Agro-Ecological Environmental Biotechnology Systems for Food and Fuel Sovereignty in Southern Africa.

Presentation to the
African Caribbean and Pacific Group of States (ACP)
Science and Technology Programme,
SANUMARC, June 03, 2010

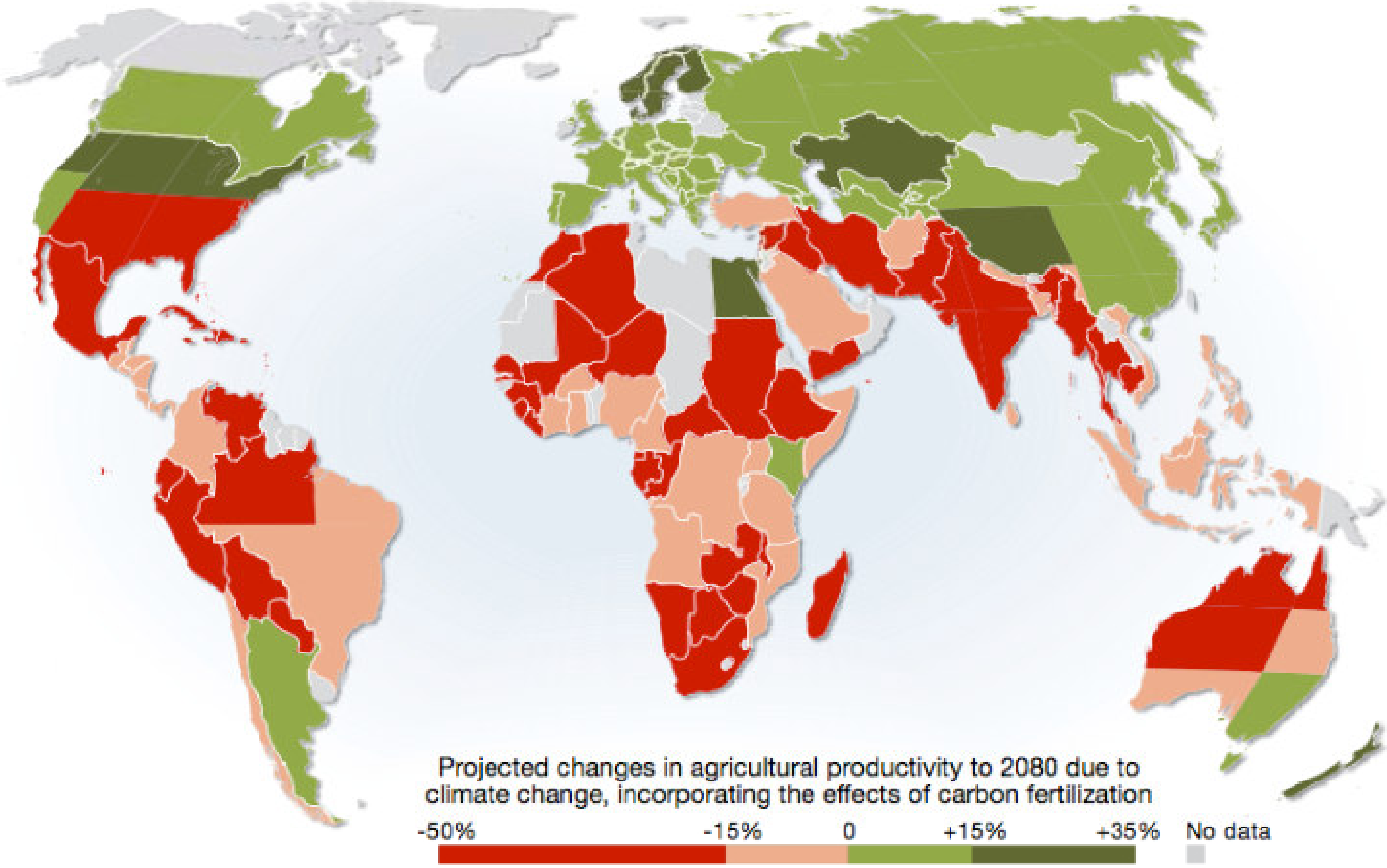
Agro-Ecology Farming Systems

The IAASTD (2008), the most comprehensive assessment of agricultural knowledge, science and technology to date.

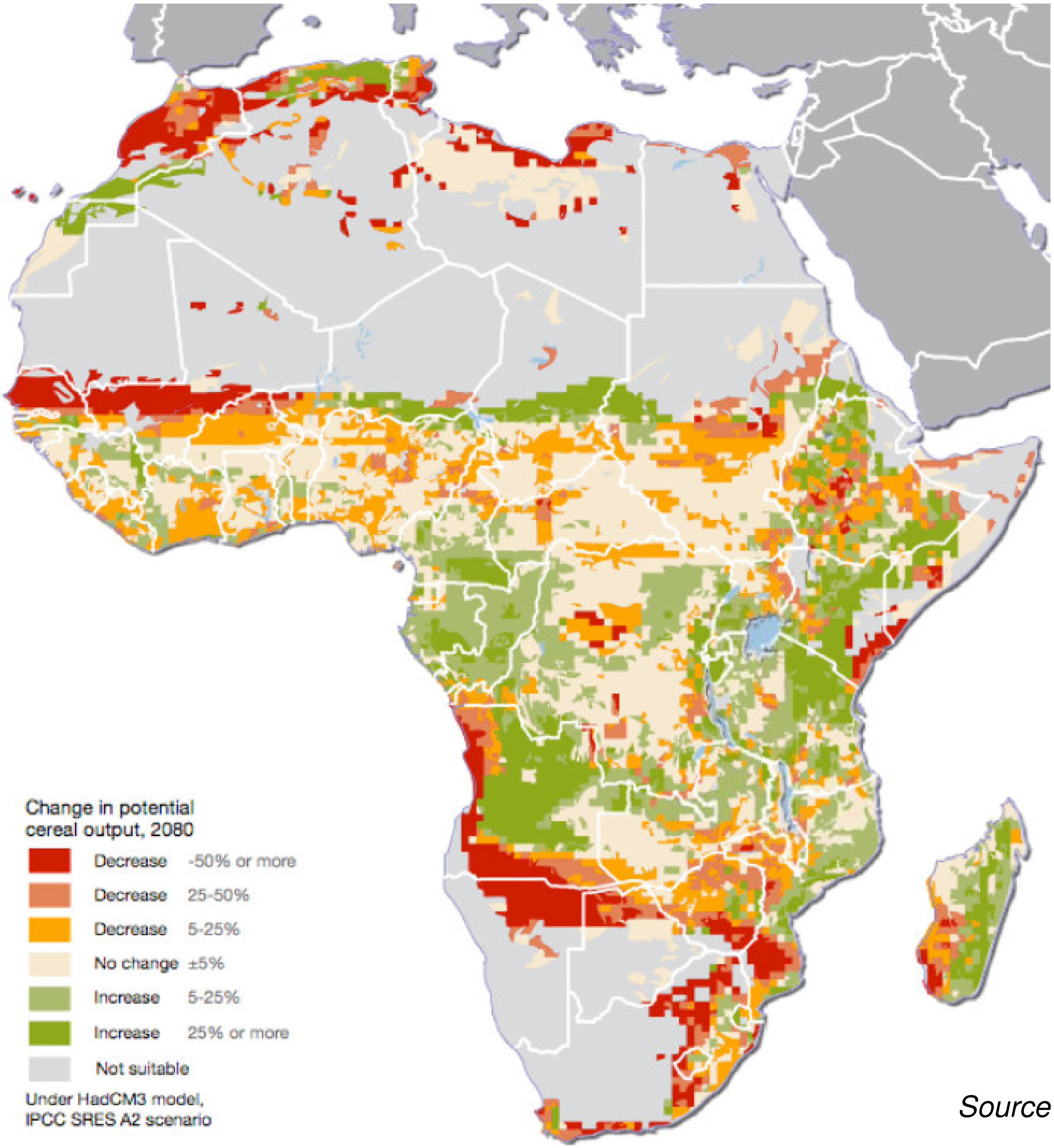
Four year study engaged over 400 scientists and agricultural experts from 110 countries, two peer reviews, concludes that small scale agroecological systems:

- generate greater yields per hectare
- more jobs per hectare
- resilient to drought and disease
- contributing positively towards climate change mitigation, adaptation and resilience.

IAASTD World Agricultural Report is ratified by 58 countries calls for governments to redirect their focus from chemical and energy intensive conventional farming systems towards productive small-scale agro-ecological farming linked to equitable distribution systems



Source UNEP 2009



Source UNEP 2009

Zero Waste Environmental Biotechnology

- In nature one natural kingdoms waste is food for another natural kingdom
- These natural processes can be used to produce energy and nutrients.
- Waste is not a problem but a resource!

Images Courtesy of ZERI SA

ENVIRONMENTAL BIOTECHNOLOGY

The optimal use of nature, in the form of plants, animals, bacteria, fungi and algae, to produce energy, food and nutrients in a synergistic integrated cycle of profit making processes where the waste of each process becomes the feedstock for another process.

