



Sustainable Development

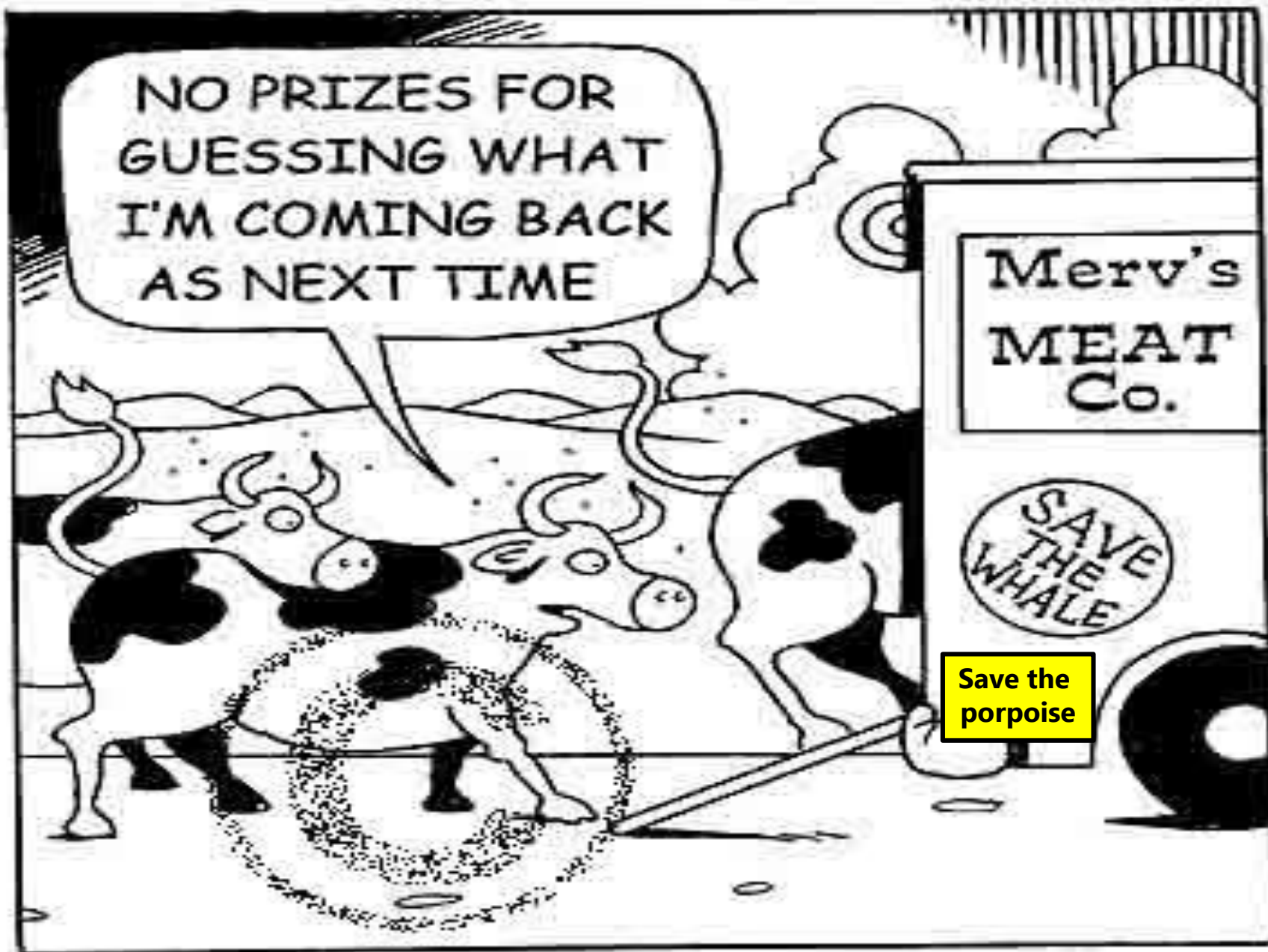
Agriculture and the Global Water Crisis

NO PRIZES FOR
GUESSING WHAT
I'M COMING BACK
AS NEXT TIME

Merv's
MEAT
Co.

SAVE
THE
WHALE

Save the
porpoise



Sustainable development

– ... development that improves the *quality of human life* while living within the carrying capacity of supported ecosystems. **IUCN (1991)**

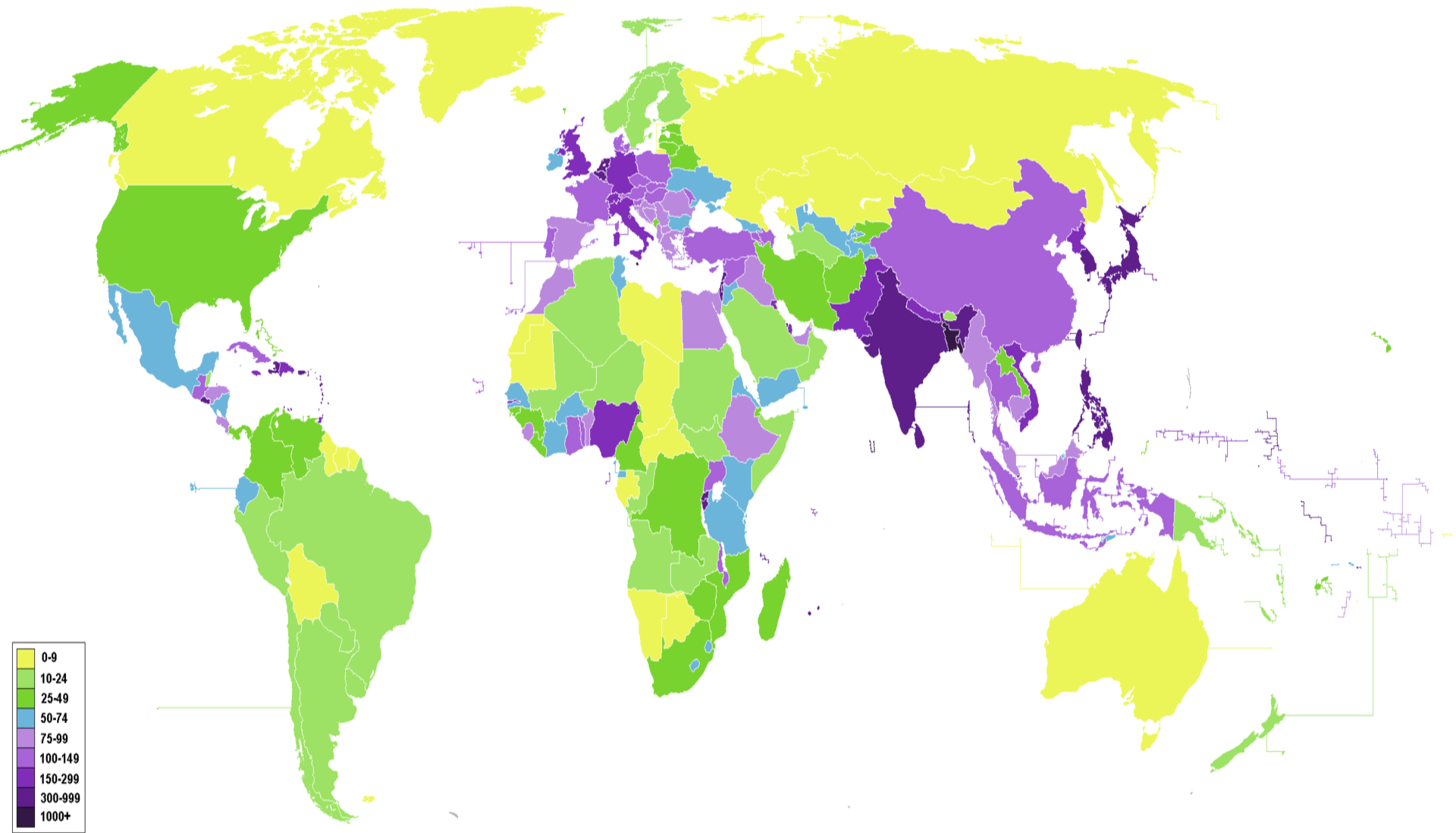
– ...development that meets the *needs of current generations without compromising* the ability of *future generations* to meet their own needs.
WCED (1987)

- In UK: 14 mill people in poverty
- Between Apr 2017 and Mar 2018, 1.3 mill emergency food supplies through food banks. 13%↑ (The Trussell Trust, 2018)

