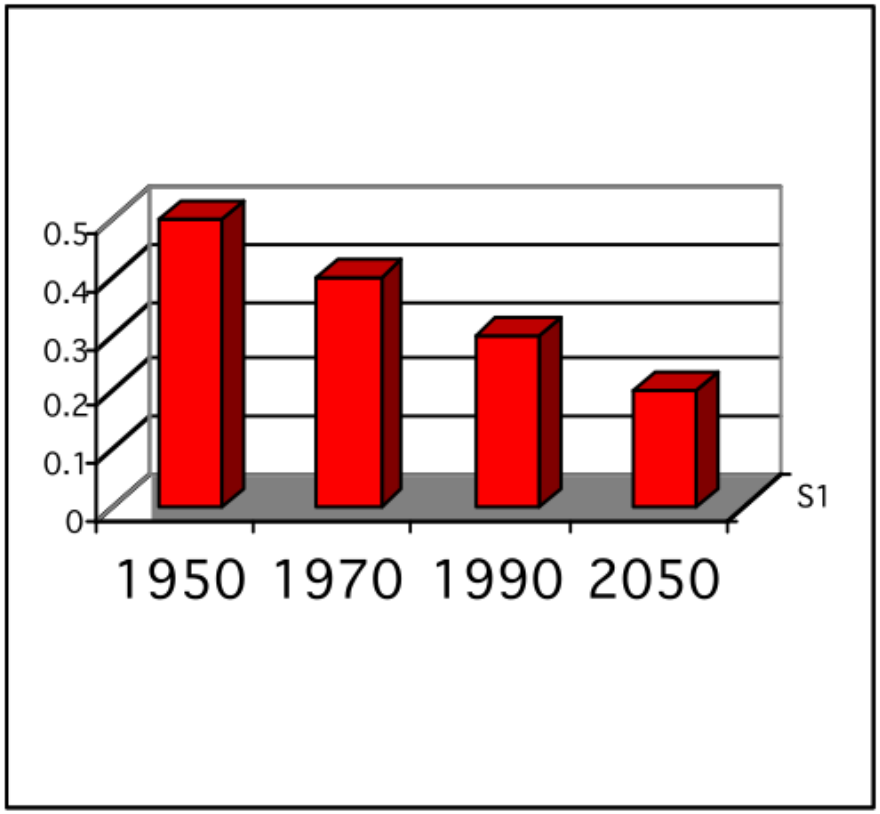
Health

Natural, Environmental & Political Challenges

Land & population



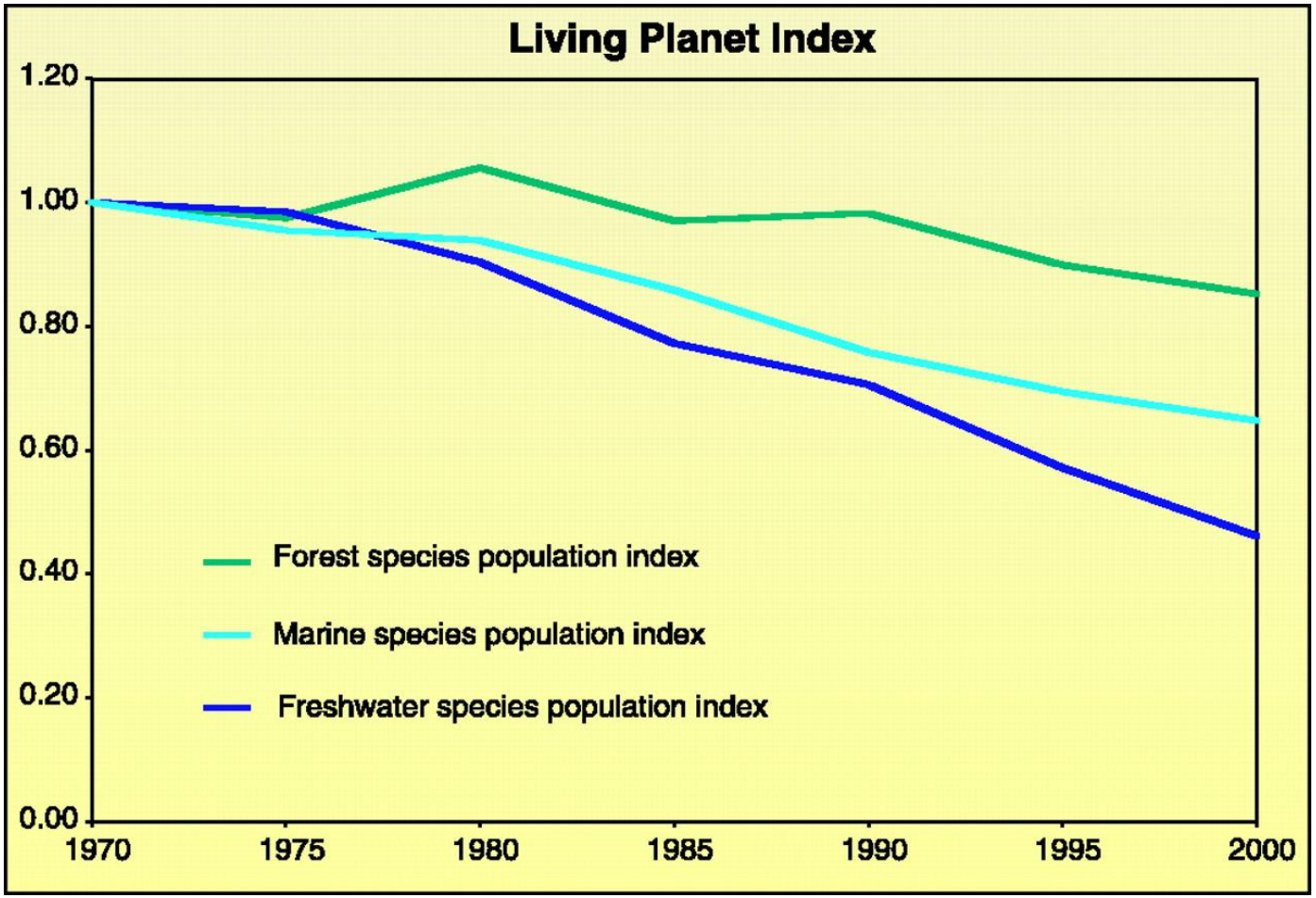
World population



Arable land per inhabitant (ha)

RUNNING OUT OF USEFULL GENES

Species population indices from 1970 to 2000 for forest, marine, and freshwater ecosystems, as included in the 2002 WWF Living Planet Index



M. Jenkins Science 302, 1175 -1177 (2003)

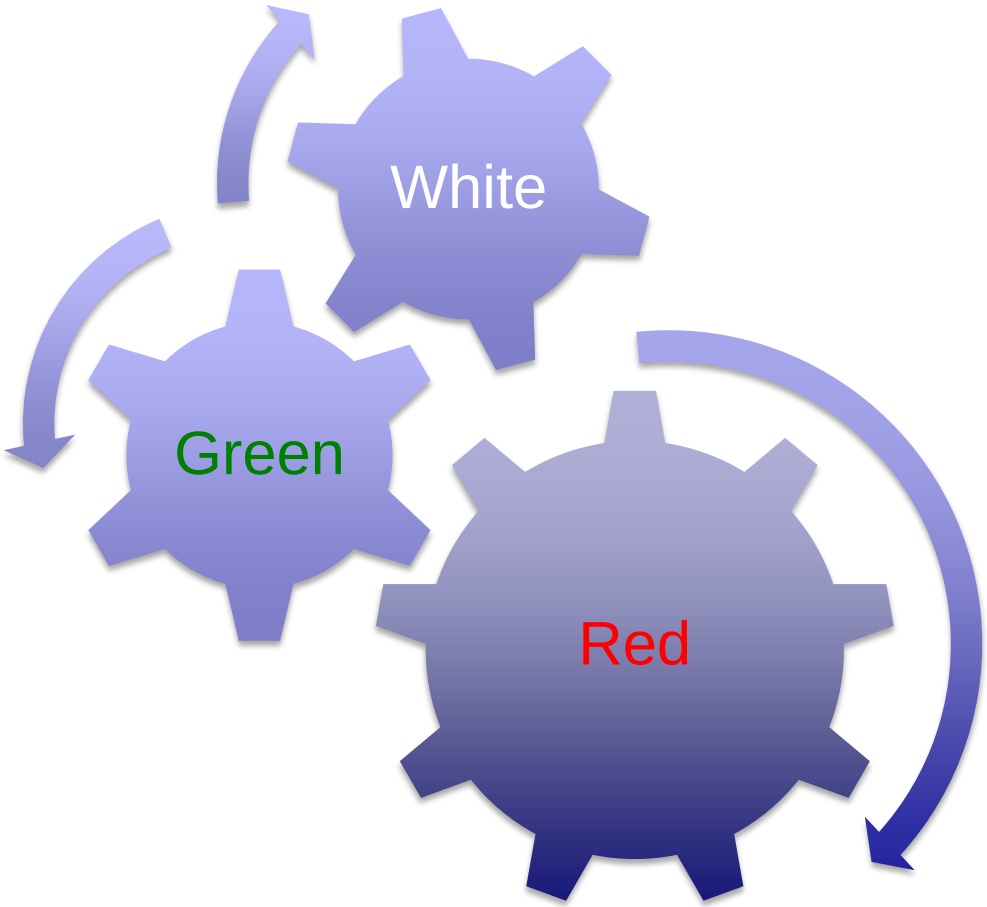
Published by AAAS

Biotech can provide some answers

Biotech uses scientific and technological innovation to:

- capture the latent value in biological processes and renewable bioresources
- utilise these resources, processes and eco-industrial clusters to produce sustainable bioproducts, jobs and income
- reduce dependence on imports, fossil-based energy and industrial feedstocks

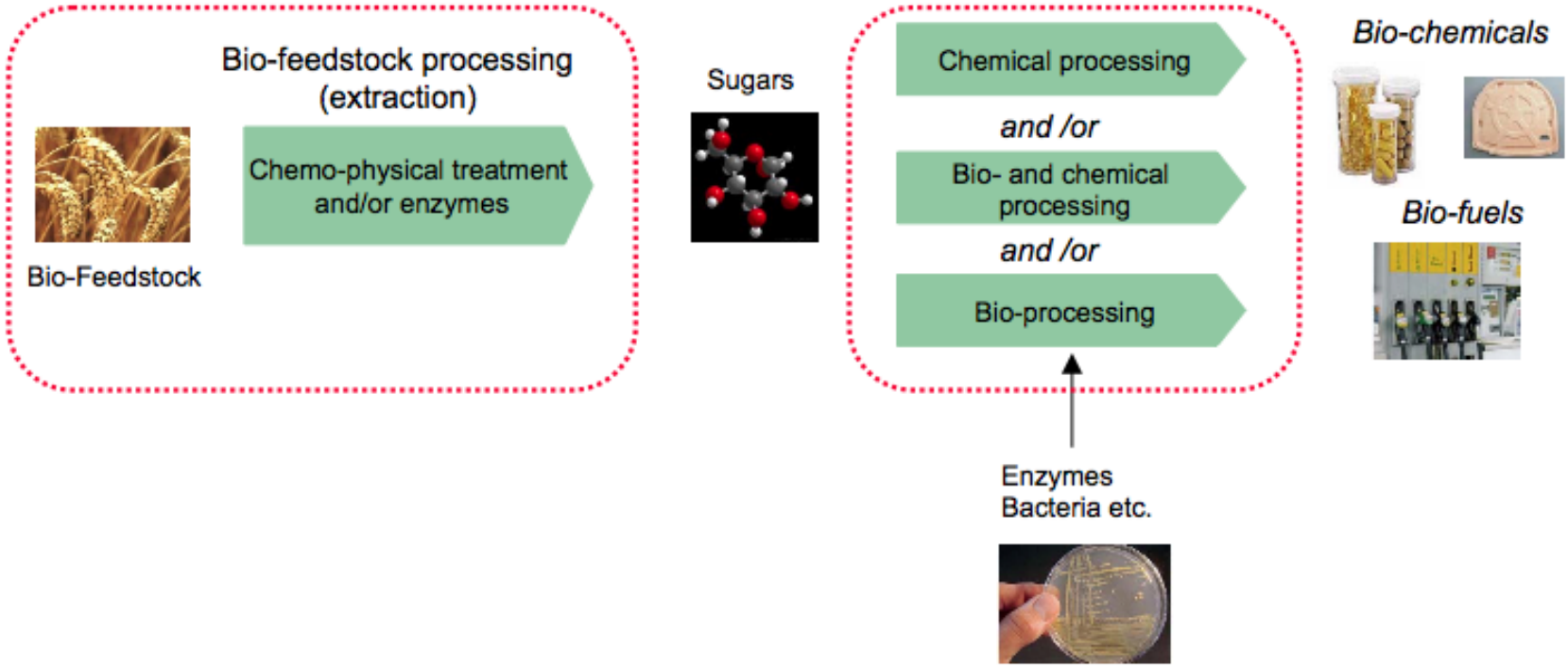
Biotech in Industry



UNIDO core services

- Agro-industries
- Cleaner industrial production
- Energy
- SME development
- Trade facilitation

White Biotech: Product Streams



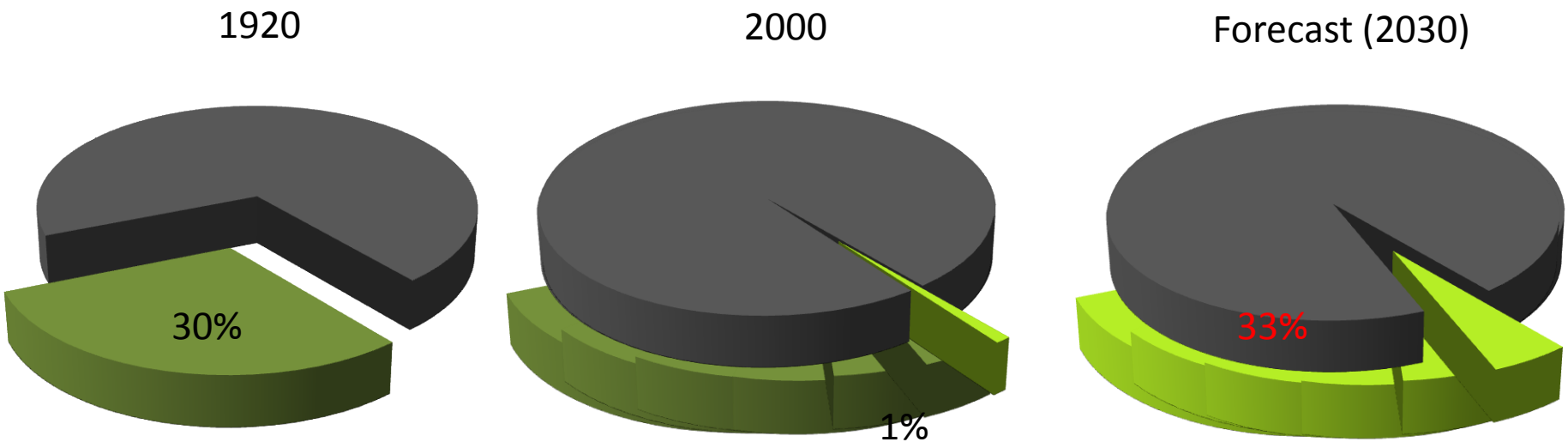
White Biotech

- Efficiency
- Less energy
- Environmental footprint

The bio-based economy

"Encapsulates the vision of a future society no longer wholly dependent on fossil fuels for energy & industrial materials"

Bio- vs. hydrocarbon-based economies	Exploitable sources
Greater compositional variety	Energy crops
Greater range of technologies to add value	Food and feed grains; Forestry; Algae
Greater geographical distribution of raw materials and refineries	Crop and forestry residues


1920
2000
Forecast (2030)
30%
1%
33%
Fossil feedstock (coal, petroleum)
Bio-based feedstock (algae, plants, etc.)

Linking conservation with income generation

Generating economic value from biodiversity

PLANT BIODIVERSITY AS AN ECOSYSTEM SERVICE

Provisioning services

Food, medicine, fuel, construction, clothing, etc.