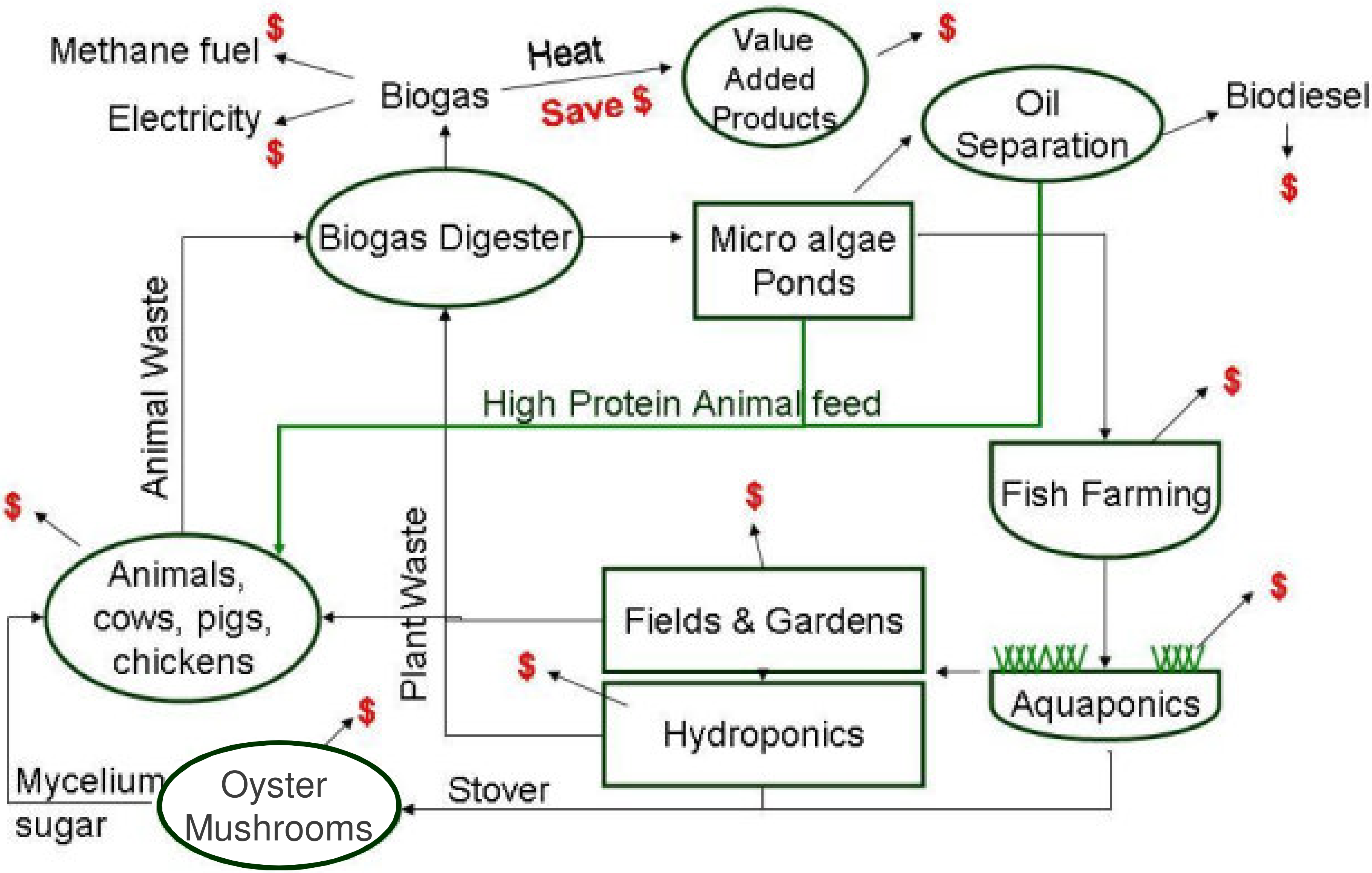
plants

animals

bacteria

fungi

algae



Simple Integrated Agro-Ecological System


Traditional farmers can utilize their kraal and biowaste resource to produce food, energy, feed & fertilizer.

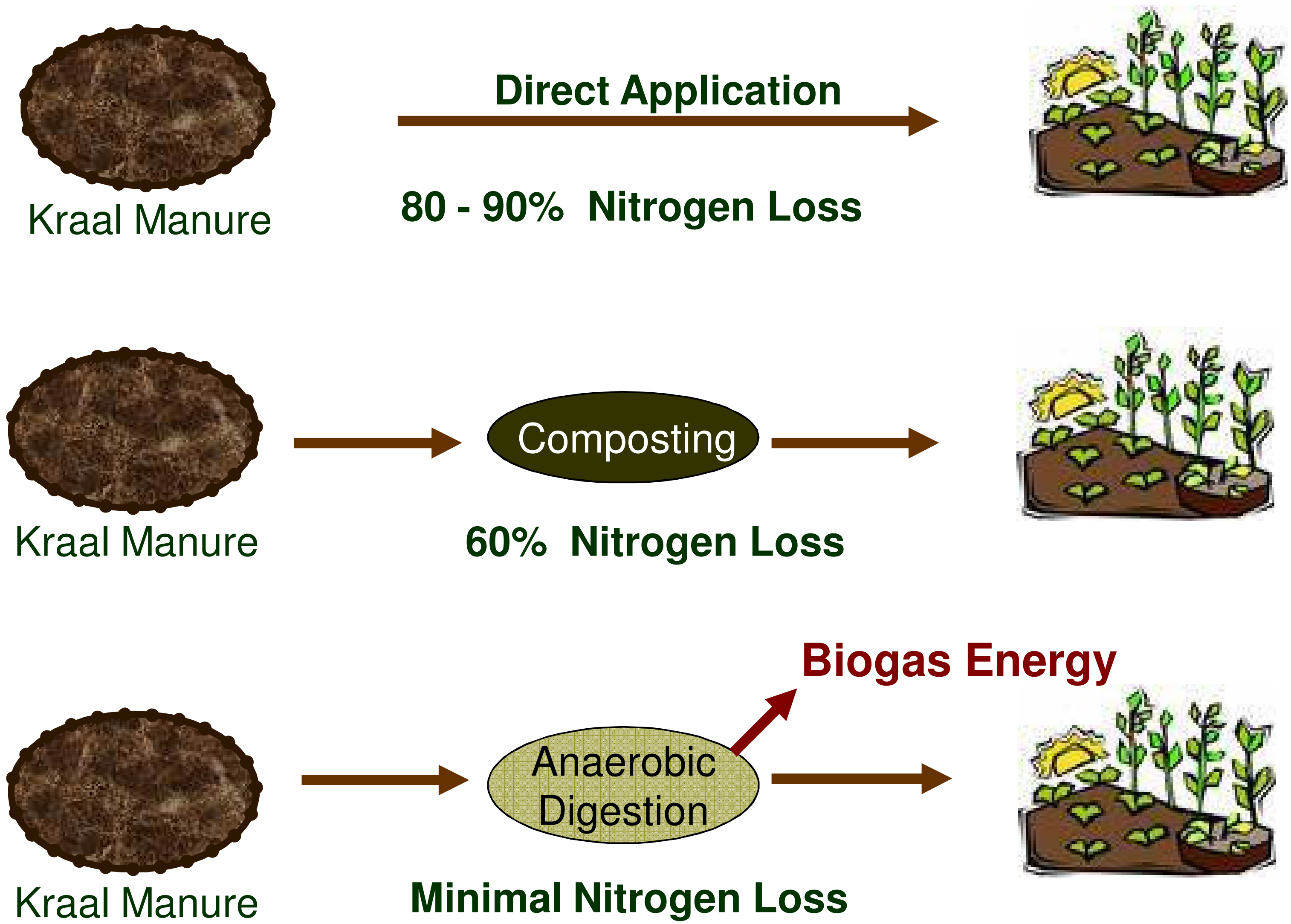
1.7 million smallholders with access to arable land

1.2 million cultivate crops like maize and sorghum

0.9 million have animals other than chickens biogas burner.MPG

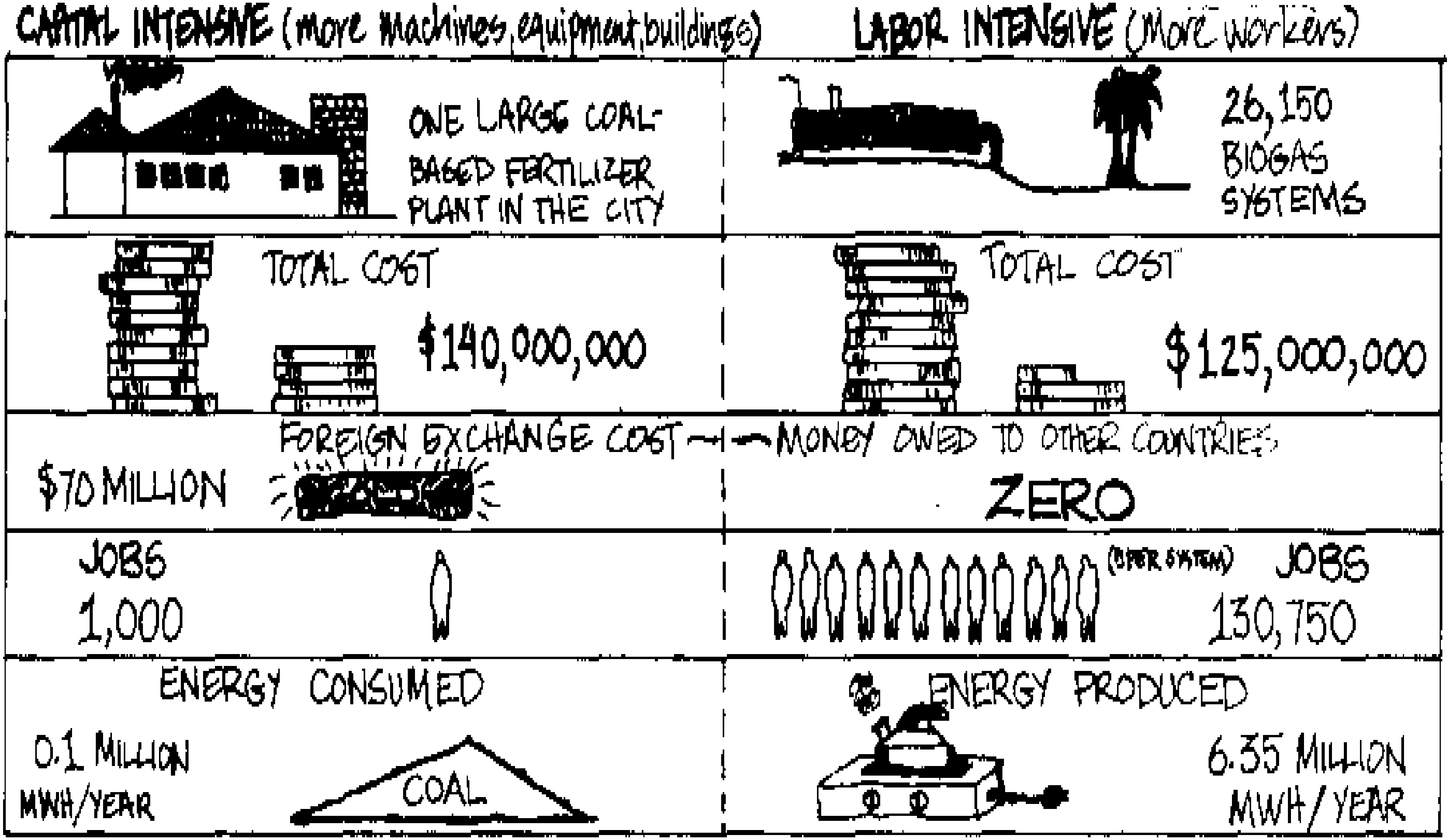
Low cost tube biogas digester for kraal waste at the Agro-ecological Cooperative in Chintsa, East Cape