Current farming practices

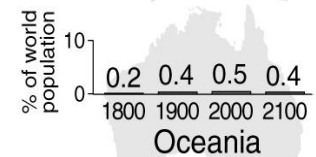
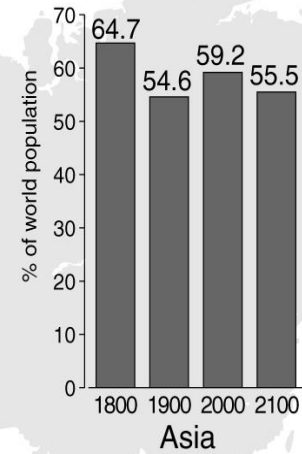
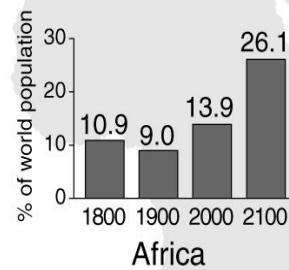
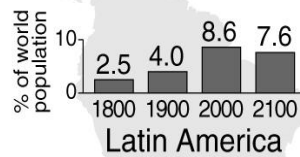
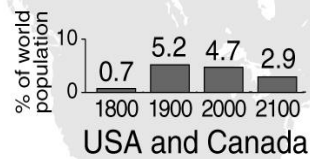


- ➔ “Together the world’s 7.7 billion people use land equal in size to South America to grow food and raise livestock—an astounding agricultural footprint. And demographers predict the planet will host 9.5 billion people by 2050. Because each of us requires a minimum of 1,500 calories a day, civilization will have to cultivate another Brazil’s worth of land—2.1 billion acres—if farming continues to be practiced as it is today. That much new, arable earth simply does not exist”. (Quick, 2019: 1)



No. People per km²

Population Density (Anon, 2014)



Global Distribution of Population

Agricultural Industry: Current situation

- ⇒ End of World War II – productivity ↑ due to new technologies
- ⇒ Continuity of supply; year-round availability; reduced risks in farming
- ⇒ Significant costs:
 - Topsoil depletion ■ Groundwater contamination
 - Decline family farms ■ ↑ costs of production
 - Disintegration economic and social conditions in rural communities

Common Agricultural Policy: Objectives

1. Increase productivity by promoting technical progress
2. Ensure a fair standard of living for farming community
3. Stabilise markets
4. Provide food for consumers at reasonable prices



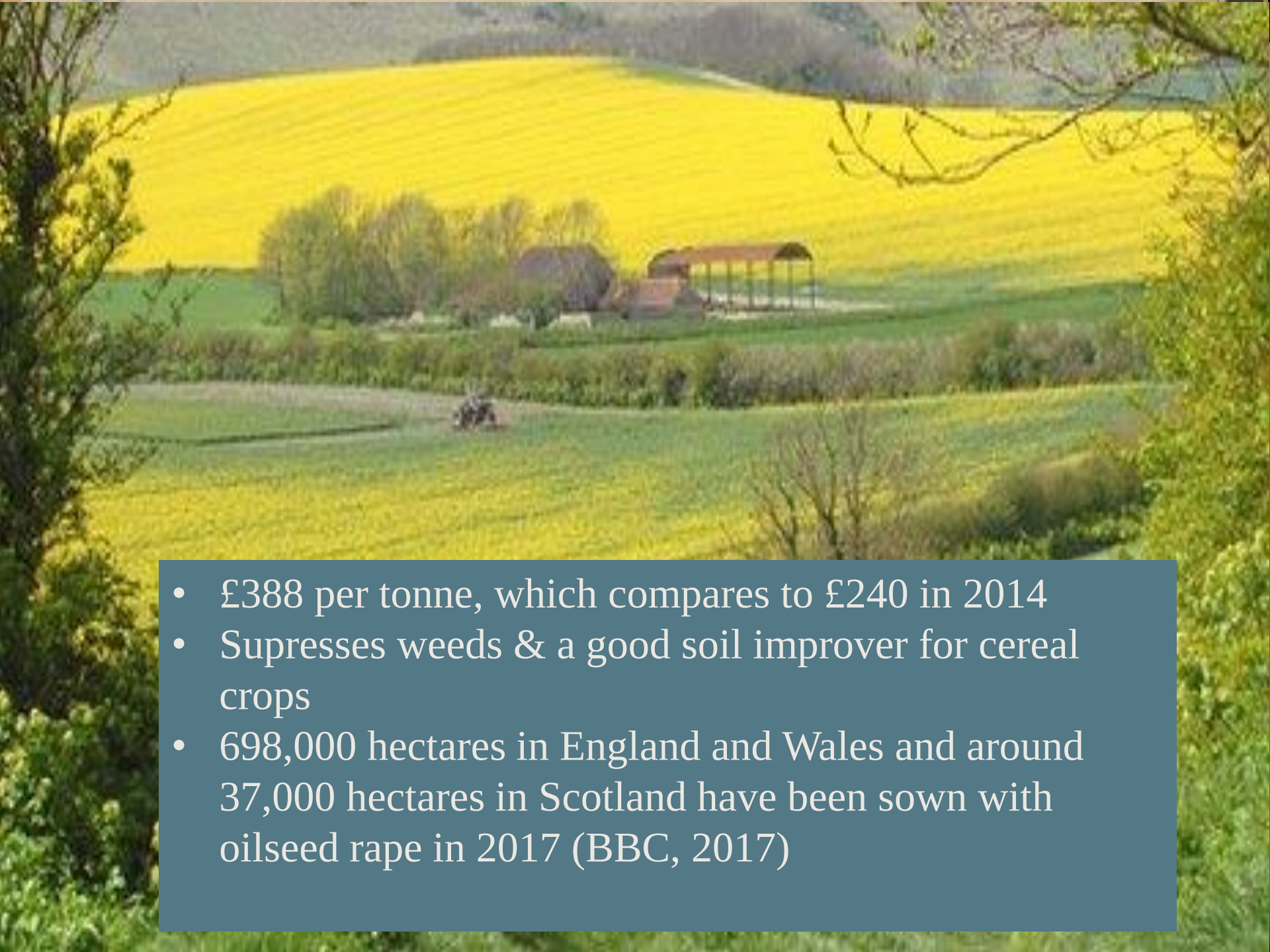
UK 'has some of the highest and most volatile food prices', claims Oxfam (Dugan, 2016)

- ⇒ 5th largest economy
- ⇒ Many now reliant on food banks – austerity measures
- ⇒ Global food index - The categories were: levels of undernourishment; affordability and volatility of food prices; quality of food and water and the health outcomes of people's diet.
- ⇒ UK came 3rd in 2017 behind Ireland & US



Common Agricultural Policy

- ⇒ System of European agricultural subsidies and programmes – price interventions
- ⇒ Minimum price to producers
- ⇒ Direct payment of a subsidy for crops planted – £40 bn pa (2016)
- ⇒ 38% EU's annual budget (2014-2020).
- ⇒ Currently a transfer of subsidy to land stewardship rather than specific crop production
- ⇒ Fischler Reforms of 2003 – Single Farm Payment

- 
- £388 per tonne, which compares to £240 in 2014
 - Suppresses weeds & a good soil improver for cereal crops
 - 698,000 hectares in England and Wales and around 37,000 hectares in Scotland have been sown with oilseed rape in 2017 (BBC, 2017)

Intensive Agriculture

⇒ Characterised by:

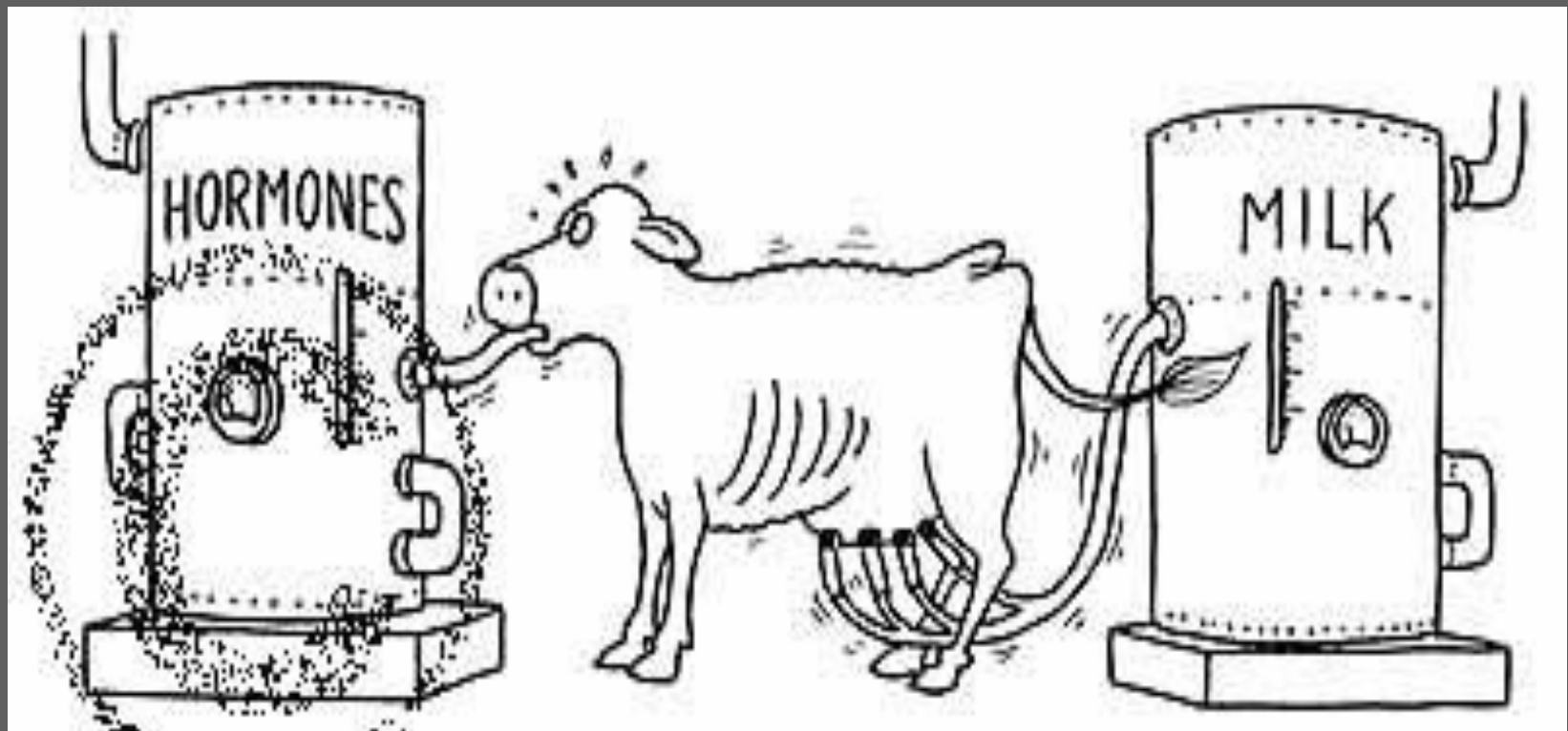
- Chemical reliance
- Soil Erosion
- Mono-crop culture
- Over-crowding and confinement of animals
- Over-use of hormone and antibiotic therapy
- LOSS OF BIODIVERSITY



A close-up photograph of a water vole (Arvicola amphibius) sitting on a dark, wet rock in a shallow stream. The vole is brown and furry, with its front paws holding a piece of light-colored wood. The water is calm, reflecting the surrounding green foliage and the vole itself. The background is filled with lush green plants, including some with large, serrated leaves. A semi-transparent green box with black text is overlaid on the upper part of the image.

**60% UK decline in species
31% have declined significantly
(RSPB, 2018: State of Nature Report)**

Intensive Agriculture



Intensive Agriculture

- ⇒ 65 billion animals slaughtered pa global → 7.7 billion people
- ⇒ Cheap food policy can cost society:
 - Rural employment
 - Human health
 - Environment
 - Animal welfare



Intensive Farming

- ⇒ Transmission of disease
- ⇒ Transportation live animals
- ⇒ Food miles
- ⇒ Equal share profits?



Sustainable Development Indicators



- ⇒ 33% ↓ 24 common birds in 25 years
- ⇒ Lapwings, skylarks, corncrake
- ⇒ Decline severest in NW Europe
- ⇒ 150 of the 453 birds regularly found in Europe – rely on sustainable agriculture to survive (RSPB, 2014)

A corncrake bird is visible in the background, standing in tall green grass. The bird has a mottled brown and grey pattern on its body and a distinctive yellow patch on its forehead. The text is overlaid on a semi-transparent dark green rectangle.

⇒ *“The decline of the corncrake has been one of the most obvious effects of the industrialisation of farming across Europe. Subsidies paid to farmers to maximise output have driven it out of much of the EU. This has been so marked you can pick out the outline of the Common Agricultural Policy imprinted on the distribution map of the bird” (Wynne, 2014:3 Chief Executive RSPB)*

Common Agricultural Policy: Failings

1. **Anti-development:** Unfair competition
2. **Artificially high food prices:** 25% higher than without CAP
3. **Disadvantaging smaller farms:** Traditionally CAP rewarded larger producers – now changed
4. **Environmental issues:** non- ecological ways of improving yield – indiscriminate use of pesticides
5. **What of water usage??**

The global picture.....



- Water demand doubling every 21 years
- Over 70% – irrigation
- Limits on irrigation $\Rightarrow$ limits on food production
- Limits on food production in poor countries $\Rightarrow$ imports, higher prices and political instability
- Water tables falling (WHO, 2015)



Sustainable Development – Quality of Life

- ▶ How do we define quality of life?
- ▶ What do you as an individual regard as quality of life
- ▶ Subjective and diverse



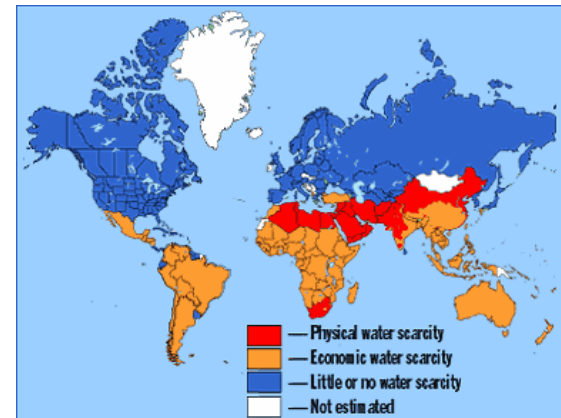
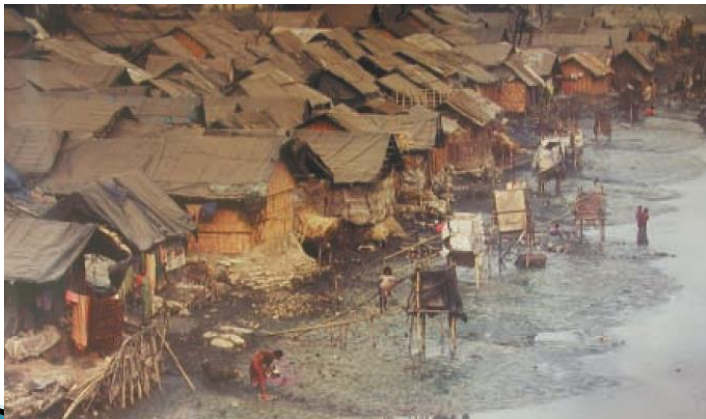


Intensive farming



Dust storm...the cost of soil erosion is calculated at £14m per year. Soil loss in the UK & USA is 17 times greater than soil formation. (UNEP, 2002)

Quality of life?



China faces most of the major challenges to sustainable agriculture

Fast socioeconomic development, rapid urbanisation and climate change, along with very limited water resources and arable land per capita

As arable land is available mainly in the water-scarce north, irrigation has become widespread, covering 45% of the country's agricultural land and accounting for 65% of national water withdrawal.



CHINA: SHIFTING NATURE (2006)

Development at any cost!

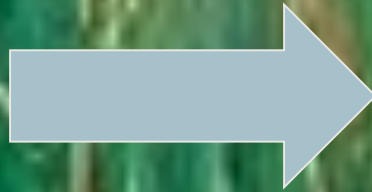
- Chinese economy growth rate 6.8% year-on-year since 1989
- Burgeoning population growth
- Environmental consequences
- Social engineering
- Increasing gap between wealthy and poor

China clearly has a water shortage problem. How might this be solved sustainably?

Twelve years post-water diversion, evaluate the success of the project in sustainability terms.

5 Previous Agri-Environmental Schemes (Wales)

- **Tir Gofal**
- **Tir Cynnal**
- **Tir Mynydd**
- **Organic Farms**
- **Better Woodlands**



Glastir - 2012

Agri-environmental Schemes

⇒ Tir Gofal:

- Maintain and enhance agricultural landscape and wildlife
- Provide opportunities for people to visit the countryside

⇒ Four elements

- Land management
- Creating new permissive access
- Capital works
- Training for farmers



Glastir

⇒ 4 elements:

- Targeted Element
- Common Land Element
- Woodlands Element
- Agricultural Carbon Reduction & Efficiency Scheme
- Legally binding for 5 years



- 
- ⇒ Are agri-environmental schemes another form of subsidy?
 - ⇒ Should farmers be stewards of their own land anyway
 - ⇒ Do other industry's get incentive payments for reducing pollution?

Agriculture: 3 challenges

1. Ecology/Technology – genetic engineering?
2. Global Economic Framework – unfair trade globally
3. Land availability – land security and payments to landowners





“Buy land? They’re not making it any more.”
(Mark Twain, nd)



How do we re-invent our rural communities?