Regulating services

Climate moderation, disease regulation, flood regulation

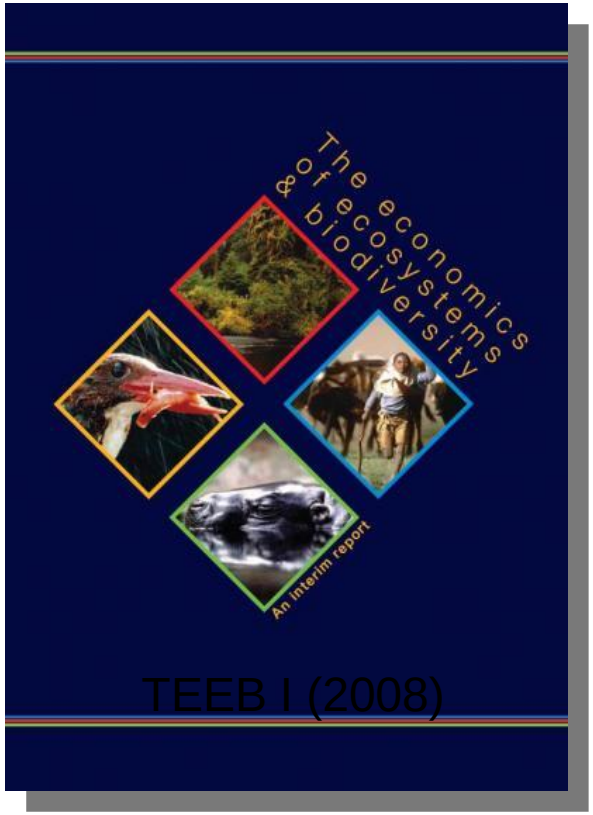
Cultural services

Spiritual, recreational, aesthetic, inspirational, educational

Supporting services

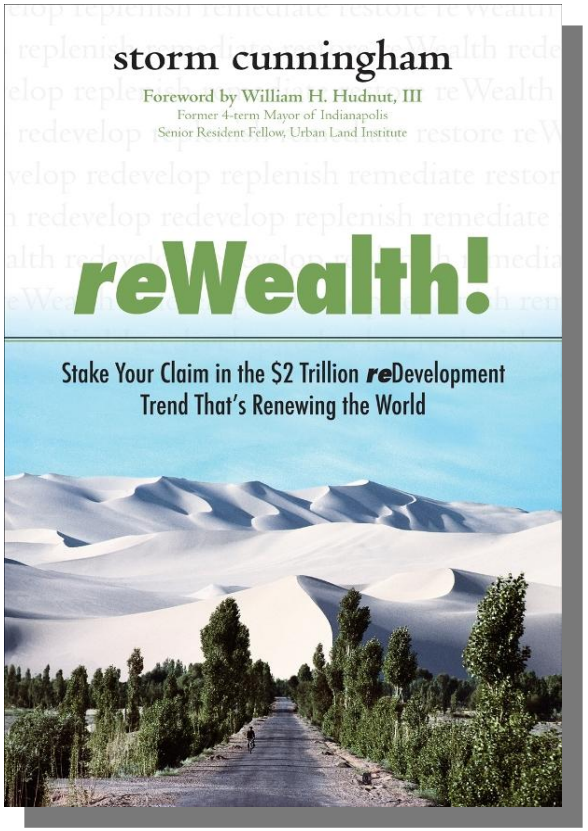
Soil formation, nutrient cycling, primary production.

SOCIAL, ECONOMIC AND FINANCIAL RELEVANCE:
the valuing of biodiversity



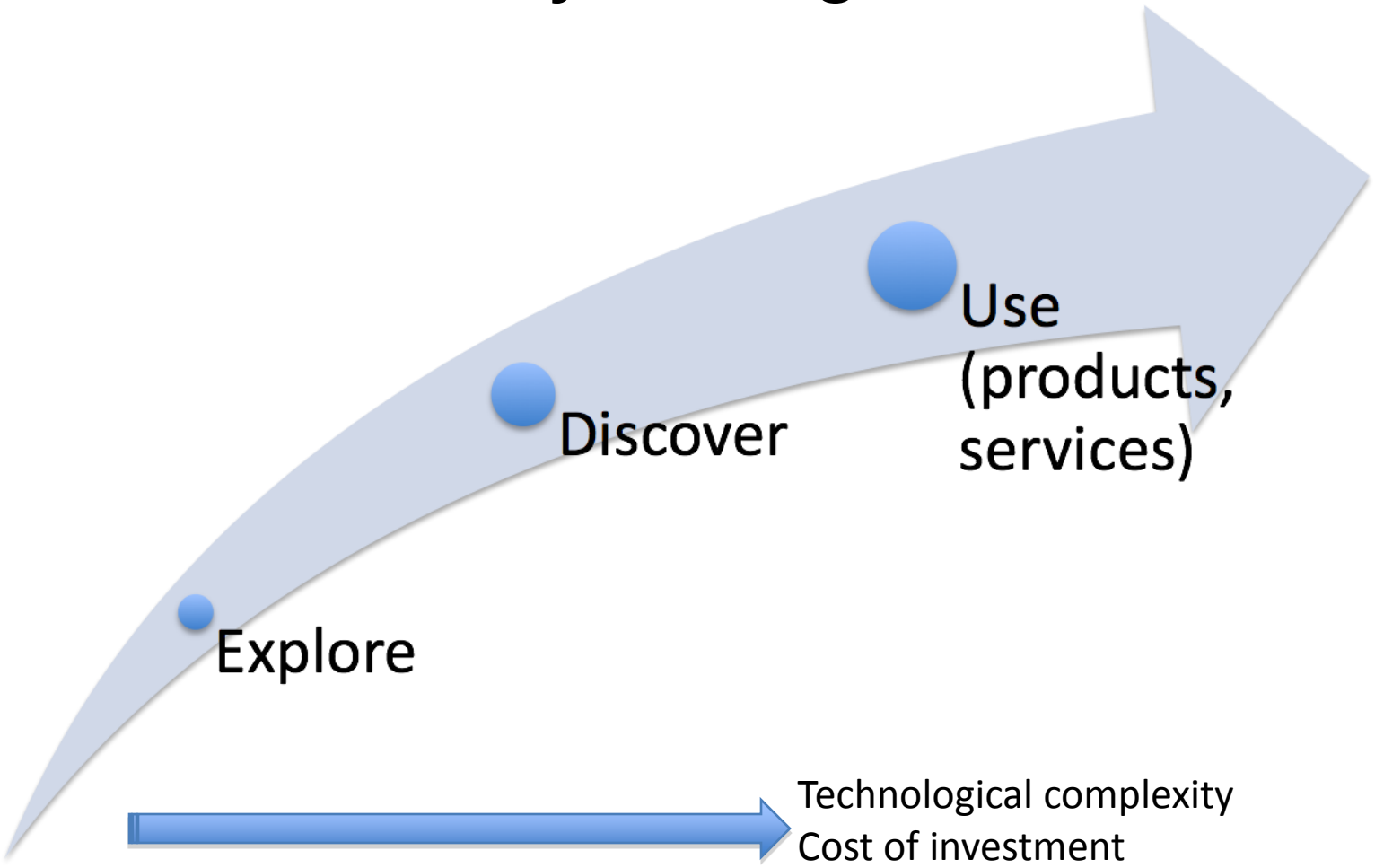
TEEB I (2008)

Economic value of Ecosystem Services is $30-40 trillion per annum

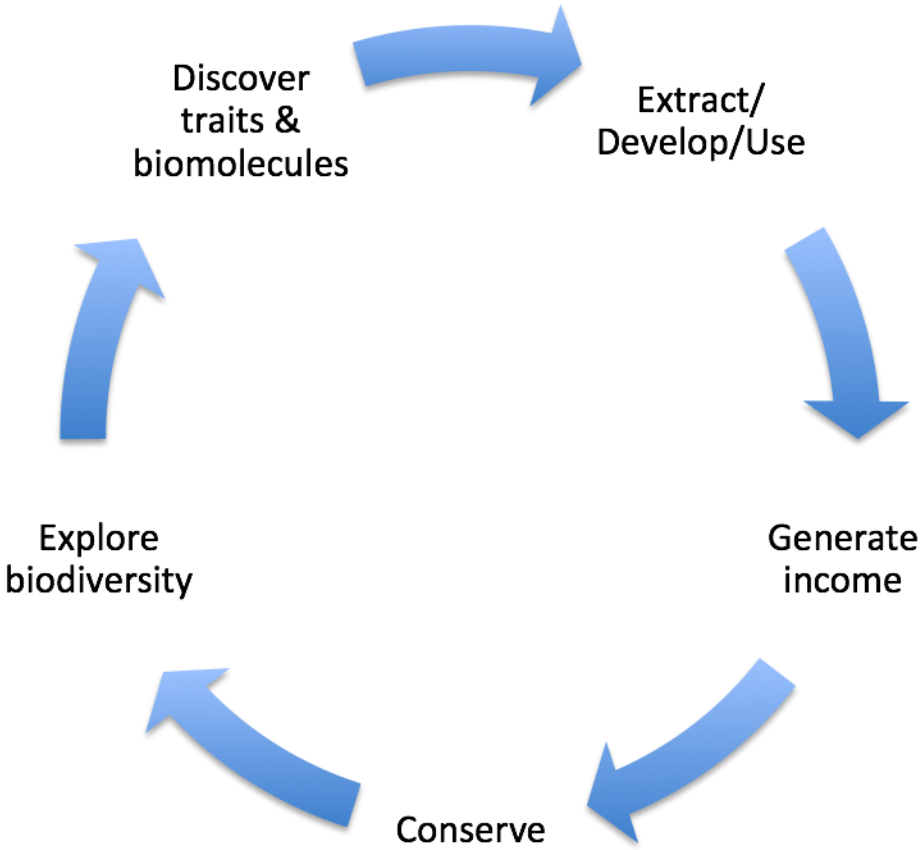


$2 trillion reDevelopment; revitalising economies; rebuilding communities; restoring structures; replenishing natural resources and degraded lands