Biogas for Biofertilizer



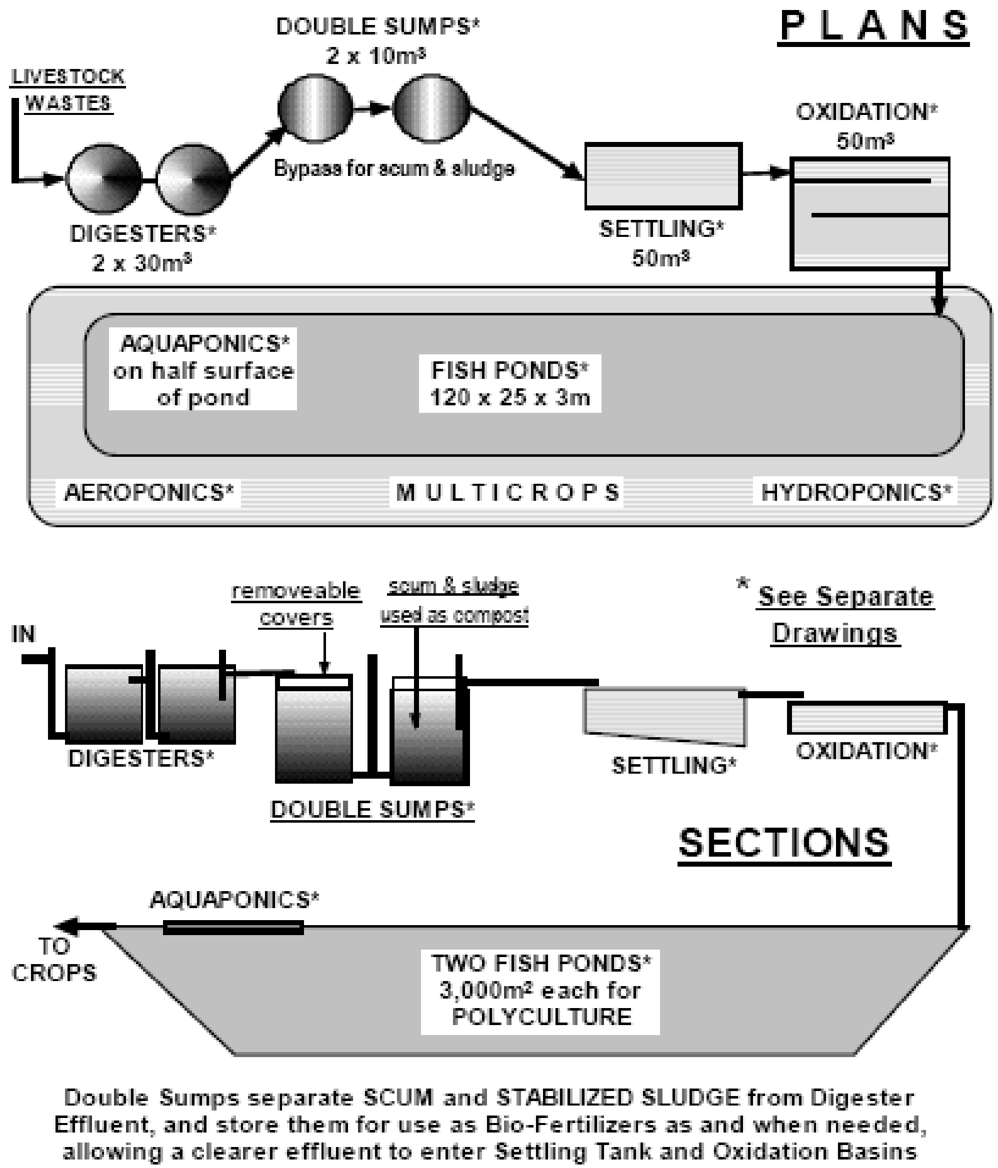
+ 20% more available Nitrogen after digestion

= 1200% more Nitrogen Available



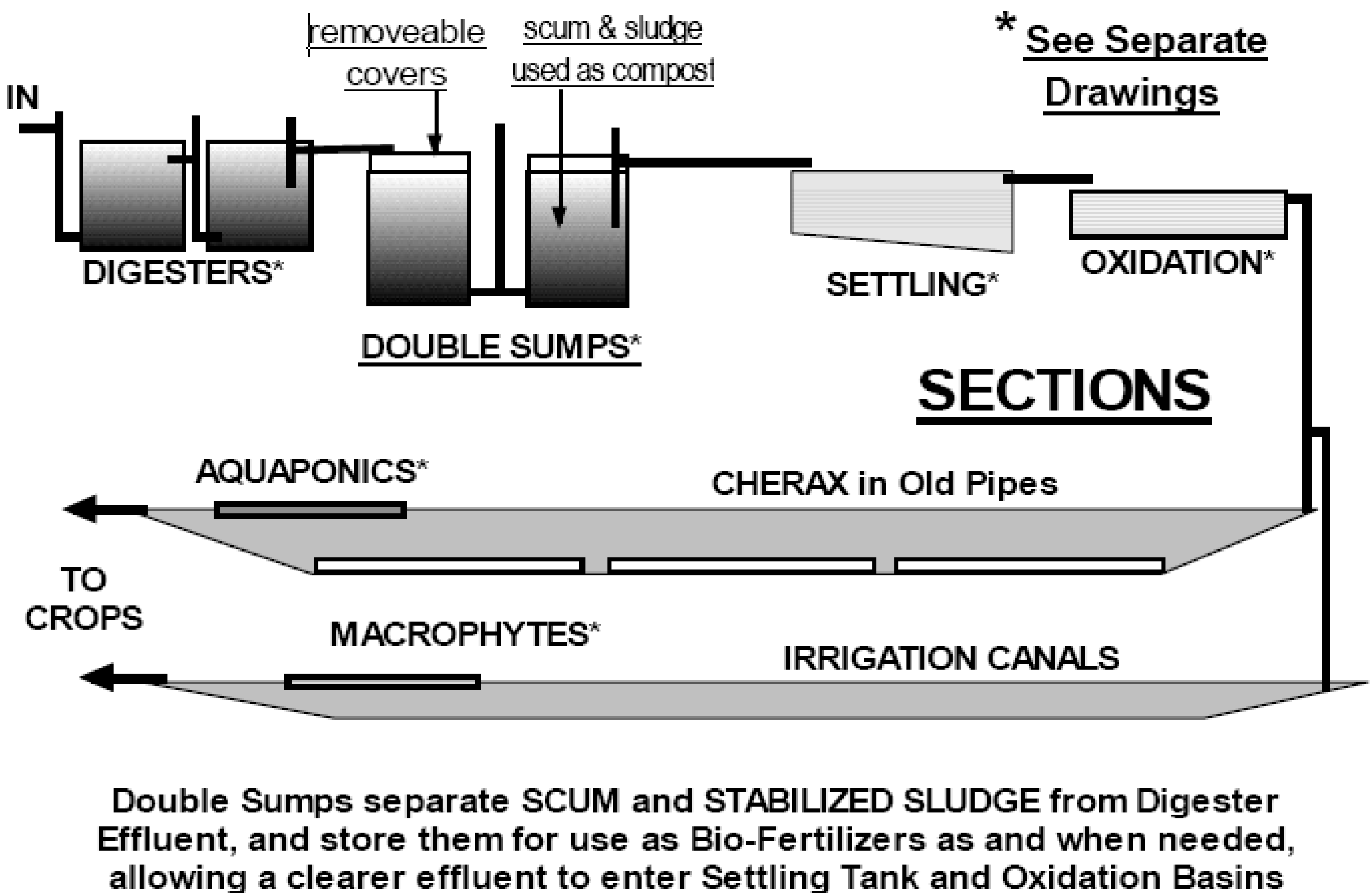
Source: US Peace Corp, 1985

Two Ways of Producing 230,000 Tons of Nitrogen-rich Fertilizer



Source (Chan, 2006)

Generic design for fin fish production



Source (Chan, 2006)

Generic design for fresh water crayfish production

Integrated Algal Systems

The production of microalgae such as Chlorella is a tried and tested oxidation method for the treatment of effluent from both large and small scale biogas digesters.

Integrated Biogas and Algal Sytsems were pioneered by Golueke and Oswald in 1970's and enhanced by Professor George Chan from the Zero Emission Research and Initiatives (ZERI) organisation.

Source (Chan, 2006)

Source (Chan, 2006)

Integrated Biogas & Algal System in Fiji

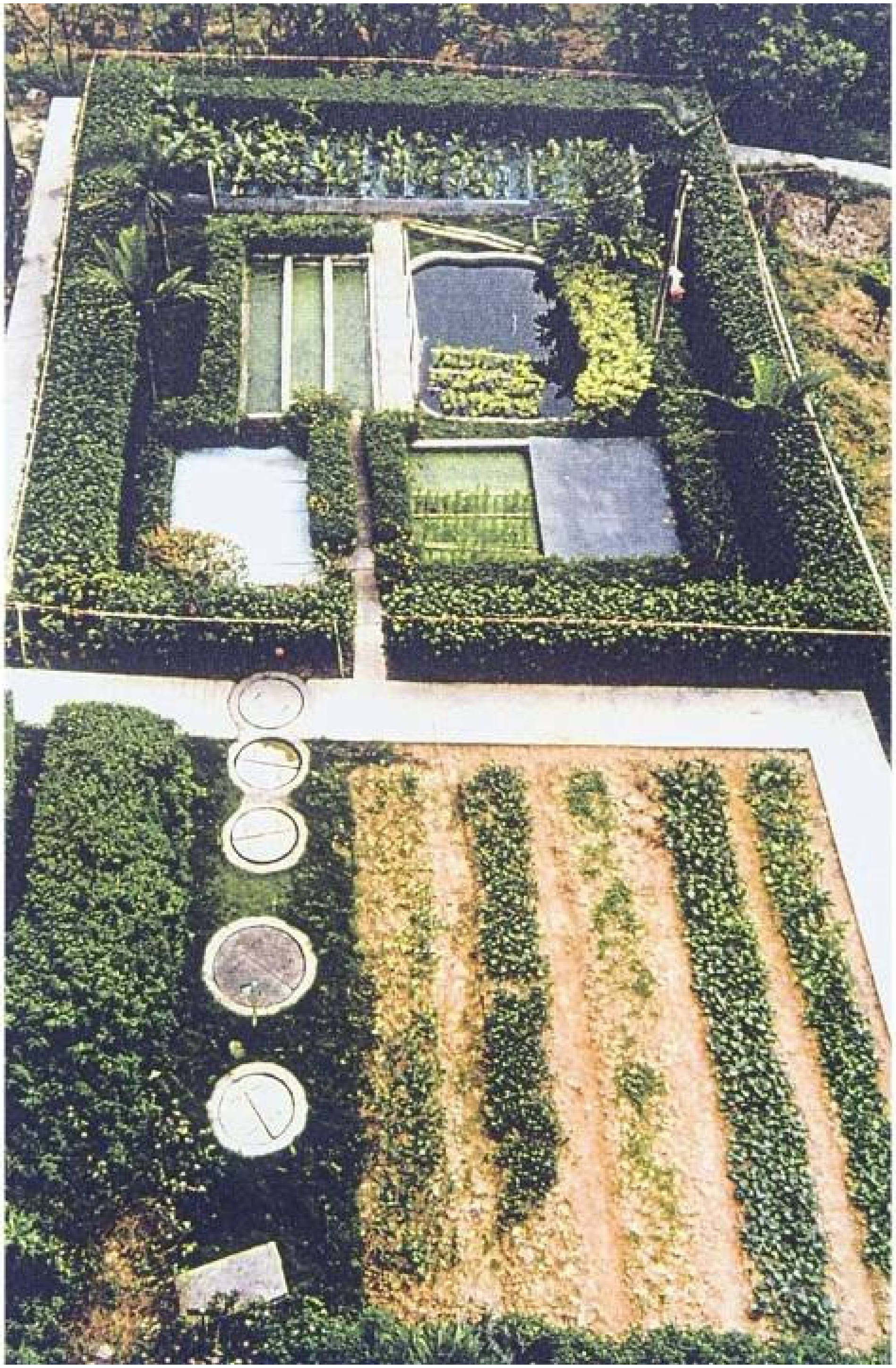
Source (Chan, 2006)

With Integrated Aquaculture

Source (Chan, 2006)

High Rate Algal Ponds, Brazil

Algal production is enhanced by movement of liquid with paddles in the basins for more exposure to solar energy & dissolved oxygen.