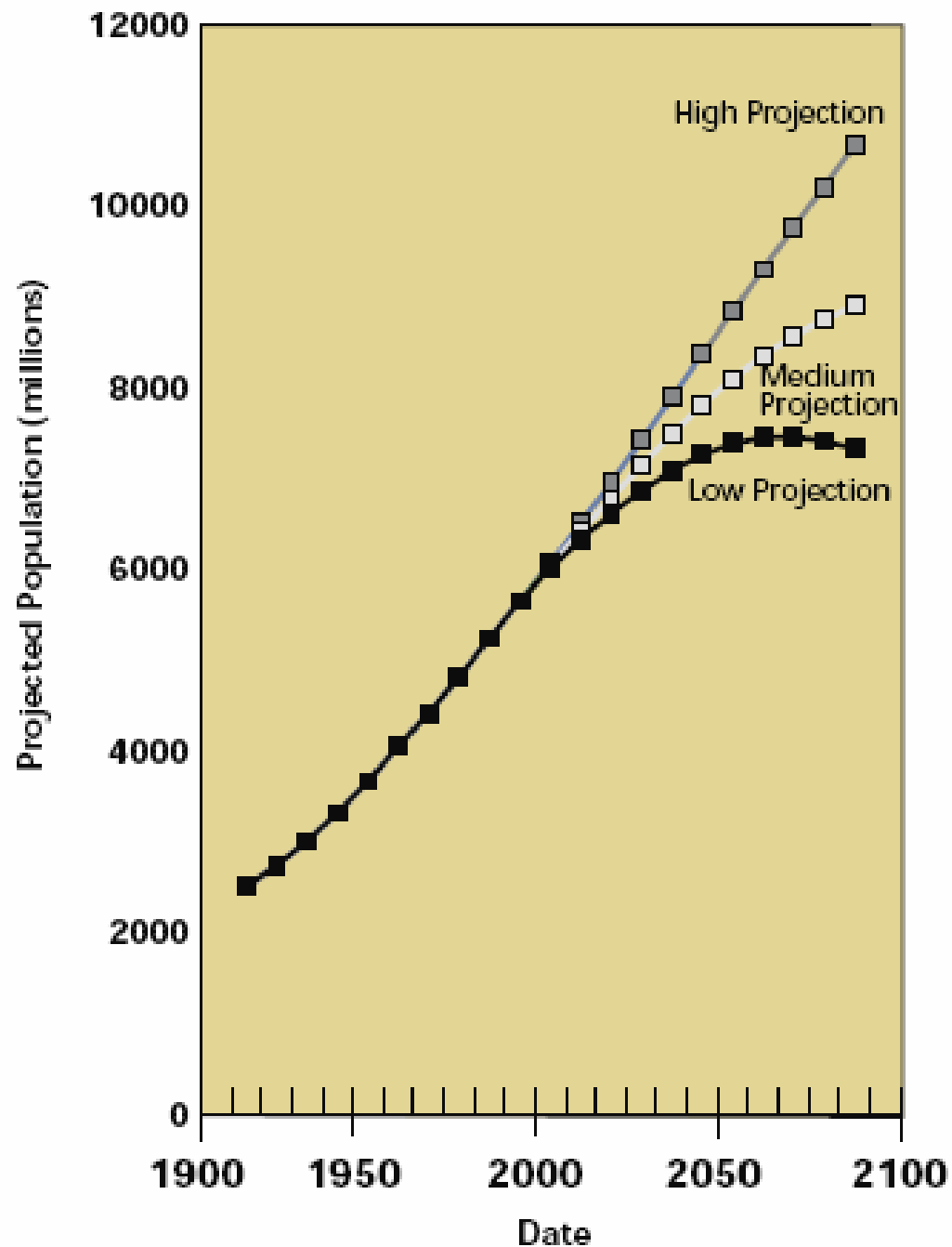
Consumers and the Food System

- ⇒ Through our choices, powerful messages are sent to producers and retailers
- ⇒ Food cost and nutritional value
- ⇒ Challenge:
 - To find strategies which allow environmental quality, resource use and social equity
 - Fair market place



Sustainable Development – Limited resources – Water scarcity





Global Population Projections:

- High
- Medium
- Low

(UNEP, 2004)

Water - unlimited supply?

- ⇒ Two-thirds earth surface – 97.5% salt
- ⇒ Fraction of 2.5% available for human use
- ⇒ 70% locked into poles
- ⇒ Soil moisture
- ⇒ Underground aquifers
- ⇒ Technology and affordability
- ⇒ Demand doubling every 21 years



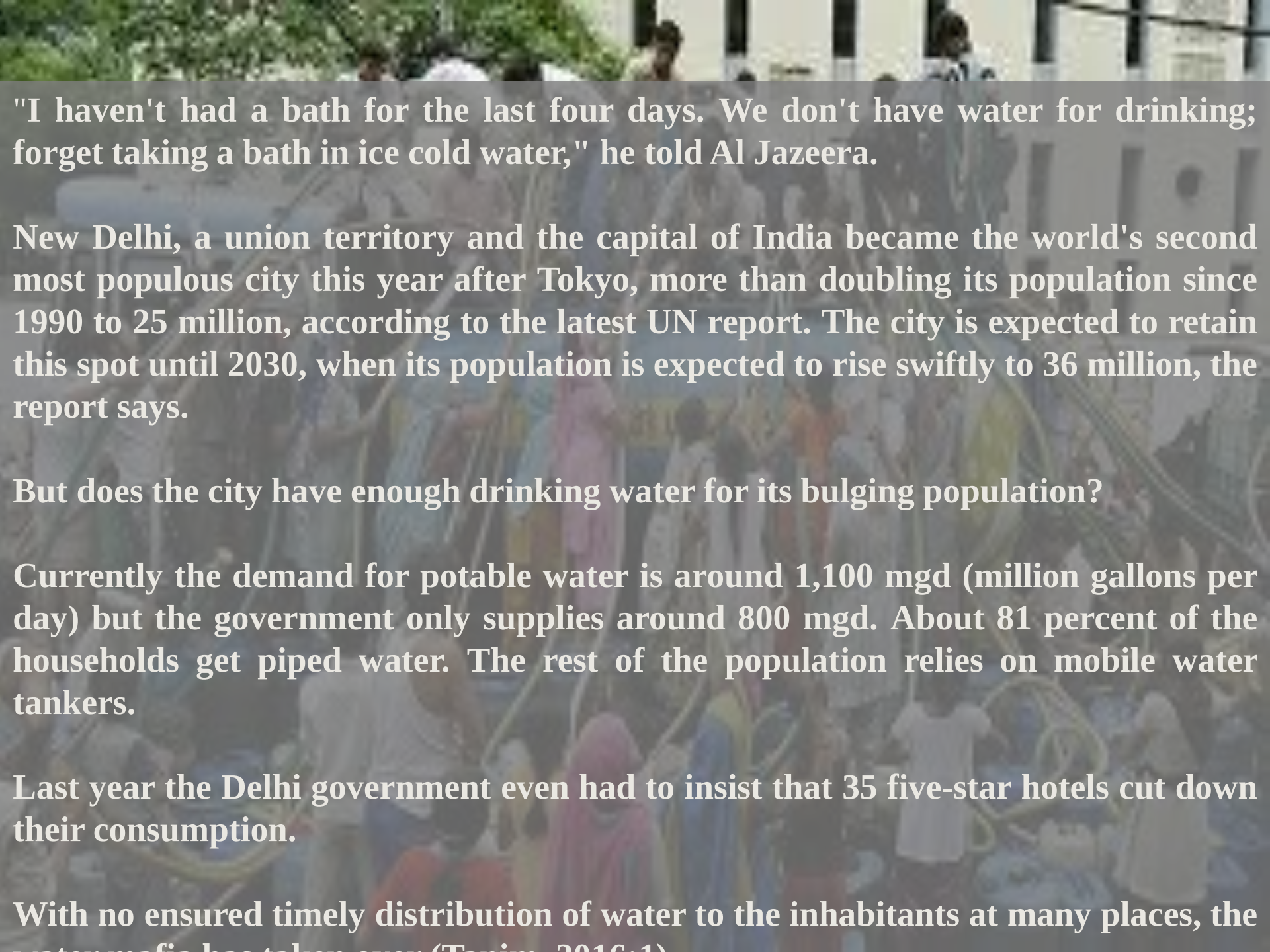
Global water crisis

- ⇒ Two out of three people in the world will be facing water shortages by 2025
- ⇒ Delhi will run out of groundwater by 2025 at current usage
- ⇒ 2025 population growth = increased food demand





India has 17% of the world's population yet just 4% of the world's accessible freshwater – how can it satisfy its needs?



"I haven't had a bath for the last four days. We don't have water for drinking; forget taking a bath in ice cold water," he told Al Jazeera.