Economic Value-Addition to Biodiversity through Biotech



Biodiversity conservation: the virtuous circle



Benefits beyond conservation

- Technology transfer through partnerships (public & private)
- SME development & job creation through product development, marketing & distribution
- Income generation though licensing agreements, royalties, etc.
- Upgrading of institutional capacities (regulatory oversight, management of intellectual assets, etc.)

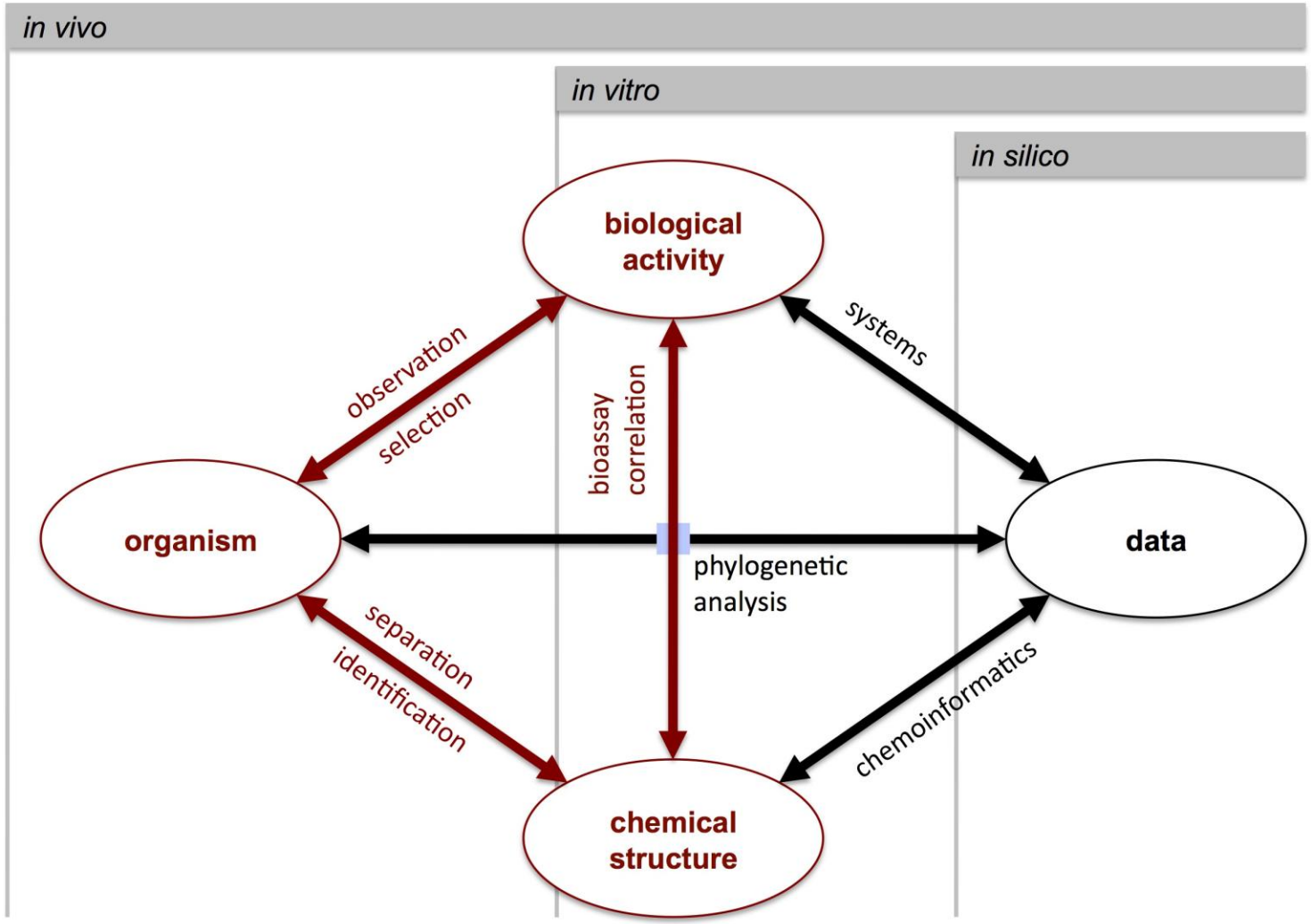
Technologies

Technology: Bioinformatics & Biotechnology

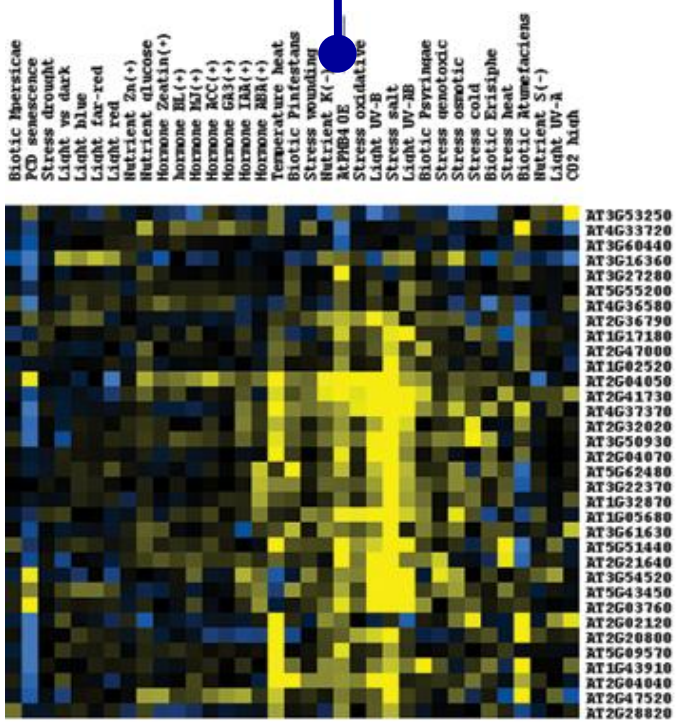
Explore
- Genetic & biochemical analysis
- Ethnobotany

Discover
- Bioinformatics
- High-throughput screening

Extract & Use
- Biotechnology, bioengineering
- Scale-up, quality control, etc.


in vivo
in vitro
in silico
biological activity
organism
data
chemical structure
observation
selection
bioassay correlation
systems
phylogenetic analysis
separation identification
chemoinformatics

Technology: Enhanced candidate gene identification



Plant Systems Biology

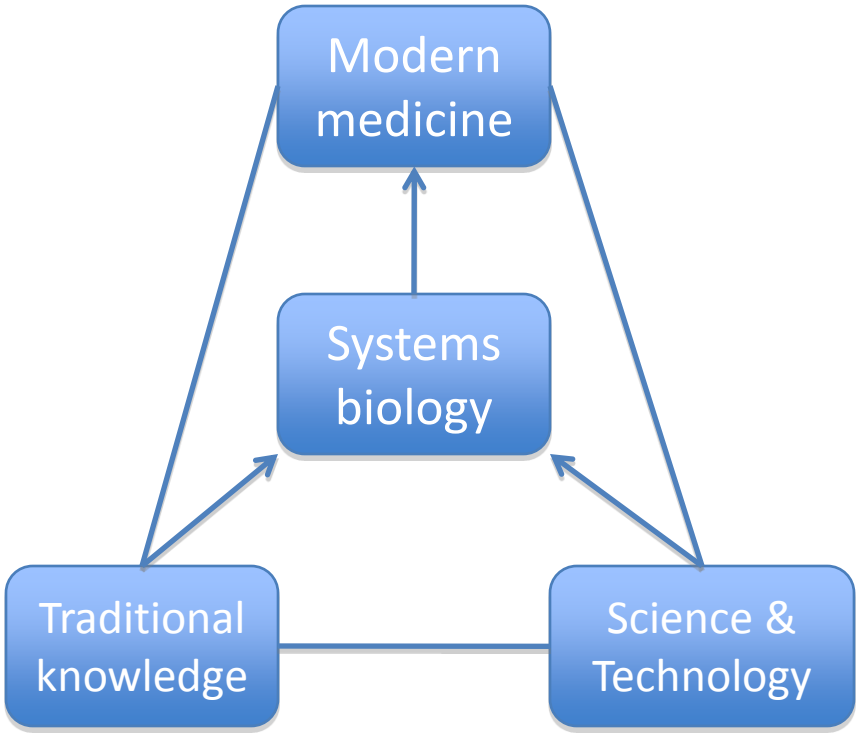
Meta-analyses of abiotic stress-related transcriptome data identified new genes that improve yield during drought stress