Urban Integrated Biogas and Algal System

Ponds at 3 blocks of apartments, Hamburg Institute, Dongguan, China

Consists of:

Biogas Digesters,

Settling tanks,

Algal oxidation basins,

Fish pond,

Hydroponics,

Garden.

Source (Chan, 2006)

Aquaponics on nutrient rich organic fertilizer

Source (Chan, 2006)

Young PAPAYA Trees were Irrigated and Fertilized by nutrient rich water after the algal ponds show quick growth and early fruit bearing.

Daily irrigation with nutrient pond water produces more growth than chemical fertilizer applied twice a year.

Source (Chan, 2006)

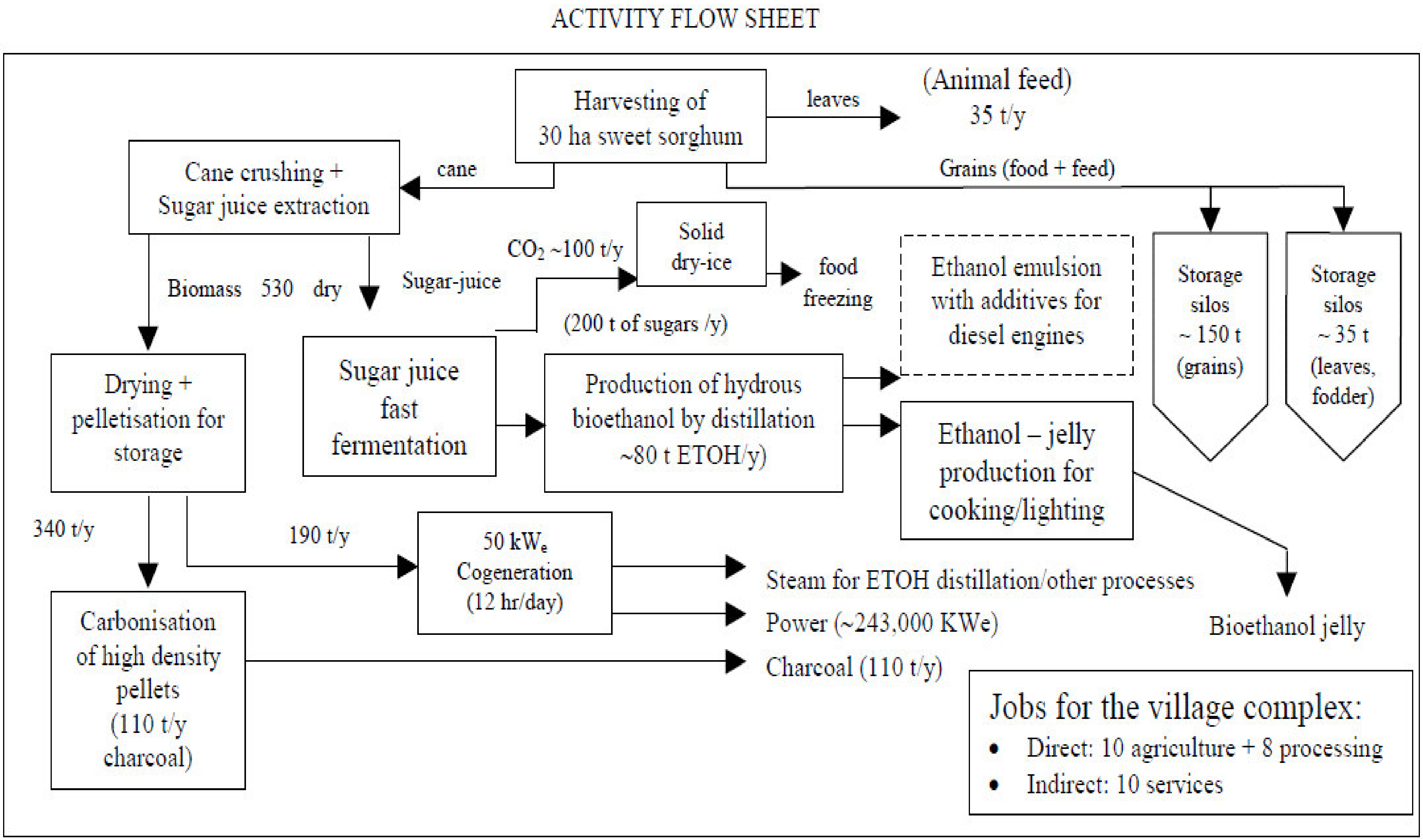
Aquaculture

Aquaponics


Aeroponics and Hydroponics from aquaculture effluent


Mushroom Production from Stover and Grass using biogas for sterilisation

Sweet Sorghum



Source: Small-Scale Modern Autonomous Bioenergy Complexes Development Instrument For Fighting Poverty And Social Exclusion In Rural Villages,G. Grassi and Zhou Qiong, European Biomass Industry Association, June 2002,

Action Required

- Establish environmental biotechnology agro-ecological reference centres that demonstrate food and fuel production and distribution for smallholders

- Develop appropriate community based biofuel processing technologies:
  - Biogas scrubbing, compression and storage
  - Oil extractors and biodiesel processing
  - Sugar sap extractors, ethanol fermentation & distillation

- Introduce applications for technologies for bioenergy utilisation for rural communities
  - e.g. Biogas powered electrical generators, chillers and vehicles
  - e.g. Ethanol powered engines, pumps, chainsaws and vehicles

- Ongoing research to enhance productivity of integrated systems

Biogas is People's Power!

Biogas

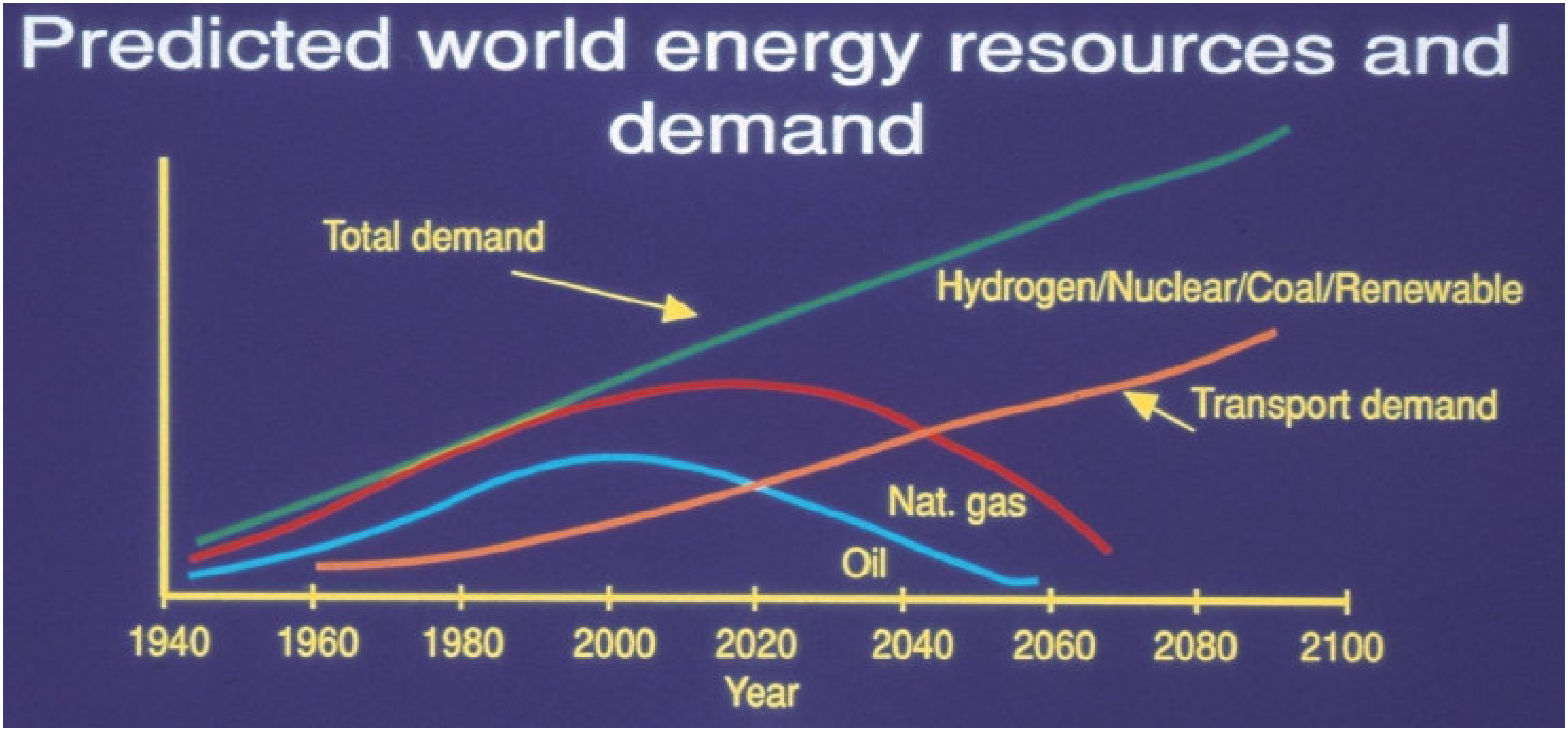
- Anaerobic fermentation is a 3000 year old technology
- There are over 15 million biogas digesters worldwide
- Sector growth is > one million digesters / year
- Produces useful methane rich biogas energy
- Produces useful biofertilizer sludge and effluent