New Delhi, a union territory and the capital of India became the world's second most populous city this year after Tokyo, more than doubling its population since 1990 to 25 million, according to the latest UN report. The city is expected to retain this spot until 2030, when its population is expected to rise swiftly to 36 million, the report says.

But does the city have enough drinking water for its bulging population?

Currently the demand for potable water is around 1,100 mgd (million gallons per day) but the government only supplies around 800 mgd. About 81 percent of the households get piped water. The rest of the population relies on mobile water tankers.

Last year the Delhi government even had to insist that 35 five-star hotels cut down their consumption.

With no ensured timely distribution of water to the inhabitants at many places, the water supply has taken over (The hindu, 2016:1)

Many people no longer work as they spend all day queuing for water. Over-exploitation has reduced the water table by 1.5m every year for the past 30 years



Developing world – developing problem

- ⇒ Inability to regulate, manage and invest in water
- ⇒ Unsustainable use of groundwater
- ⇒ UK – 150 litres/person/day (av)
129litres/person/day – meter
162litres/person/day – no meter
4645 litres/day (virtual water)
- ⇒ Poorer nations – less than a bucket full per person per day

(Water UK, 2017-2018 data)



HOW DO YOU USE YOUR WATER?

The average person uses **150 litres** of water every day,
and here's exactly how it's used



toilet flush



clothes washing



personal washing
(showers)



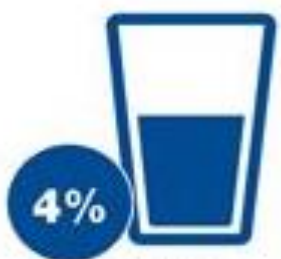
personal washing
(baths & taps)



washing up



outdoor



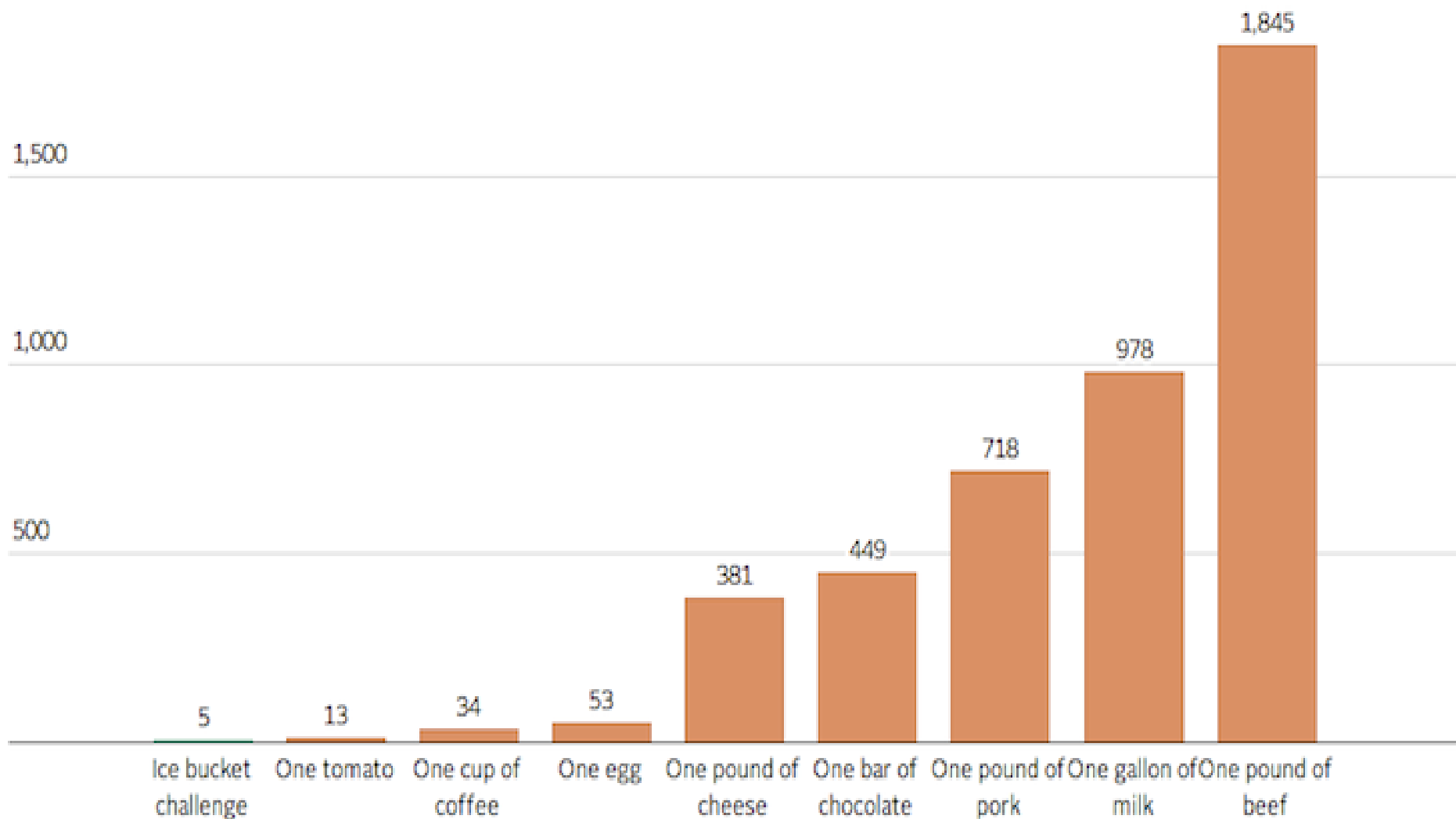
drinking



other

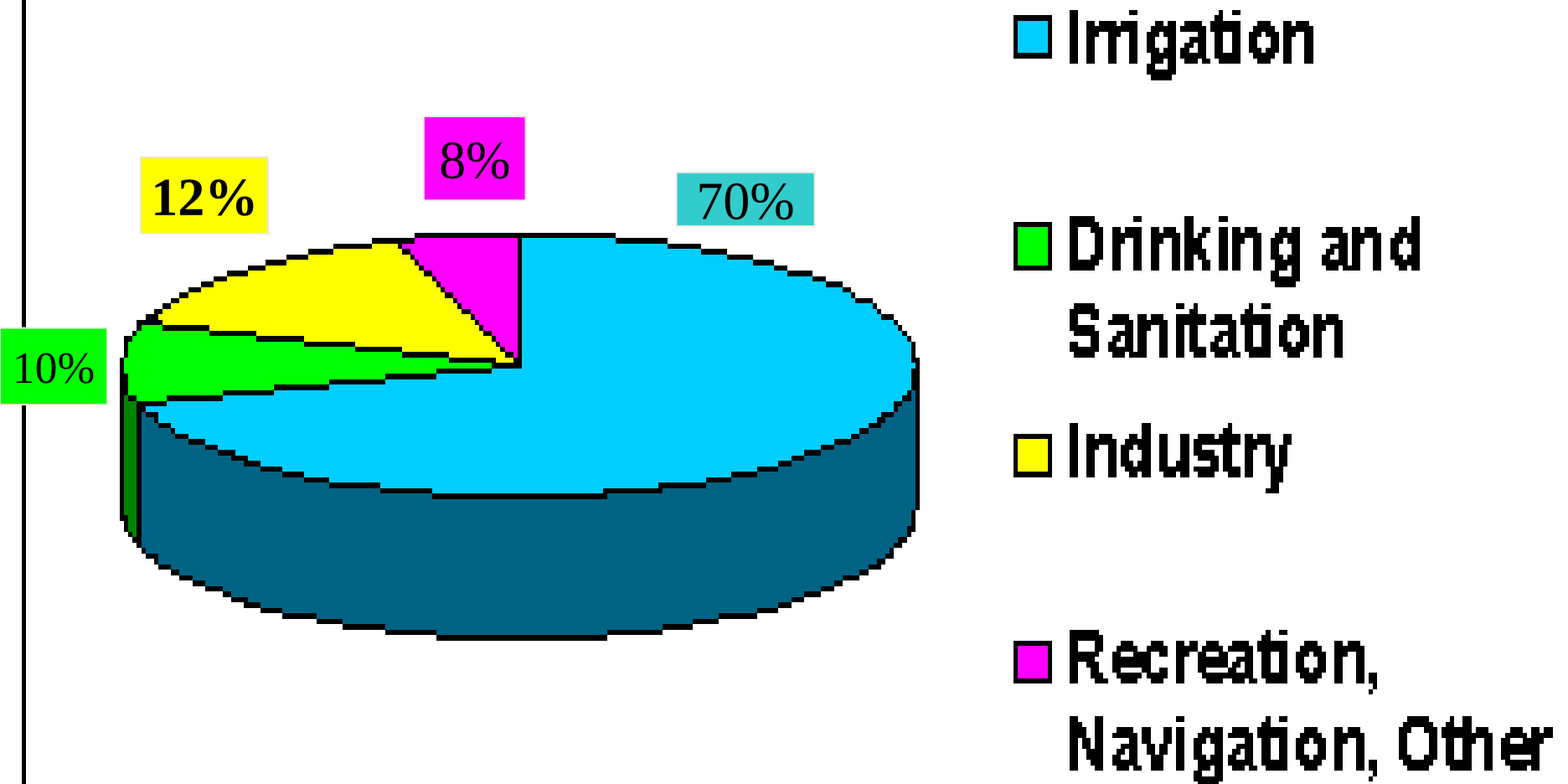
The ice bucket challenge versus common food products