UNIDO

Technology: Systems biology can facilitate the transition from traditional to modern medicine

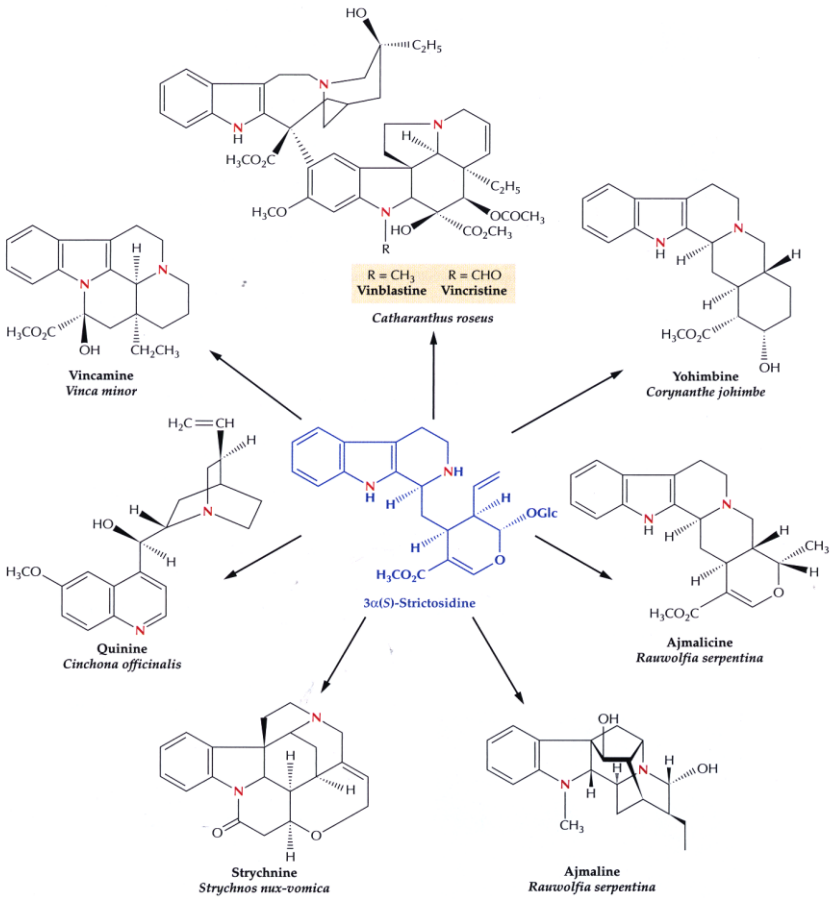
The role of Systems Biology

- Systems Biology studies the interactions of different components within an organism to elucidate relevant physiological functions and behavior.
- It may help decipher
  - ✓ How a herbal mixture may display diverse activities by interacting with more than one molecular target, or
  - ✓ How multiple active ingredients in a botanical preparation might act together synergistically



Technology: Metabolic engineering

ENHANCING METABOLIC OUTPUT



- Catharanthus roseus produces vinblastine & vincristine
- Use: Hodgkin's disease, acute leukemia, breast cancer
- Content in plants: In leaves ~ 0.0003 % (500 kg plant material is needed to obtain 1 g vincristine)
- Price: ~13 000 € / g

Rischer et al., PNAS (2006)

Plant Systems Biology

UNIDO

Technology adoption potential depends on level of development

- Advanced developing countries:
  Innovation potential: Cuba developed the world's first and only meningitis B vaccine, South Africa a maize streak virus resistant corn variety
- Developing countries:
  Adaptation of imported technology: Imported genetic stock to improve domestic crops (e.g. Papaya, oil palms and other crops), licensed technology to develop vaccines
- Least developing countries:
  Import of embodied technology: Rely on imports of pharmaceuticals, agricultural seeds, etc.

Which way to go?

IIBN

Biotech Adoption Considerations for Industry

1. Technical / cost improvement potential of industrial biotechnology options
2. Adoption implications: need to change entire production lines or only distinct steps?
3. Technical maturity of biotech solutions
4. Genetic modification involved: issue of public acceptance
5. Life Cycle assessment

Adapted from: Alan T. Bull, Biotechnology for Industrial Sustainability. Korean J Chem Eng 18(2) 137-148 (2001)

What are requirements for investment in biochemical assets?

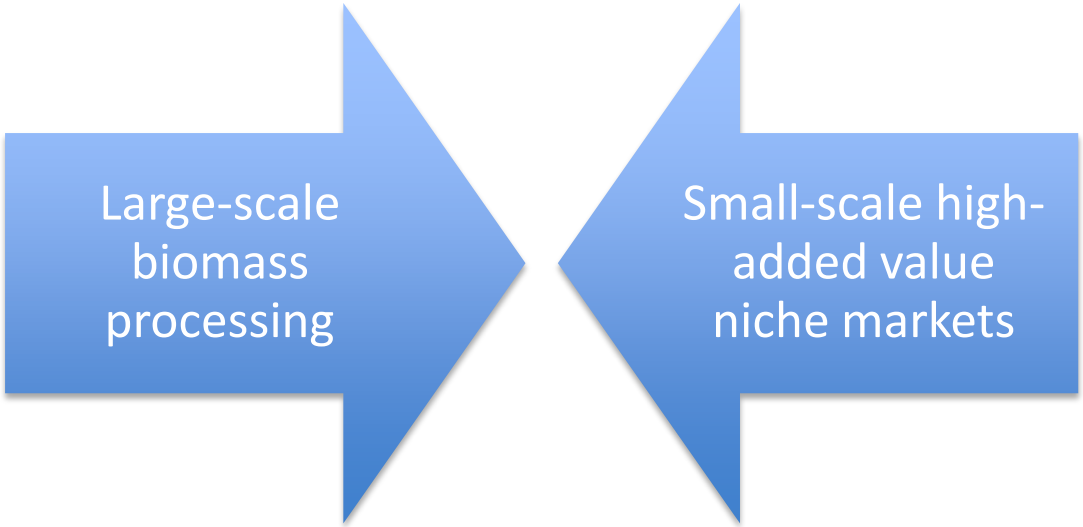
1. Further feedstock price differential needed for sustainable cost advantage
2. Location match of bio-feedstock supply markets and distribution markets necessary
3. Strategic priorities need to be competitive with China and the Middle East
4. Large network site investments need to be captured
5. Uncertainty about cellulose converting technology needs to resolve

Source: Dr. Rainer Brosch, The Boston Consulting Group (Dec 2007)