Biogas digester advantages

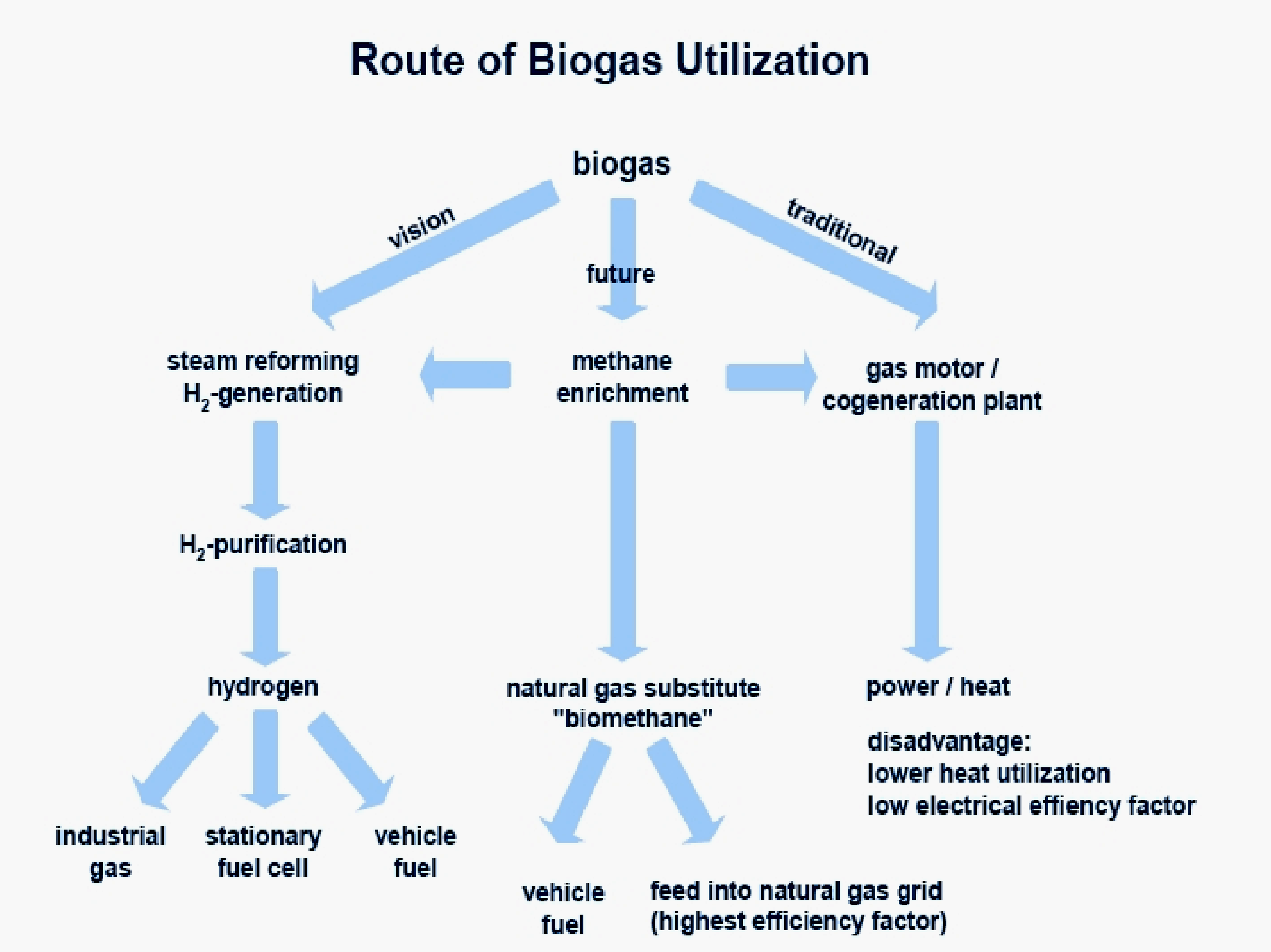
- Low maintenance ecological sanitation
- Digests food waste (40% of solid waste), leads to 80% reduction of municipal waste removal cost
- Enhanced Nutrient capture & fertilizer production
- Water recycling & purification
- No Chemical and Electrical Inputs
- No bad smells

BIOGAS COMPOSITION

Composition of biogas		
Substances	**Symbol**	**Percentage**
Methane	CH_4	50 – 70
Carbon Dioxide	CO_2	30 – 40
Hydrogen	H_2	5 – 10
Nitrogen	N_2	1 – 2
Water vapour	H_2O	0.3
Hydrogen Sulphide	H_2S	Traces



Biogas is rich in bio-methane, a sustainable renewable fuel not linked to the unstable price of fossil fuels


Route of Biogas Utilization
biogas
vision
future
traditional
steam reforming
H_2-generation
methane
enrichment
gas motor /
cogeneration plant
H_2-purification
hydrogen
natural gas substitute
"biomethane"
power / heat
disadvantage:
lower heat utilization
low electrical effiency factor
industrial
gas
stationary
fuel cell
vehicle
fuel
vehicle
fuel
feed into natural gas grid
(highest efficiency factor)

Source (Japan for Sustainability, 2009)

Biogas powered vehicles?

Source (Examiner, 2009)

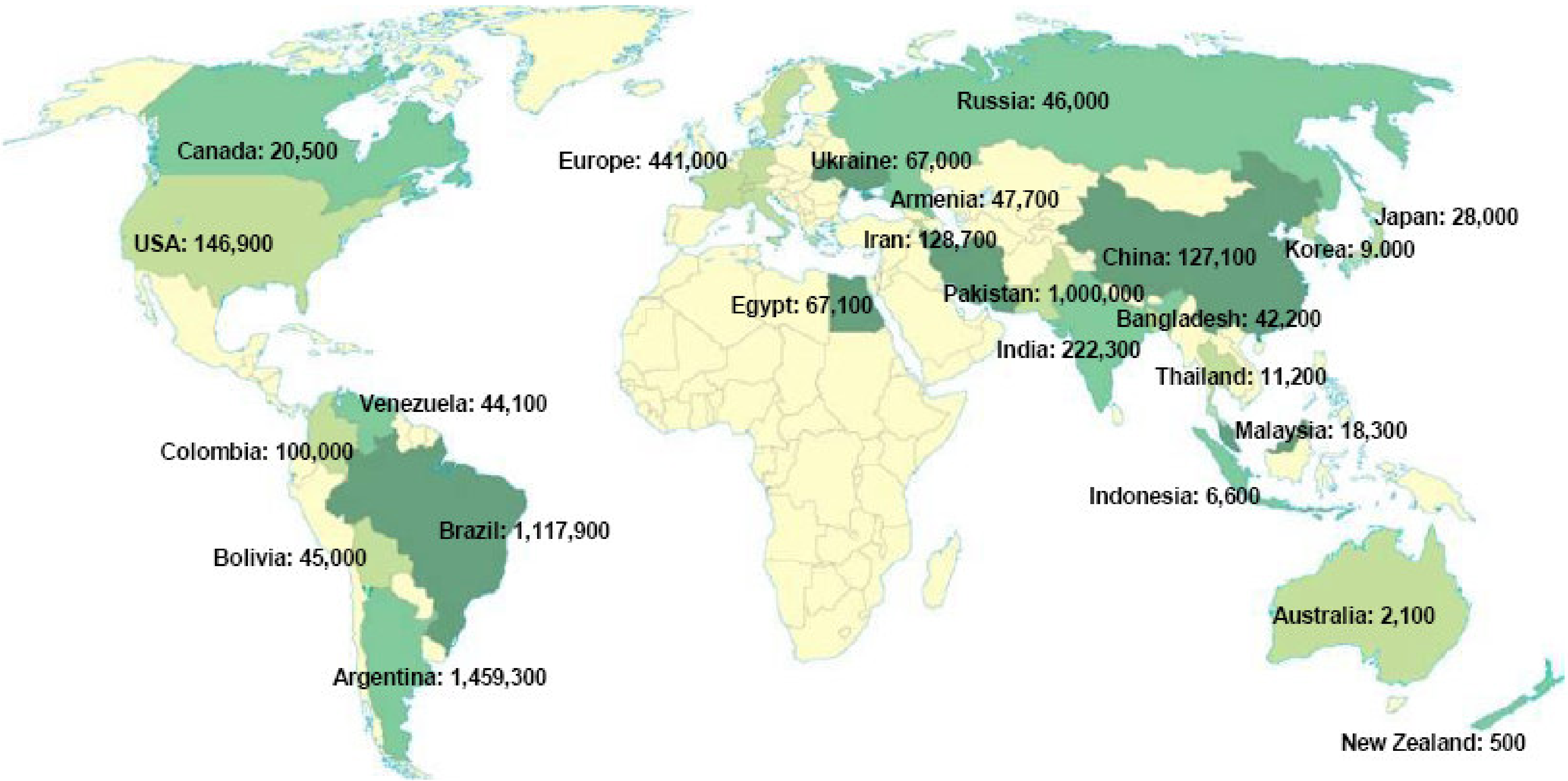
Twin-turbo 3.0-liter Audi A4 Quattro

364.6km/h speed record on biogas from grass clippings,

Maximum Horse Power = 800 (597 kW)