Gallons of water used



Source: Eric Holthaus/Slate

Worldwide Water Use by Category

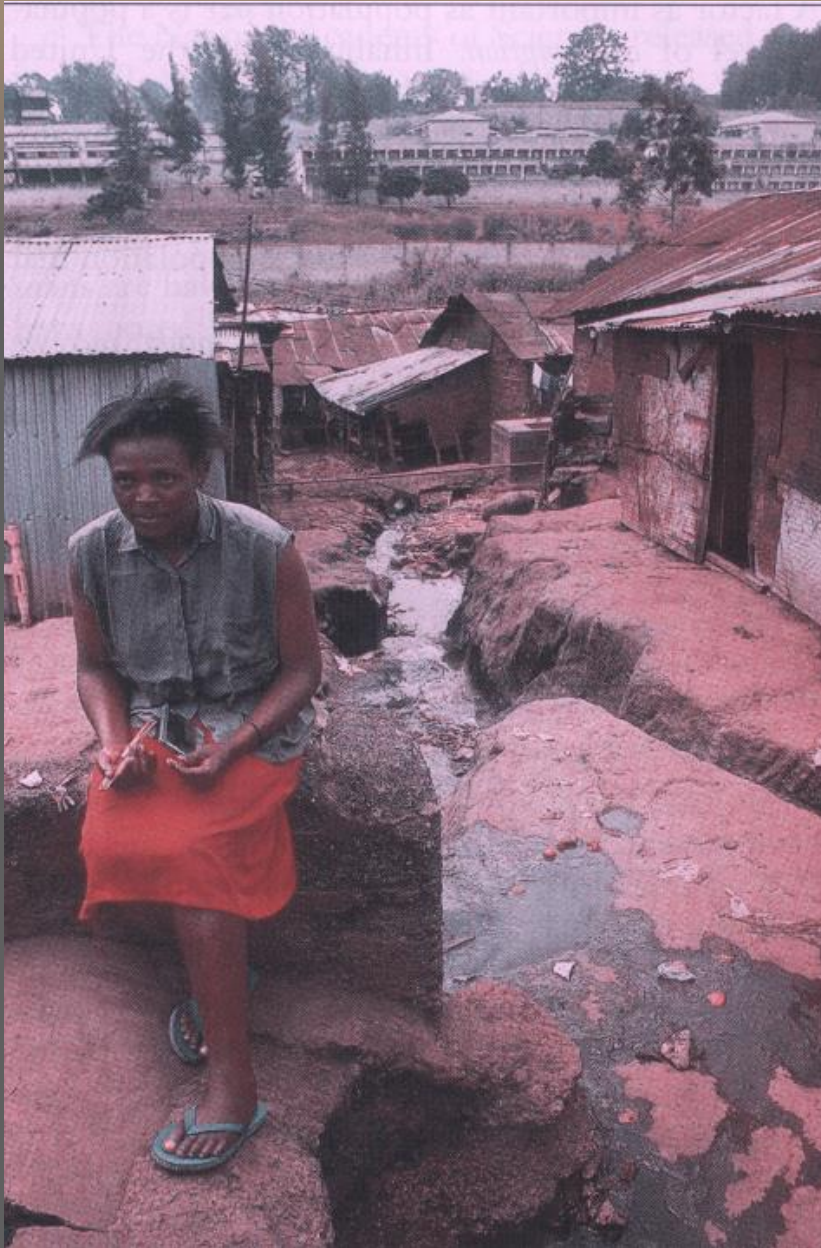


(Unesco 1999; Aquastat 2015)

Emerging water crisis

- ⇒ 450 million in 29 countries
- ⇒ 20% under capacity by 2050
- ⇒ Over pumping aquifers
- ⇒ Aquatic pollution
- ⇒ Upstream withdrawals
- ⇒ There are practical limits to how much additional water can be extracted from the environment





Poverty: a slum in Kenya,
East Africa.

Many of the world's poor
live in extreme poverty

Water crisis

- ⇒ 'the severity of this crisis has prompted the United Nations to conclude that water scarcity, not a lack of arable land, will be the chief constraint to increased food production in the next few decades'



➡ With escalating population figures, unsustainable agricultural practices and a declining water supply, what is the way forward?

Irrigated farmland is 5 times more productive than rain-fed farmland. Today irrigation-fed agriculture supplies 45% of the world's food. However it is managed, increased population demands increased food production, which needs more land and more water.



Sustainable Agriculture

Water: Supply & Use

1. Water conservation and storage methods
2. Incentives for selection of drought-tolerant crops
3. Reduced-volume irrigation systems
4. Managing land to reduce water loss



Sustainable Agriculture

Water: Quality

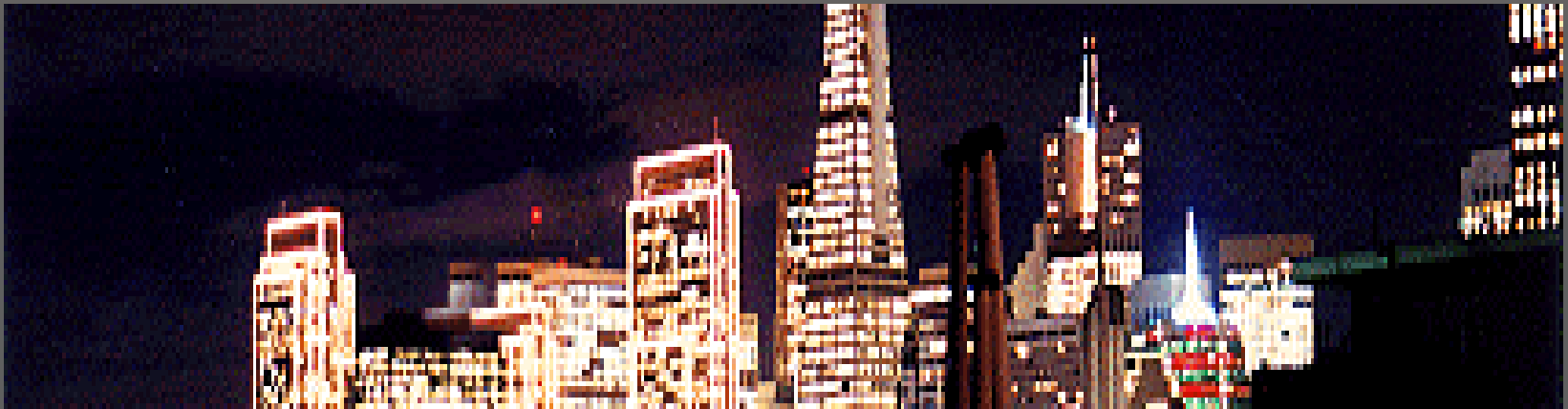
Salinisation and pesticide contamination

- ⇒ Use of salt-tolerant crops
- ⇒ Drought tolerant forages
- ⇒ Low volume irrigation
- ⇒ Use of agroforestry to minimise impacts of salinity and high water tables



Sustainable Agriculture

Energy



Heavily dependent on fossil fuels – petroleum. 20% US fuel demands – derived from agriculture - ghgs

High fuel prices – high food prices

- Reduced reliance
- Substitution of renewable sources or labour to an extent which is economically feasible

Sustainable Agriculture Wildlife

Destruction habitat within watersheds – erosion and sedimentation, pesticide leaching, reduced biodiversity

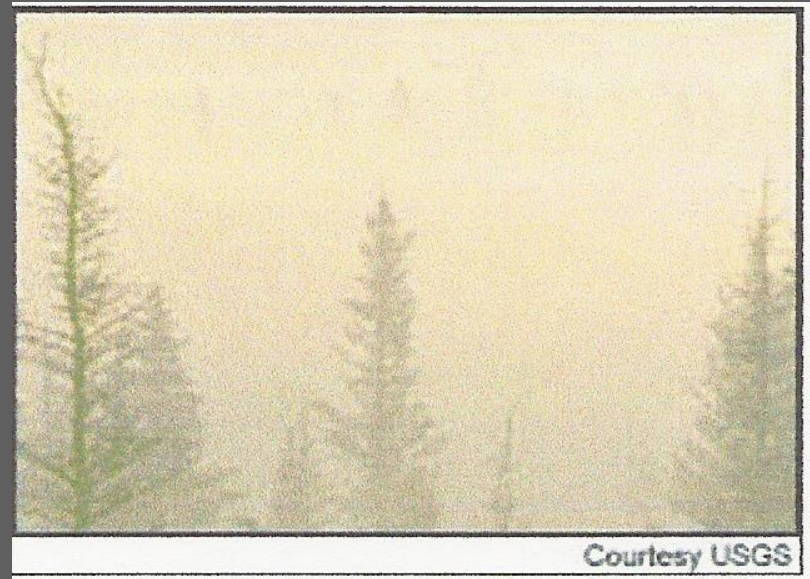
- Maintaining biodiversity helps agriculture through pest management



Sustainable Agriculture

Air pollution

- Smoke from burning
- Dust from tillage, traffic and harvesting
- Pesticide drift
- NO and NO₂ emissions from use of nitrogen fertiliser
- Incorporating crop residue into soil
- Planting wind breaks



Courtesy USGS

The way forward?