Available options

- Biofuels, chemical feedstock, forestry and food crops

- Fine chemicals; herbal medicine; nutriceuticals

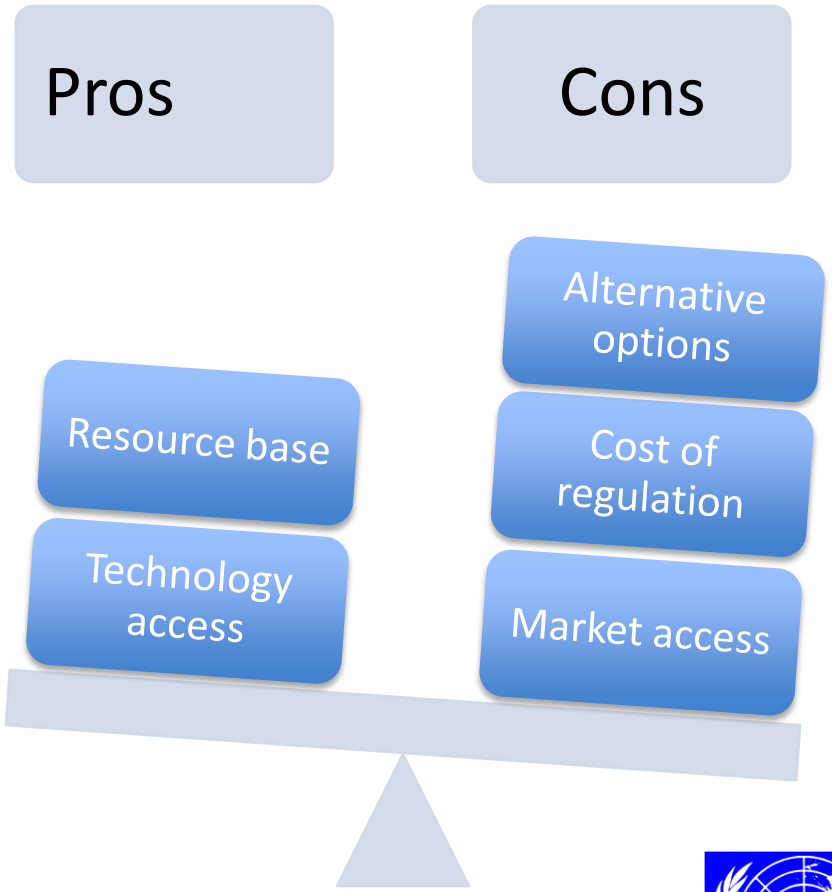


Promising areas of biotech commercialisation

- ✓ Chemical feedstock from agro-industrial residues
- ✓ Biofuel for rural or local industrial use
- ✓ Botanicals and nutriceuticals

<u>Rationale:</u>

- Using technologies/products which do not require stringent regulatory scrutiny
- Adapting technologies available in the public domain
- Using technology solutions which no not interfere with food security concerns (waste material)
- Instead on final products, focus on high-added value product components, commercialisation via partnerships



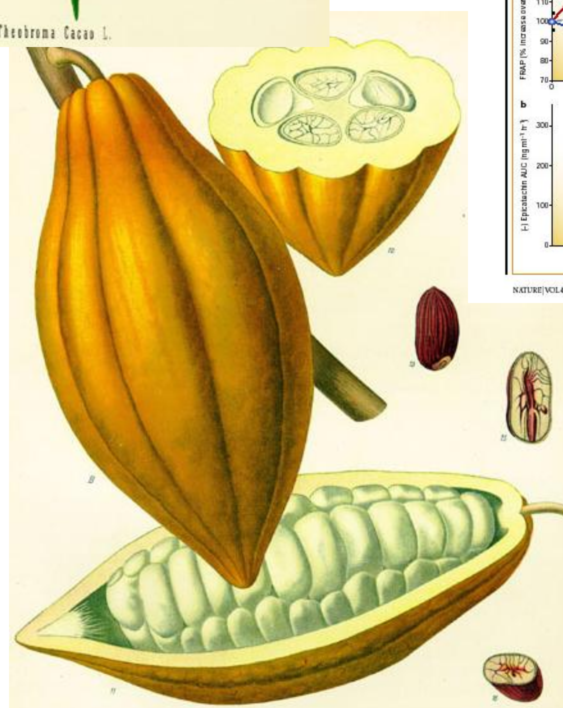
The potential

NICHE APPLICATIONS

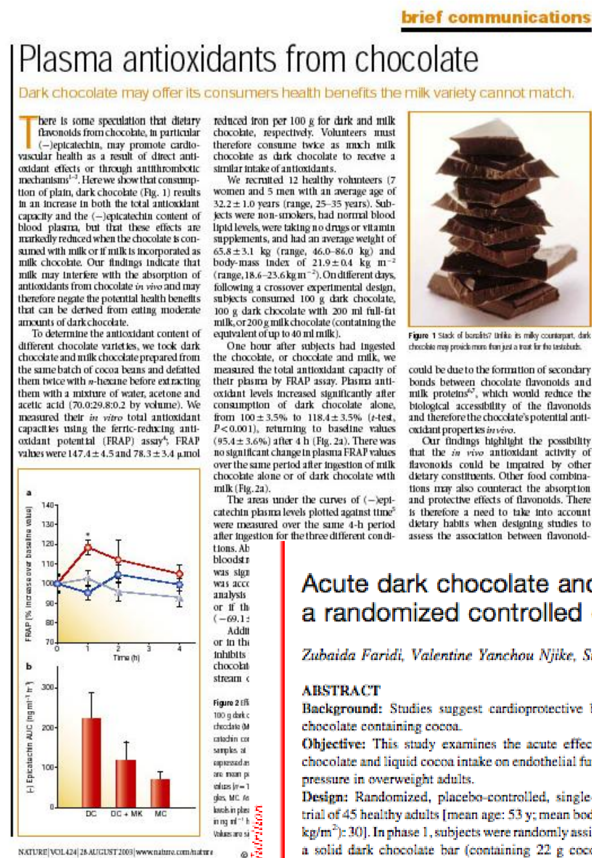
New markets for neglected crops: the example of Quinoa

- Highly drought tolerant;
- Health-conscious market emerging;
- Doctors recommend diet switch to Quinoa in cases of IBS;
- I in 5 Americans have IBS;
- Possible > $billion market if quality seed were available;
- Great investment opportunity!

Cacao-medical food?



Theobroma cacao



brief communications

Plasma antioxidants from chocolate

Dark chocolate may offer its consumers health benefits the milk variety cannot match.

There is some speculation that dietary flavonoids from chocolate, in particular (−)epicatechin, may promote cardiovascular health as a result of direct antioxidant effects or through antithrombotic mechanisms[1–3]. Here we show that consumption of plain, dark chocolate (Fig. 1) results in an increase in both the total antioxidant capacity and the (−)epicatechin content of blood plasma, but that these effects are markedly reduced when the chocolate is consumed with milk or if milk is incorporated as milk chocolate. Our findings indicate that milk may interfere with the absorption of antioxidants from chocolate *in vivo* and may therefore negate the potential health benefits that can be derived from eating moderate amounts of dark chocolate.

To determine the antioxidant content of different chocolate varieties, we took dark chocolate and milk chocolate prepared from the same batch of cocoa beans and defatted them twice with *n*-hexane before extracting them with a mixture of water, acetone and acetic acid (70.0:29.8:0.2 by volume). We measured their *in vitro* total antioxidant capacities using the ferric-reducing antioxidant potential (FRAP) assay[4]; FRAP values were 147.4 ± 4.5 and 78.3 ± 3.4 μmol reduced iron per 100 g for dark and milk chocolate, respectively. Volunteers must therefore consume twice as much milk chocolate as dark chocolate to receive a similar intake of antioxidants.

We recruited 12 healthy volunteers (7 women and 5 men with an average age of 32.2 ± 1.0 years (range, 25–35 years). Subjects were non-smokers, had normal blood lipid levels, were taking no drugs or vitamin supplements, and had an average weight of 65.8 ± 3.1 kg (range, 46.0–86.0 kg) and body-mass index of 21.9 ± 0.4 kg m^{-2} (range, 18.6–23.6 kg m^{-2}). On different days, following a crossover experimental design, subjects consumed 100 g dark chocolate, 100 g dark chocolate with 200 ml full-fat milk, or 200 g milk chocolate (containing the equivalent of up to 40 ml milk).

One hour after subjects had ingested the chocolate, or chocolate and milk, we measured the total antioxidant capacity of their plasma by FRAP assay. Plasma antioxidant levels increased significantly after consumption of dark chocolate alone, from 100 ± 3.5% to 118.4 ± 3.5% (*t*-test, $P < 0.001$), returning to baseline values (95.4 ± 3.6%) after 4 h (Fig. 2a). There was no significant change in plasma FRAP values over the same period after ingestion of milk chocolate alone or of dark chocolate with milk (Fig. 2a).