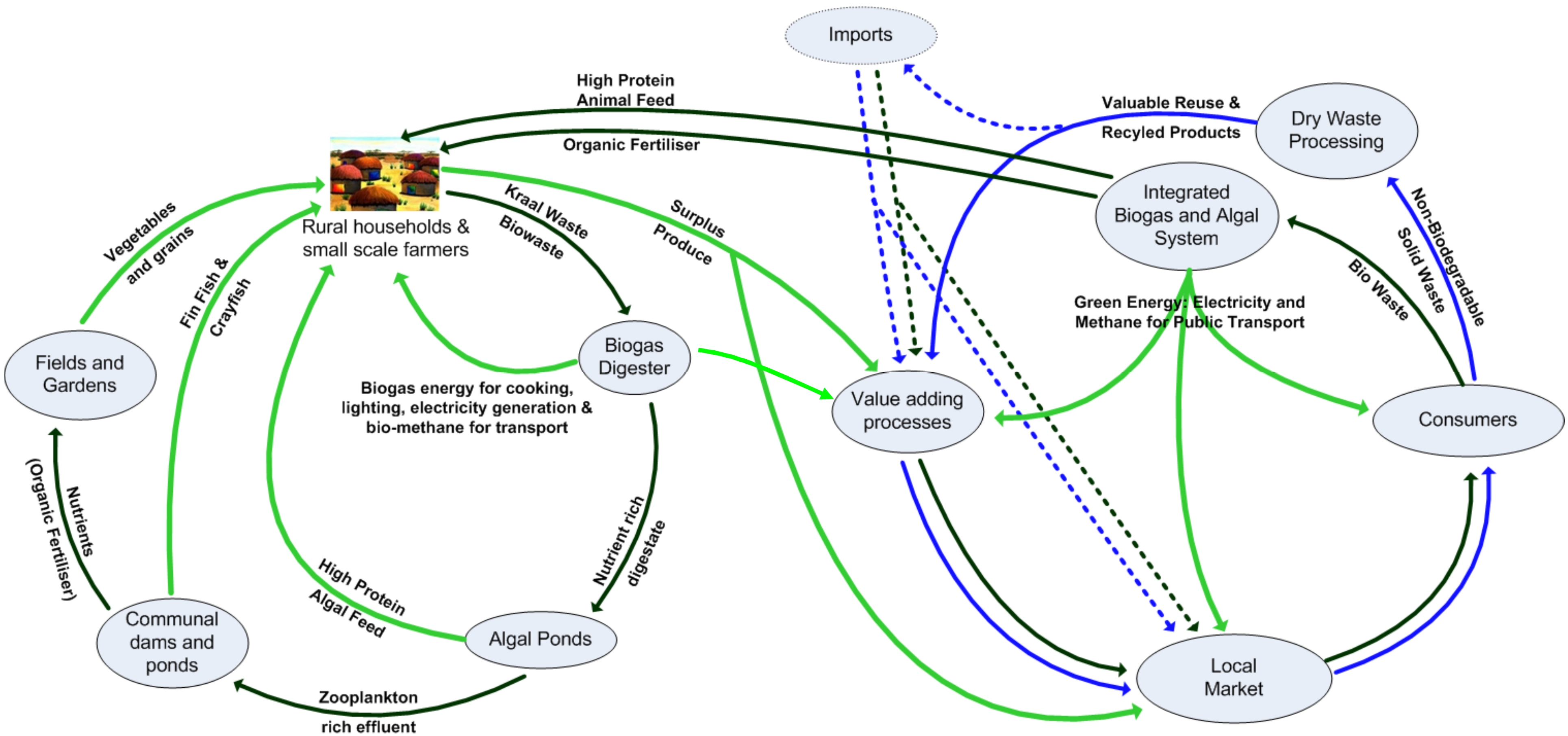
Biogas powered vehicles, Sweden

Over 7 Million Natural Gas Vehicles (NGVs)



30 Million NGVs by 2020

Closing the Rural and Urban Loop in a Zero Waste Economy



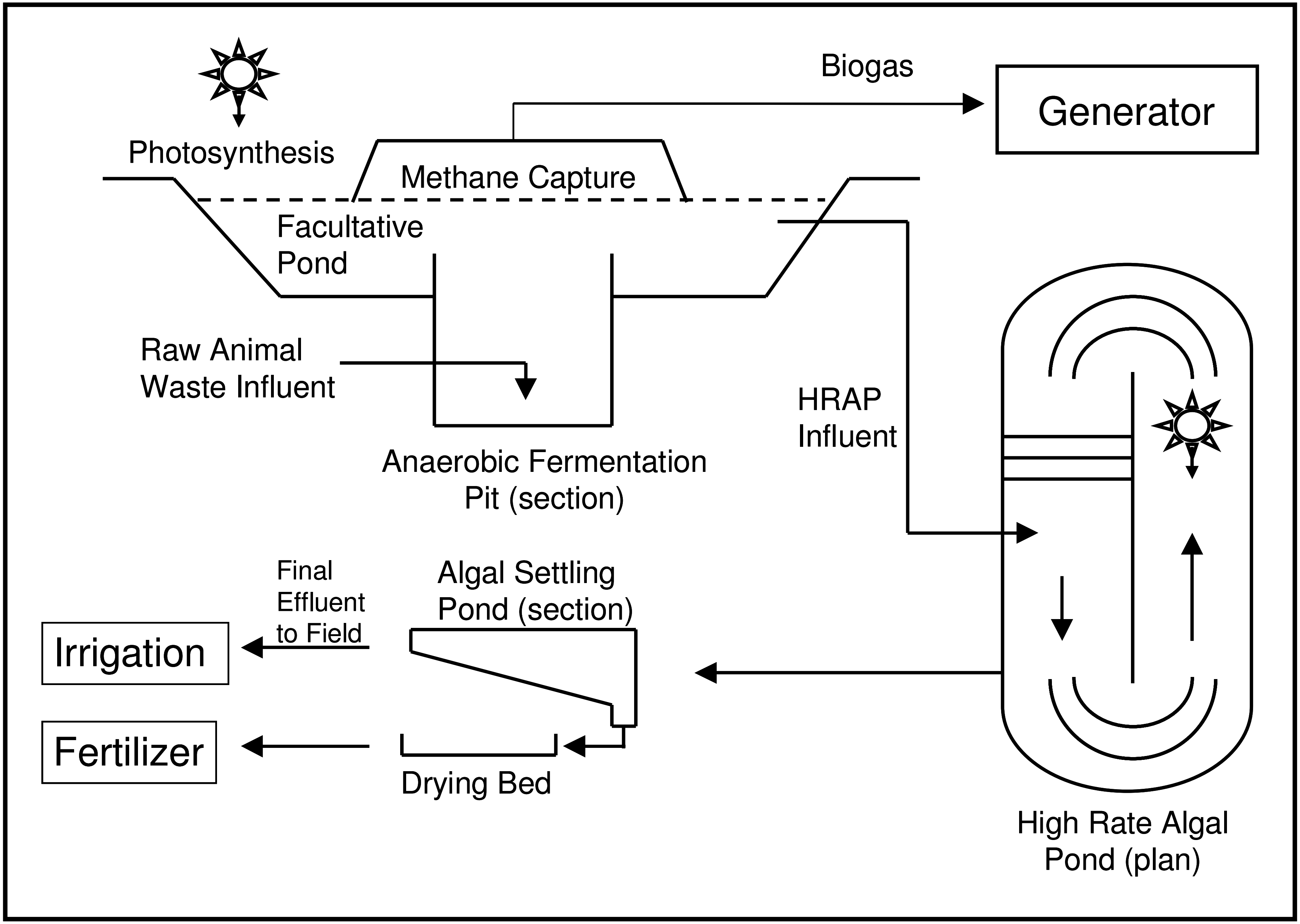
Job creation, food security, energy & fuel security, environmental protection, and nutrient beneficiation

Source (Render, 2008)

Integrated System AIPS™ reference plant at EBRU, Grahamstown

AIWPS® or AIPS Algae technology

- The AIPS™ system has been used for wastewater treatment for more than 30 years
- There are hundreds of AIPS™ plants internationally with the largest plant processing 7.2 million litres of waste water per day
- The Dept of Water Affairs and Forestry DWAF brought the patent into the public domain in South Africa after 12 years of extensive tests at the 500 person reference plant at the Institute of Environmental Biotechnology, Rhodes University (IEBRU)



Source (Render, 2008)

The AIPS Process

AIWPS® or AIPS Benefits

- Fermentation pit design captures heavy metals
- Algae is excellent source of nutrients
  - Fertilizer & Foliar feed
  - Oils for biodiesel
  - Nutracueticals & Metabolites
  - Pigments
  - Amino Acids
  - Plant Hormones
  - ß-carotene

Source (Render, 2008)

High Rate Algal Ponds sized for 1000 people

AIPS Disinfection mechanism

Combined interaction of:

- Anaerobic fermentation
  - Digestion of solids into elemental nutrients
  - Prolonged (100+ day) oxygen free environment destroys most aerobic pathogens
- Algal Ponds with
  - Sunlight (UV)
  - DO (Dissolved Oxygen) – Supersaturated to 30mg per litre
  - pH – up to 10.5 (ph of 9.2 will kill 100% ecoli)

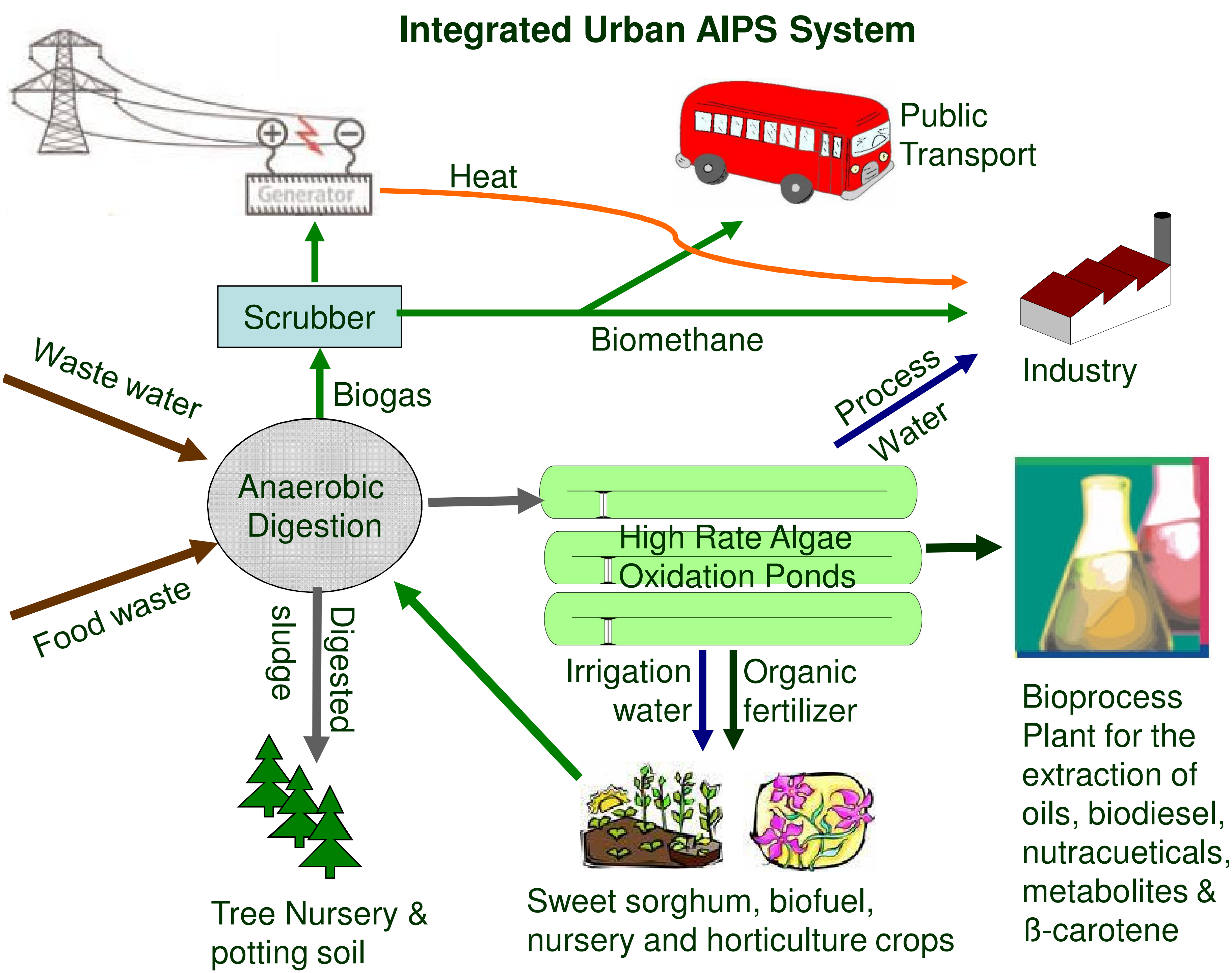
Source (Render, 2008)