- ⇒ Site specific conditions
- ⇒ Selection crop/animal species suited to site and conditions on farm
- ⇒ Diversification of crops / livestock
- ⇒ Crop rotation – ↓ pathogens & insect pests, suppress weeds
- ⇒ Efficient use of inputs – develop efficient biological systems which require minimum inputs – conservation headlands



- ⇒ Do we need to change people's behaviour towards food?
- ⇒ Is there a need for educating 'the masses' on where our food comes from?
- ⇒ Can city's ever play a role in sustainable agriculture?



City Agriculture

- ⇒ City Farms
- ⇒ Roof gardens
- ⇒ Allotments
- ⇒ 'Plant a Row' Schemes - Bristol



City/Community Farms

- ⇒ Offer children and adults the opportunity to get up close to a range of farmyard animals;
- ⇒ plant vegetables and other food plants;
- ⇒ learn new skills to live a healthier, happier life with a lower environmental impact.



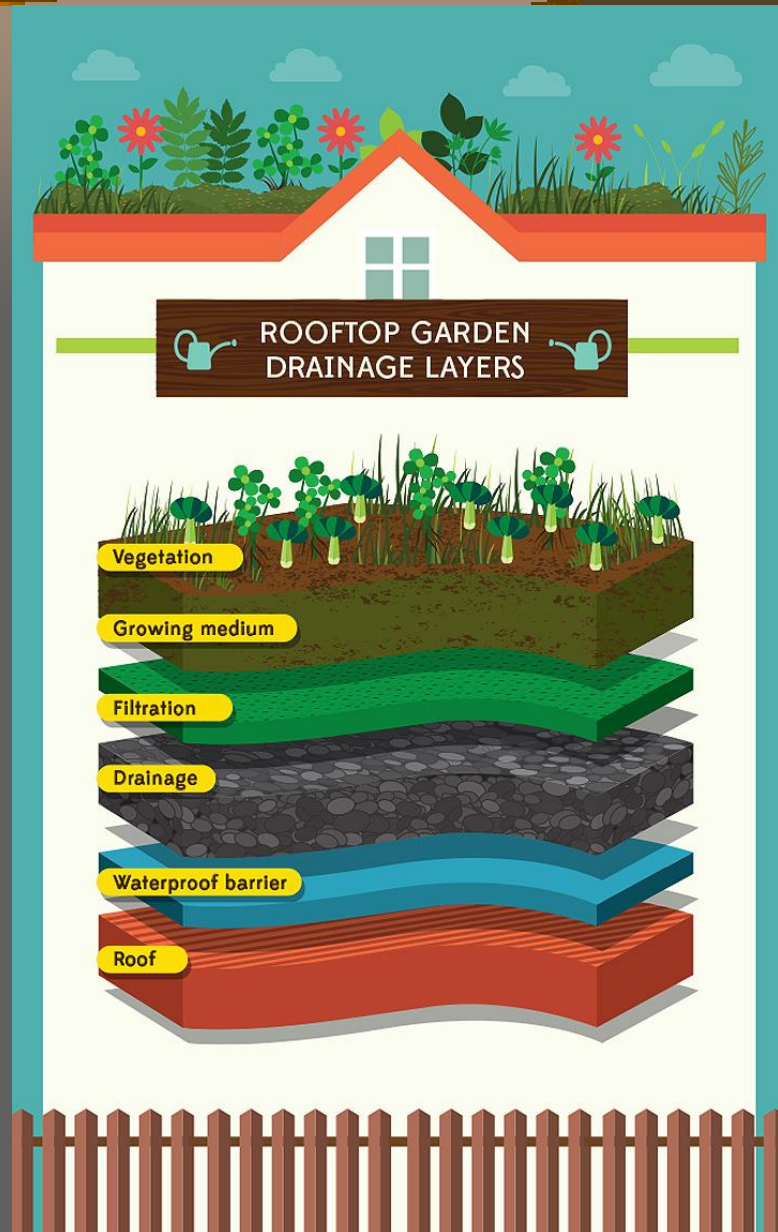
City Farms – Urban Agriculture

- ➔ 200 city and school farms
- ➔ 1,000 community gardens
- ➔ 200 city farms and community gardens in development
- ➔ Around 550 people employed
- ➔ Thousands of volunteers
- ➔ Three million visitors each year.
- ➔ Their estimated combined annual turnover is £40 million.



Roof top gardens

- Based on food security
- Educational
- Community-based – social
- Economic – increase value by utilising usable space
- Environmental – biodiversity, air quality, rain-fed irrigation
- Horticultural – experimenting new techniques
- Personal – relaxation and enjoyment



Urban gardens – using containers

There are several reasons why urban gardens using containers are effective:

- ➔ utilization of limited space.
- ➔ “intercropping” (planting a variety of plants in one container) which ensures the health of plants due to diversity.
- ➔ conserves both soil and water as containers prevent run offs of soil and excessive watering.
- ➔ make use of urban wasteland (vacant lots, brown fields, unused parking lots, and roof tops)
- ➔ meaningful employment for persons with limited skills and formal education.
- ➔ Creative ways to “recycle” old tyre
- ➔ use urban gardening to “rehabilitate, create income generation projects, and provide therapy.”



Guerrilla Gardeners – why not?



Allotments

In Camden in London there are 883 people waiting up to 40 years for a chance to till one of the 195 allotments



The average time is three years and two months

Over 100,000 people on a waiting list for an allotment around Britain

(Wallop, 2015)

There is a clear need to maximise any space possible





Agroforestry

- ⇒ land use management system in which trees or shrubs are grown around or among crops or pastureland
- ⇒ Practiced around the world for centuries



Alley cropping

- ⇒ planting crops between rows of trees to provide income while the trees mature. The system can be designed to produce fruits, vegetables, grains, flowers, herbs, bioenergy feedstocks



Forest Farming

- ⇒ Cultivation high-value crops under the protection of a forest canopy
- ⇒ Modified to provide correct level of shade
- ⇒ Gingseng, shiitake mushrooms
- ⇒ High income products and quality timber products



Silvopasture

- ⇒ Combines trees with forage and livestock production.
- ⇒ The trees are managed for high-value sawlogs
- ⇒ Provides shade and shelter for livestock and forage,
- ⇒ Reduces stress



Agroforestry – contribution to sustainable agriculture

- ⇒ Reducing poverty - increased production of wood and other tree products for home consumption and sale
- ⇒ Food security - restoring the soil fertility for food crops
- ⇒ Increases shade & reduces soil evaporation rates
- ⇒ Mixed farming i.e. crop production and animal grazing.
- ⇒ Reducing deforestation and pressure on woodlands by providing farm-grown fuelwood
- ⇒ Reducing or eliminating the need for toxic chemicals (insecticides, herbicides, etc.)
- ⇒ Providing growing space for medicinal plants