The areas under the curves of (−)epicatechin plasma levels plotted against time[5] were measured over the same 4-h period after ingestion for the three different conditions. Ab… bloodst… was sign… was acc… analysis… or if th… (−69.1… Addi… or in th… inhibits… chocolat… stream…

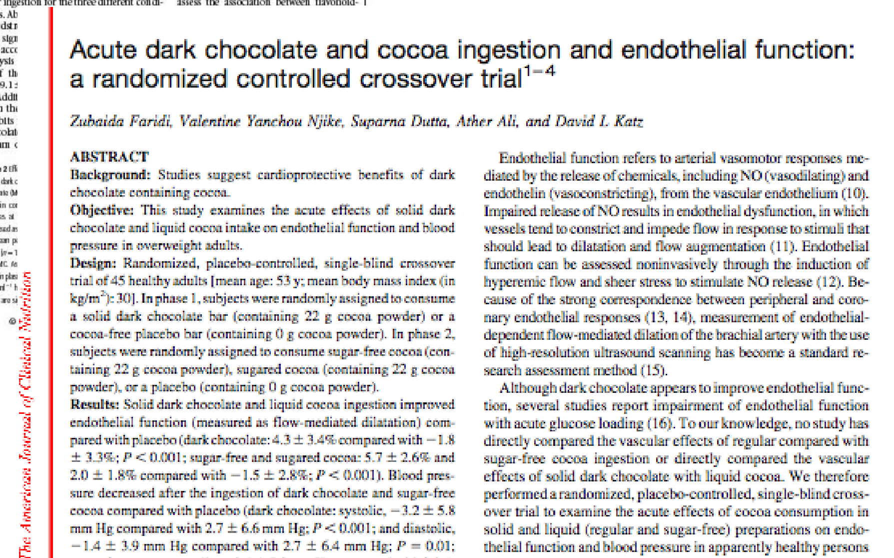
Figure 1 Stack of benefits? Unlike its milky counterpart, dark chocolate may provide more than just a treat for the tastebuds.

could be due to the formation of secondary bonds between chocolate flavonoids and milk proteins[6,7], which would reduce the biological accessibility of the flavonoids and therefore the chocolate's potential antioxidant properties *in vivo*.

Our findings highlight the possibility that the *in vivo* antioxidant activity of flavonoids could be impaired by other dietary constituents. Other food combinations may also counteract the absorption and protective effects of flavonoids. There is therefore a need to take into account dietary habits when designing studies to assess the association between flavonoid-

Figure 2 Eff… 100 g dark c… chocolate (M… catechin co… samples at… expressed as… are mean p… values (n = 1… gles, MC; … levels in plas… in ng ml⁻¹ h… Values are si…

Nature, 424 (28 aug.), 1013, (2003)



The American Journal of Clinical Nutrition

Acute dark chocolate and cocoa ingestion and endothelial function: a randomized controlled crossover trial[1–4]

Zubaida Faridi, Valentine Yanchou Njike, Suparna Dutta, Ather Ali, and David L Katz

ABSTRACT

Background: Studies suggest cardioprotective benefits of dark chocolate containing cocoa.

Objective: This study examines the acute effects of solid dark chocolate and liquid cocoa intake on endothelial function and blood pressure in overweight adults.

Design: Randomized, placebo-controlled, single-blind crossover trial of 45 healthy adults [mean age: 53 y; mean body mass index (in kg/m^2): 30]. In phase 1, subjects were randomly assigned to consume a solid dark chocolate bar (containing 22 g cocoa powder) or a cocoa-free placebo bar (containing 0 g cocoa powder). In phase 2, subjects were randomly assigned to consume sugar-free cocoa (containing 22 g cocoa powder), sugared cocoa (containing 22 g cocoa powder), or a placebo (containing 0 g cocoa powder).

Results: Solid dark chocolate and liquid cocoa ingestion improved endothelial function (measured as flow-mediated dilatation) compared with placebo (dark chocolate: 4.3 ± 3.4% compared with −1.8 ± 3.3%; $P < 0.001$; sugar-free and sugared cocoa: 5.7 ± 2.6% and 2.0 ± 1.8% compared with −1.5 ± 2.8%; $P < 0.001$). Blood pressure decreased after the ingestion of dark chocolate and sugar-free cocoa compared with placebo (dark chocolate: systolic, −3.2 ± 5.8 mm Hg compared with 2.7 ± 6.6 mm Hg; $P < 0.001$; and diastolic, −1.4 ± 3.9 mm Hg compared with 2.7 ± 6.4 mm Hg; $P = 0.01$;

Endothelial function refers to arterial vasomotor responses mediated by the release of chemicals, including NO (vasodilating) and endothelin (vasoconstricting), from the vascular endothelium (10). Impaired release of NO results in endothelial dysfunction, in which vessels tend to constrict and impede flow in response to stimuli that should lead to dilatation and flow augmentation (11). Endothelial function can be assessed noninvasively through the induction of hyperemic flow and sheer stress to stimulate NO release (12). Because of the strong correspondence between peripheral and coronary endothelial responses (13, 14), measurement of endothelial-dependent flow-mediated dilation of the brachial artery with the use of high-resolution ultrasound scanning has become a standard research assessment method (15).

Although dark chocolate appears to improve endothelial function, several studies report impairment of endothelial function with acute glucose loading (16). To our knowledge, no study has directly compared the vascular effects of regular compared with sugar-free cocoa ingestion or directly compared the vascular effects of solid dark chocolate with liquid cocoa. We therefore performed a randomized, placebo-controlled, single-blind crossover trial to examine the acute effects of cocoa consumption in solid and liquid (regular and sugar-free) preparations on endothelial function and blood pressure in apparently healthy persons

Am J Clin Nutr, 88, 58-63 (2008)

DEMAND FOR SEEDS AS NON-WOODY FOREST PRODUCTS

(2005, FAO)

Country → Product ↓	**Africa**	**Asia**	World total (tonnes)
Food*	88,823	3,562,991	4,278,035
Medicine / aromatics	20,400	90,181	121,505
Exudates	12,575	1,495,663	1,566,684
Other products	11,175	606,782	1,296,819

*mainly oilseeds and nuts;

Market Potential for Botanicals

Worldwide sales of medicinal plants, crude extracts & finished products

- ✓ US $ 15 billion in 1999
- ✓ US $ 23 billion in 2002
- ✓ US $ 65 billion in 2009 (estimate)

The World Bank projects an annual growth rate of 10-15%.

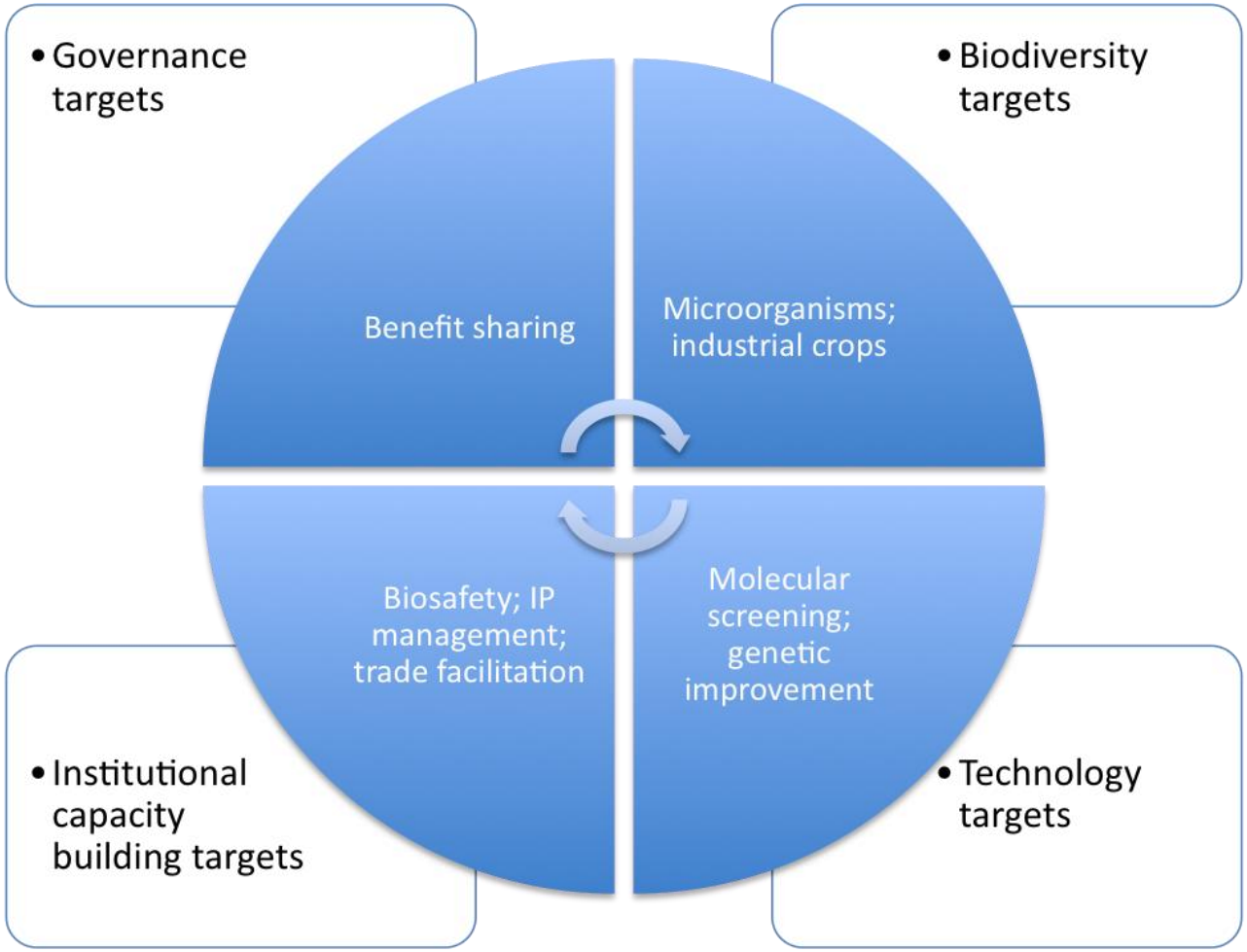
Source: Y. Liu, M-W Wang 2008, Life Sciences 82: 445-449