Pathogen free 'bright' water from algal pond

Source (Render, 2008)

Pathogen free algal biofertilizer

1.4 x more effective than 2:3:2, N:P:K fertilizer (Horen, 2004)



Integrated Urban AIPS System
Generator
Heat
Public Transport
Scrubber
Biomethane
Industry
Waste water
Biogas
Process Water
Anaerobic Digestion
High Rate Algae Oxidation Ponds
Food waste
Digested sludge
Irrigation water
Organic fertilizer
Bioprocess Plant for the extraction of oils, biodiesel, nutracueticals, metabolites & ß-carotene
Tree Nursery & potting soil
Sweet sorghum, biofuel, nursery and horticulture crops

Hoodpoint Integrated Biogas Intervention Feasibility Study (ongoing)

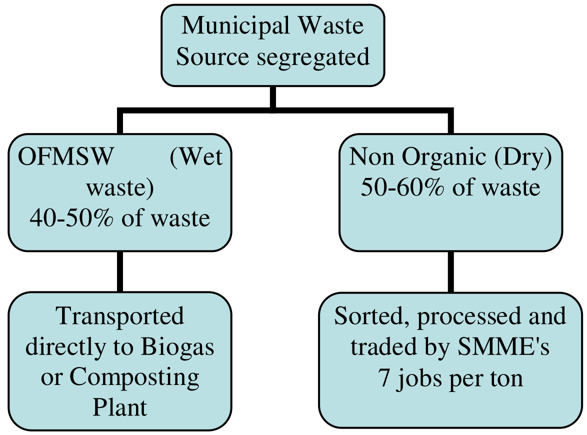
Unlicensed (illegal) shoreline discharge 10Ml/day of sewage and 3Ml/day of waste activated sludge at Hoodpoint

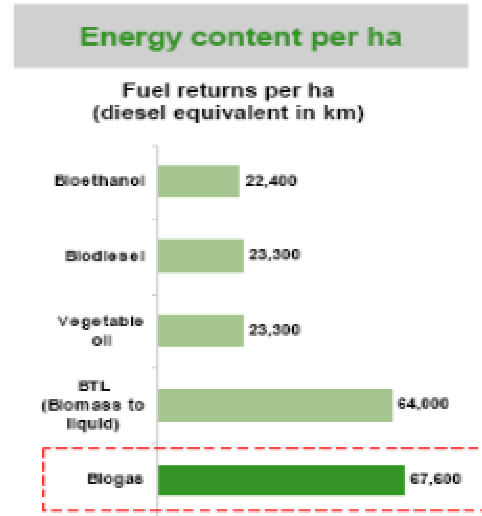
Moratorium on R200million pipeline until alternatives investigated

An integrated Biogas Intervention with codigestion of 90 tons of biowaste could create 3million litres of petrol equivalent in biogas per annum; generate more than 862 tons of algal fertilizer

PEOPLE'S POWER AFRICA CONVERTING WASTE INTO ENERGY
ELEMENT Consulting Engineers A FIFTH DIMENSION TO ENGINEERING
Environmental Biotechnology Research Unit
DBSA Development Bank of Southern Africa
IZWA Institute for Zero Waste in Africa
LeAF

Queenstown Central Anaerobic Digester Feasibility Study (ongoing)





Feedstock:

- 1000m^3 WAS per day
- Up to 10000 tons OFMSW (municipal biowaste)
- Manure from from 3000sow piggery
- Biowaste from 100LSU abattoir
- 300 ha of bioenergy crops (sweet sorghum)

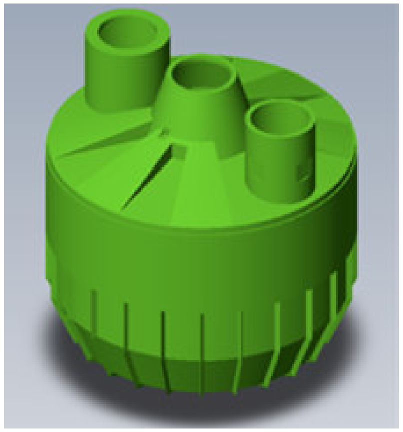
DBSA Development Bank of Southern Africa

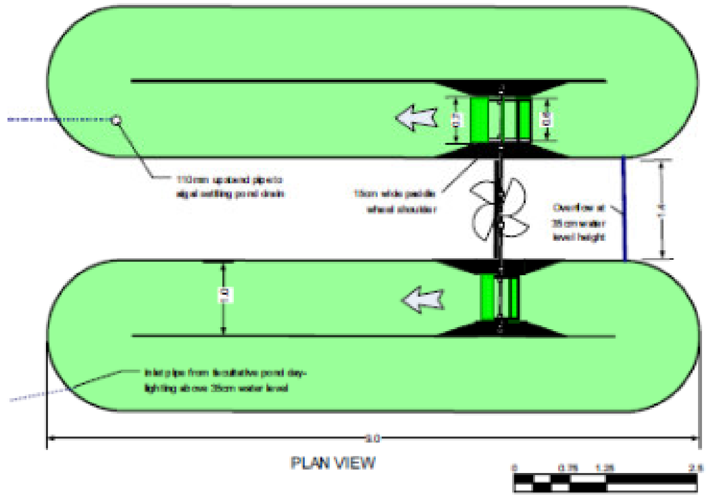
CES

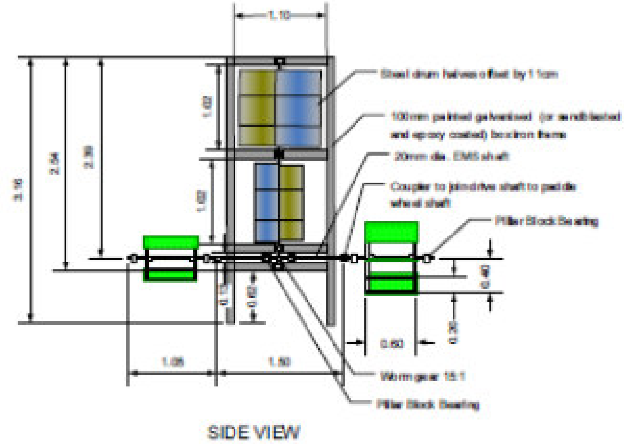
PEOPLE'S POWER AFRICA
CONVERTING WASTE INTO ENERGY

CHRIS HANI DISTRICT MUNICIPALITY
SUSTAINING GROWTH THROUGH OUR PEOPLE

Chris Hani District Municipality Rural Schools Integrated Biogas Pilot







Objectives:

•Waterborne sanitation for 170 students and staff & codigestion of canteen waste;

•Demonstrate resource recovery and energy generation from biowaste streams;

•Biogas energy to for cooking of school meals;

•Pathogen free algal biofertilizer for schools gardens;

•Water recycling & aquaculture (second cycle of soluble nutrients) for irrigation;

•compliance with environmental health legislation & regulations;

•Compliment WESSA schools greening programme with a working life science laboratory demonstrating food and fuel security.

DBSA Development Bank of Southern Africa

PEOPLE'S POWER AFRICA CONVERTING WASTE INTO ENERGY

WILDLIFE AND ENVIRONMENT SOCIETY OF SA People caring for the Earth

CHRIS HANI DISTRICT MUNICIPALITY SUSTAINING GROWTH THROUGH OUR PEOPLE

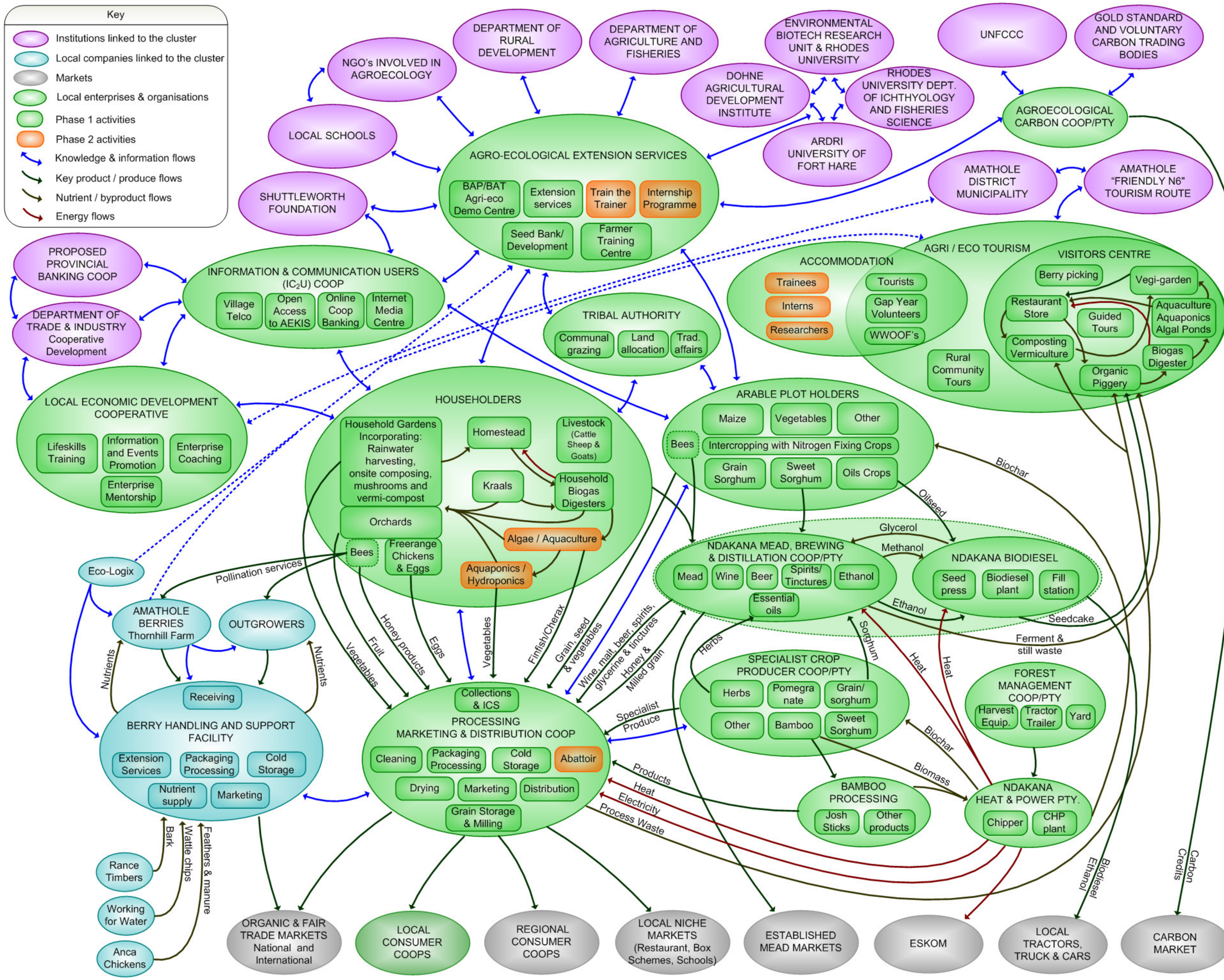
ZERO WASTE AGRICULTURAL BUSINESS CLUSTER

Local Spatial Development Framework called for the development of a zero waste agricultural business cluster in the Ndakana area with:

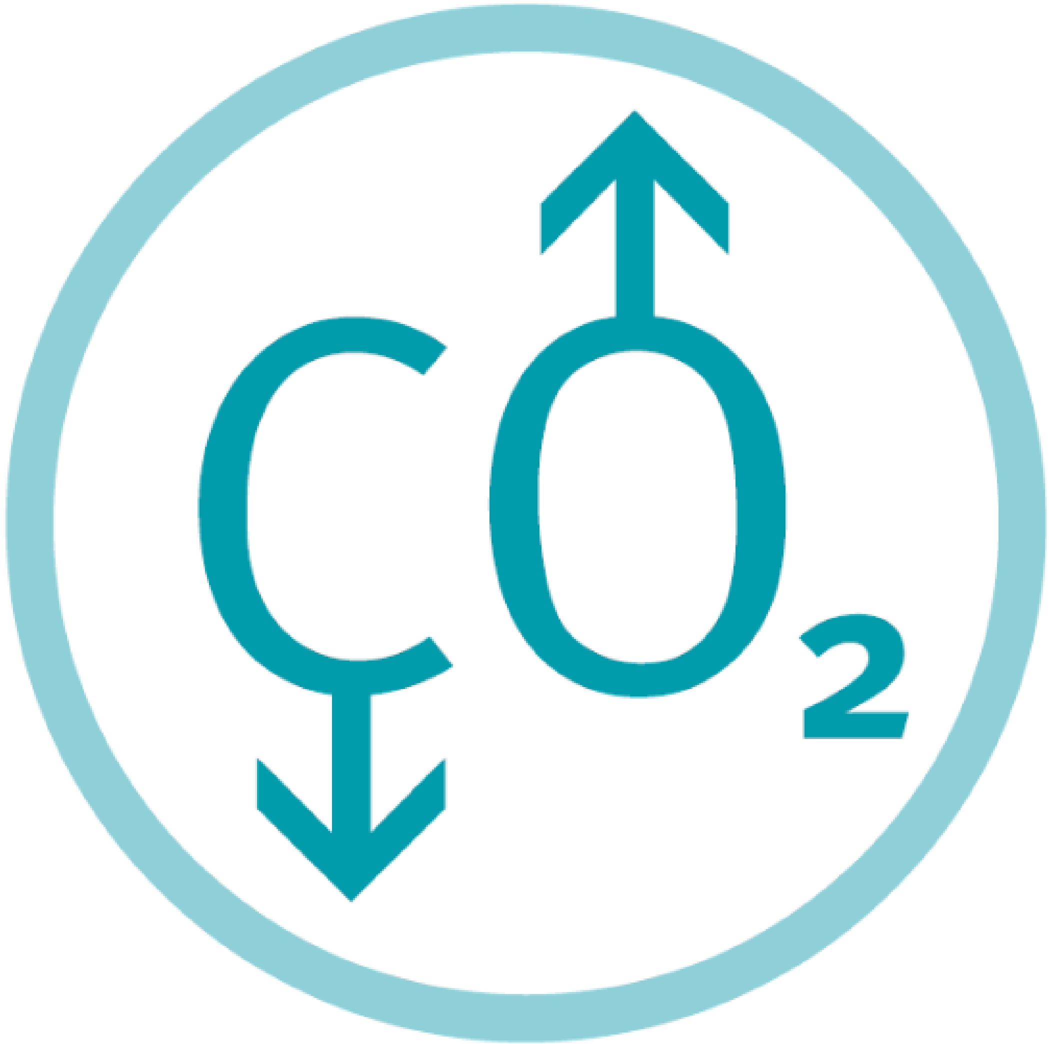
1. 2350ha of tribal land owned by the Amazibula tribe
2. four villages, 1500 houses 8000 people
3. 60% of households have subsistence household food gardens
4. 90% of households have livestock

Pre-feasibility study identified potential for 2500 sustainable livelihoods and jobs in food and value add cluster along with the following bioenergy production:

1. 1MWe from CHP using invasive wattle and/or waste bamboo
2. Surplus heat from CHP for boilers, pasteurisation, dehydration, drying, chilling (coldrooms), brewing, distillation biodiesel manufacture.
3. 100 000 l/year of biodiesel produced from oil seed crops
4. 1000 000 l/year of bioethanol produced from drought resistant sweetsorghum
5. 450 000 tons/year of biomethane (equivalent to 700 000 litres petrol) from anaerobic fermentation of kraal manure



Key
Institutions linked to the cluster
Local companies linked to the cluster
Markets
Local enterprises & organisations
Phase 1 activities
Phase 2 activities
Knowledge & information flows
Key product / produce flows
Nutrient / byproduct flows
Energy flows
NGO's INVOLVED IN AGROECOLOGY
DEPARTMENT OF RURAL DEVELOPMENT
DEPARTMENT OF AGRICULTURE AND FISHERIES
ENVIRONMENTAL BIOTECH RESEARCH UNIT & RHODES UNIVERSITY
UNFCCC
GOLD STANDARD AND VOLUNTARY CARBON TRADING BODIES
DOHNE AGRICULTURAL DEVELOPMENT INSTITUTE
RHODES UNIVERSITY DEPT. OF ICHTHYOLOGY AND FISHERIES SCIENCE
ARDRI UNIVERSITY OF FORT HARE
AGROECOLOGICAL CARBON COOP/PTY
LOCAL SCHOOLS
AGRO-ECOLOGICAL EXTENSION SERVICES
BAP/BAT Agri-eco Demo Centre
Extension services
Train the Trainer
Internship Programme
Seed Bank/ Development
Farmer Training Centre
SHUTTLEWORTH FOUNDATION
AMATHOLE DISTRICT MUNICIPALITY
AMATHOLE "FRIENDLY N6" TOURISM ROUTE
PROPOSED PROVINCIAL BANKING COOP
INFORMATION & COMMUNICATION USERS (IC_2U) COOP
Village Telco
Open Access to AEKIS
Online Coop Banking
Internet Media Centre
DEPARTMENT OF TRADE & INDUSTRY Cooperative Development
TRIBAL AUTHORITY
Communal grazing
Land allocation
Trad. affairs
AGRI / ECO TOURISM
ACCOMMODATION
Trainees
Interns
Researchers
Tourists
Gap Year Volunteers
WWOOF's
Rural Community Tours
VISITORS CENTRE
Berry picking
Vegi-garden
Restaurant Store
Guided Tours
Aquaculture Aquaponics Algal Ponds
Composting Vermiculture
Biogas Digester
Organic Piggery
LOCAL ECONOMIC DEVELOPMENT COOPERATIVE
Lifeskills Training
Information and Events Promotion
Enterprise Coaching
Enterprise Mentorship
HOUSEHOLDERS
Household Gardens Incorporating: Rainwater harvesting, onsite composing, mushrooms and vermi-compost
Homestead
Livestock (Cattle Sheep & Goats)
Kraals
Household Biogas Digesters
Orchards
Algae / Aquaculture
Bees
Freerange Chickens & Eggs
Aquaponics / Hydroponics
ARABLE PLOT HOLDERS
Maize
Vegetables
Other
Bees
Intercropping with Nitrogen Fixing Crops
Grain Sorghum
Sweet Sorghum
Oils Crops
Biochar
Oilseed
Glycerol
Methanol
NDAKANA MEAD, BREWING & DISTILLATION COOP/PTY
Mead
Wine
Beer
Spirits/ Tinctures
Ethanol
Essential oils
NDAKANA BIODIESEL
Seed press
Biodiesel plant
Fill station
Ethanol
Seedcake
Ferment & still waste
Eco-Logix
Pollination services
AMATHOLE BERRIES Thornhill Farm
OUTGROWERS
Nutrients
Nutrients
Receiving
BERRY HANDLING AND SUPPORT FACILITY
Extension Services
Packaging Processing
Cold Storage
Nutrient supply
Marketing
Vegetables
Fruit
Honey products
Eggs
Vegetables
Finfish/Cherax
Grain, seed & vegetables
Wine, malt, beer, spirits, glycerine & tinctures
Honey & Milled grain
Herbs
Sorghum
Heat
Heat
Collections & ICS
PROCESSING MARKETING & DISTRIBUTION COOP
Cleaning
Packaging Processing
Cold Storage
Abattoir
Drying
Marketing
Distribution
Grain Storage & Milling
Specialist Produce
SPECIALIST CROP PRODUCER COOP/PTY
Herbs
Pomegranate
Grain/ sorghum
Other
Bamboo
Sweet Sorghum
FOREST MANAGEMENT COOP/PTY
Harvest Equip.
Tractor Trailer
Yard
Biochar
Biomass
Products
Heat
Electricity
Process Waste
BAMBOO PROCESSING
Josh Sticks
Other products
NDAKANA HEAT & POWER PTY.
Chipper
CHP plant
Biodiesel
Ethanol
Carbon Credits
Bark
Wattle chips
Feathers & manure
Rance Timbers
Working for Water
Anca Chickens
ORGANIC & FAIR TRADE MARKETS National and International
LOCAL CONSUMER COOPS
REGIONAL CONSUMER COOPS
LOCAL NICHE MARKETS (Restaurant, Box Schemes, Schools)
ESTABLISHED MEAD MARKETS
ESKOM
LOCAL TRACTORS, TRUCK & CARS
CARBON MARKET



Support climate change resilient integrated smallholder agroecological food and bioenergy production linked to equitable distribution systems!

Thank you

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