World Bank 2005, Capitalizing on the Bio-Economic Value of Multi-Purpose Medicinal Plants for the Rehabilitation of Drylands in Sub-Saharan Africa

Regulation pathways for botanicals in USA

Dietary suppl.	Medical food	Botanical drug
Intended to supplement diet of healthy population	Intended to meet deficiency in diseased population	Intended to treat specific disease
No pre-market approval required	No pre-market approval required	Pre-market approval required
Disclaimer required	Labeled for use under physician's supervision	Labeled and promoted as drug

UNIDO Biotech Programme targets:



International Industrial Biotechnology Network

IIBN

The International Industrial Biotechnology Network IIBN

Objective:

to assist countries in accessing and developing biotechnologies for sustainable industrial development

Implementation:

- Establishment of a South-South cooperation network for the promotion of industrial biotechnology for sustainable development
- Establishment of a knowledge management hub in Ghent to serve as network coordinator

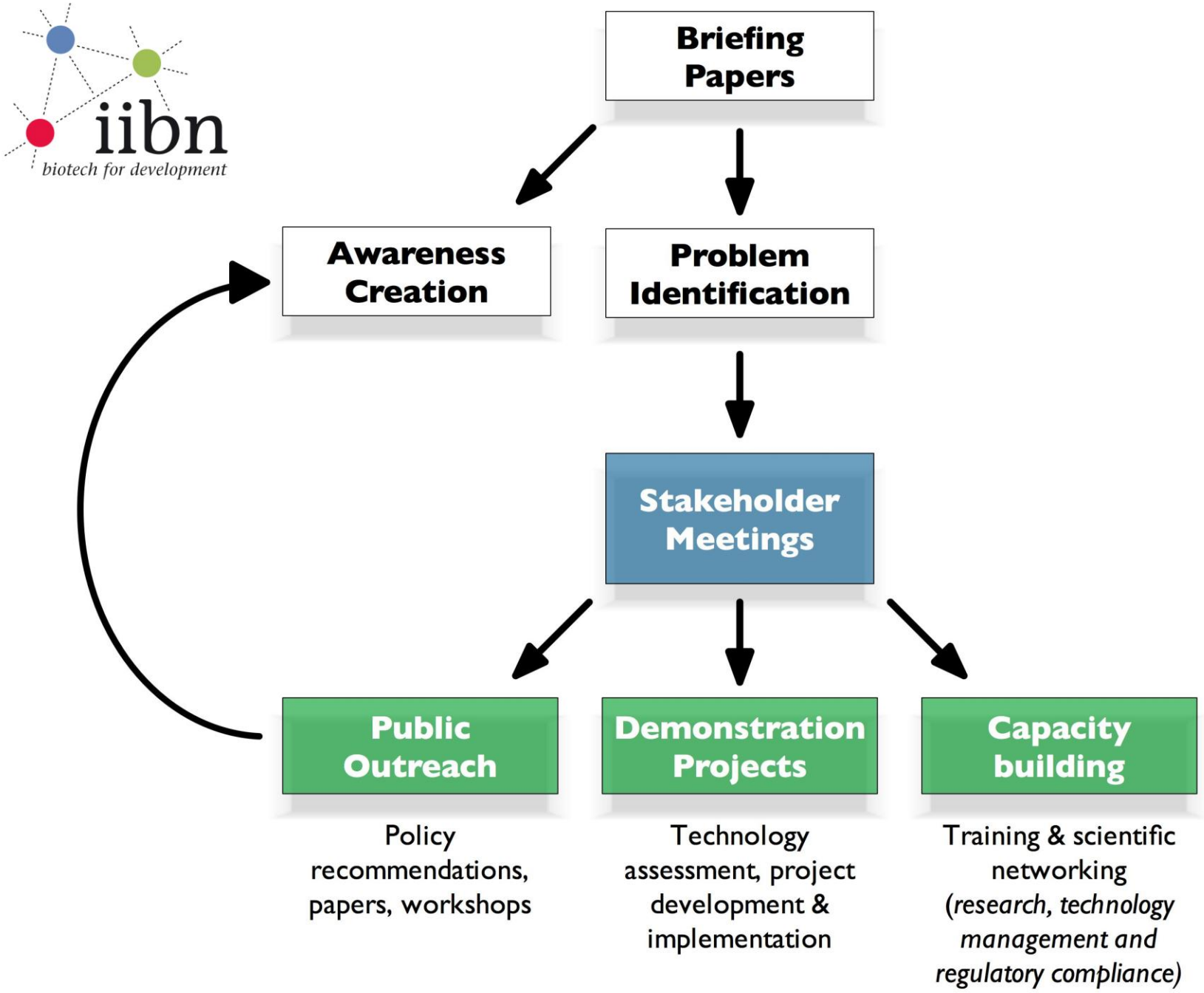
Key Recommendations for Transition to KBBE

Recommendation	Description
Integrated KBBE Policy	Includes R&D funding and multipurpose infrastructure development, market development for bio-based products, facilitation of technology access, standardised LCA
Research & Innovation	Cooperation through public-private networks, concentration on key areas (cradle-to-market), demonstration plants (close gap scientific feasibility – industrial applicability)
Support eco-sustainable SMEs	Proof-of-concept to attract investors, technology transfer incentives
Communication & Education	Involvement of stakeholder to (i) reflect social needs,(ii) increase technology awareness and (iii) built multi-disciplinary welfare
Support renable industry conversion	Foster market growth for renable-based markets, enact renewable-stimulating regulation
Development of science-based sustainability criteria	To provide testable data on impact-mitigating effects of renewable feedstock production, consumption, use

Adapted from: Clever Consult BVBA Belgium. The Knowledge Based Bio-Economy (KBBE) in Europe. Achievements and Challenges (Sep 2010)

Programme Components

- Awareness raising
- Environmental, economic & social impact assessment of emerging technologies
- Public / private partnerships for product development at pilot scale
- Institutional capacity building through research and training


Briefing Papers
Awareness Creation
Problem Identification
Stakeholder Meetings
Public Outreach
Demonstration Projects
Capacity building
Policy recommendations, papers, workshops
Technology assessment, project development & implementation
Training & scientific networking (research, technology management and regulatory compliance)

Technology Focus

IIBN focuses on technologies for

- the development of novel bio-products and bio-processes
- the production of energy and chemical feedstocks for local use, particularly in regions compromised by climate change and ecological erosion
- the reduction of the environmental footprint of industry

Network Structure

- Network Secretariat: UNIDO
- Network Coordinator: IPBO
- Network Nodes: research institutes and technology groups

IIBN seeks the active involvement of industry and in particular SMEs committed to sharing expertise and technology resources.

IIBN is funded by the Flemish Government and welcomes partnerships with other governments or development agencies.

With the support of the Flemish authorities

Contacts

Institute of Plant Biotechnology
for Developing Countries
Em. Prof. Marc Van Montagu
Ivan Ingelbrecht Ph.D.
Ghent University
K.L. Ledeganckstraat 35
9000 Ghent, Belgium
T +32 9 264 5349
F +32 9 264 8795
ivan.ingelbrecht@ugent.be

UNITED NATIONS
INDUSTRIAL DEVELOPMENT
ORGANIZATION

United Nations Industrial
Development Organization
George Tzotzos Ph.D.
Biotechnology Programme
Wagramer Straße 5
1400 Vienna, Austria
T +43 1 26026 4336
F +43 1 26026 6810
g.tzotzos@unido.org

www.indbiotech.net