There's something growing on the roof

ROOFTOP GREENHOUSES ▲ Idea ▲ Planning ▲ Implementation



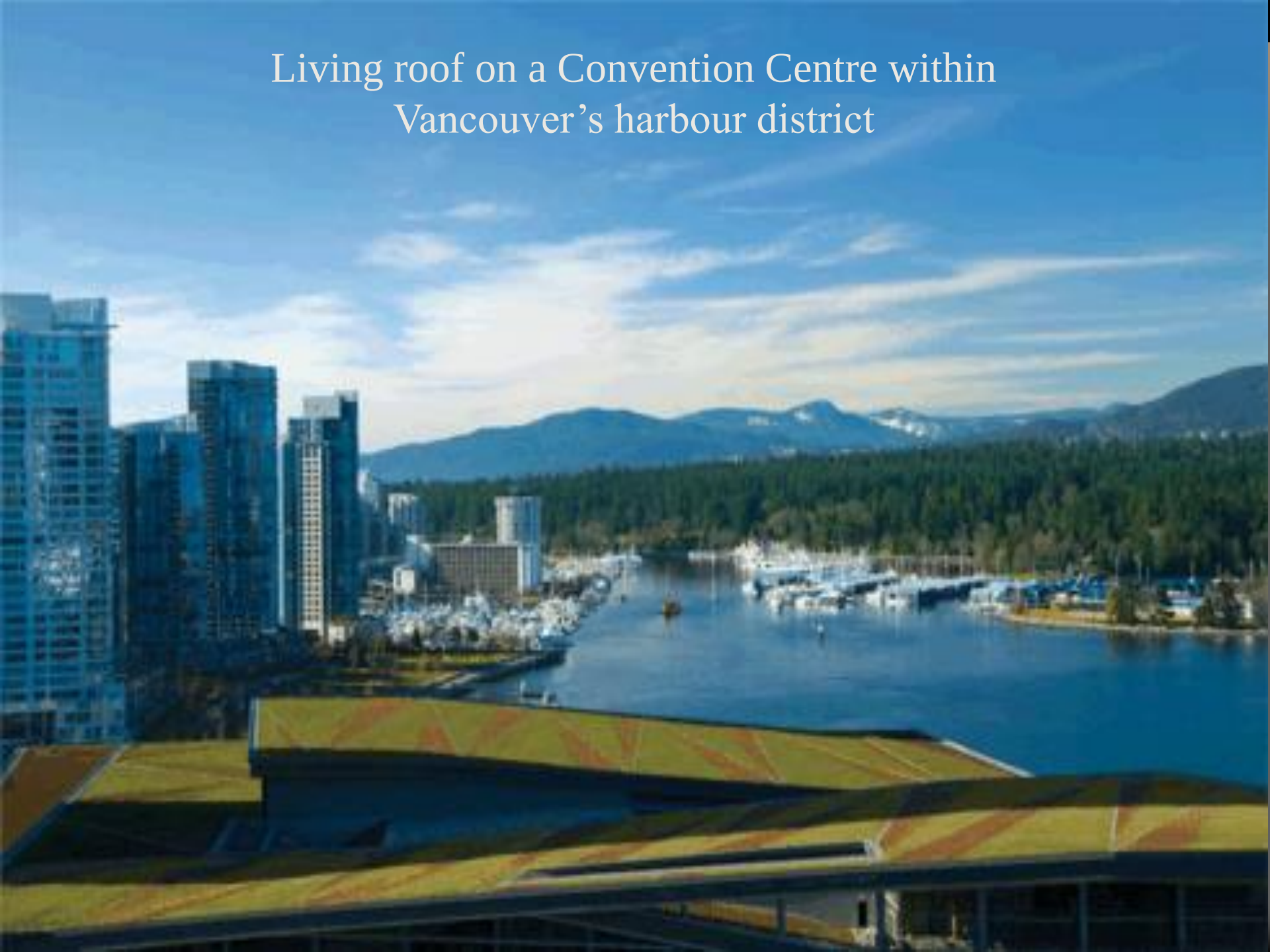
Roof
Greenhouses —
why not?





Rooftop Food Garden
YWCA Vancouver, BC
Photo © Michael Levenston
www.cityfarmer.info

Living roof on a Convention Centre within
Vancouver's harbour district



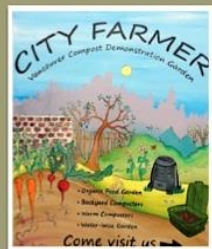
Green / Living Roof

- ⇒ Sound insulation
- ⇒ Thermal performance
- ⇒ Biodiversity
- ⇒ Reduction surface water run-off
- ⇒ Air quality
- ⇒ Protection water-proofing









Urban agriculture has the potential to make a significant contribution to the solution of many current urban problems that fall within the rubric of healthy communities and sustainable development.

These include:

- environmental degradation and ecological restoration
- resource consumption
- health and nutrition issues
- food security and access for lower income citizens
- ecological education
- local economic development and diversification
- community building

VANCOUVER COMPOST DEMONSTRATION GARDEN

Visit the Compost Garden from 9am-4pm, Monday through Saturday, or call our **Compost Hotline at 604-736-2250**. Learn how to compost in your back yard, on your apartment balcony, or at your school. Visit our beautiful 30-year old 'built with compost' garden in Kitsilano and see many types of compost bins, an organic food garden, a water-wise garden, a natural lawn, a bug friendly garden, a green roof, and a climate-change garden.

Urban agriculture in New York





⇒ Can city's technology ever play a role in sustainable agriculture?

Vertical Farming

➔ Modern day agriculture –

- Water scarcity
- Land availability
- Pesticides
- Soil erosion
- Monoculture
- Waste!
- 90% salad crops are wasted because of spoilage



➔ Grown closer to market under controlled conditions:

- Accurately predict and grow the market
- Fresher products
- Longer shelf-life
- Eliminate crop losses through pests, weather, drought

Vertical Farming - Challenges

⇒ Cost of technology outlay – need a system that has low initial capital outlay, scalability, flexibility, efficiency and reduced labour through automation.

⇒ Energy – sunshine is free! – Need Smart energy that can also contribute to the National Grid



Stackable Shipping Containers

- ➔ outfitted with vertical hydroponics, LED lighting and intuitive climate controls
- ➔ Podponics has built a large scale vertical farm in Atlanta consisting of over 100 stacked "growpods".
- ➔ Similar farms currently under construction in Oman
- ➔ Terrafarms – commercially viable as of Dec 2017 – 40 shipping containers remotely monitored



Economically viable?

- ⇒ Just a passing fad?
- ⇒ Food miles?
- ⇒ Some suggest it would be better to simply grow crops on a roof garden
- ⇒ Initial costs 60 hectare farm? \$100mill



Human health benefits

⇒ Traditional framing hazards:

- Diseases such as malaria
- Exposure to chemicals
- Encounter with venomous snakes
- Accidents

⇒ Food security

⇒ Urban growth

⇒ Energy sustainability
– methane-digesters

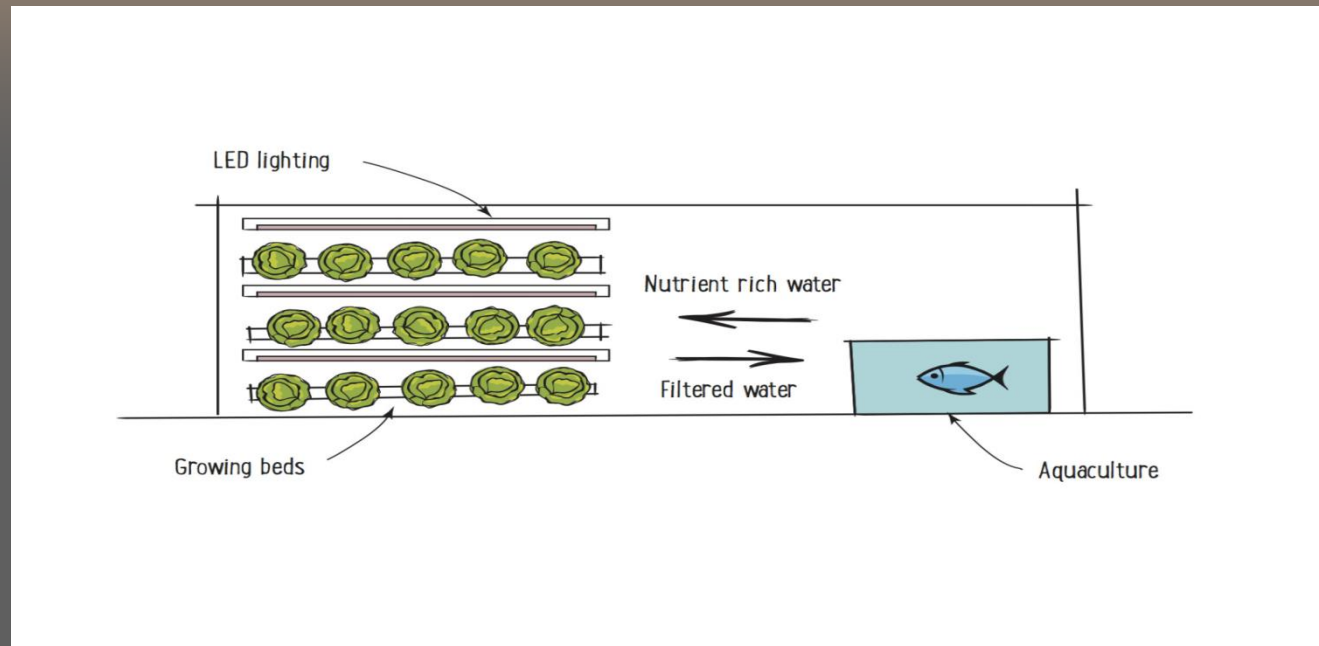


Vertical Farming



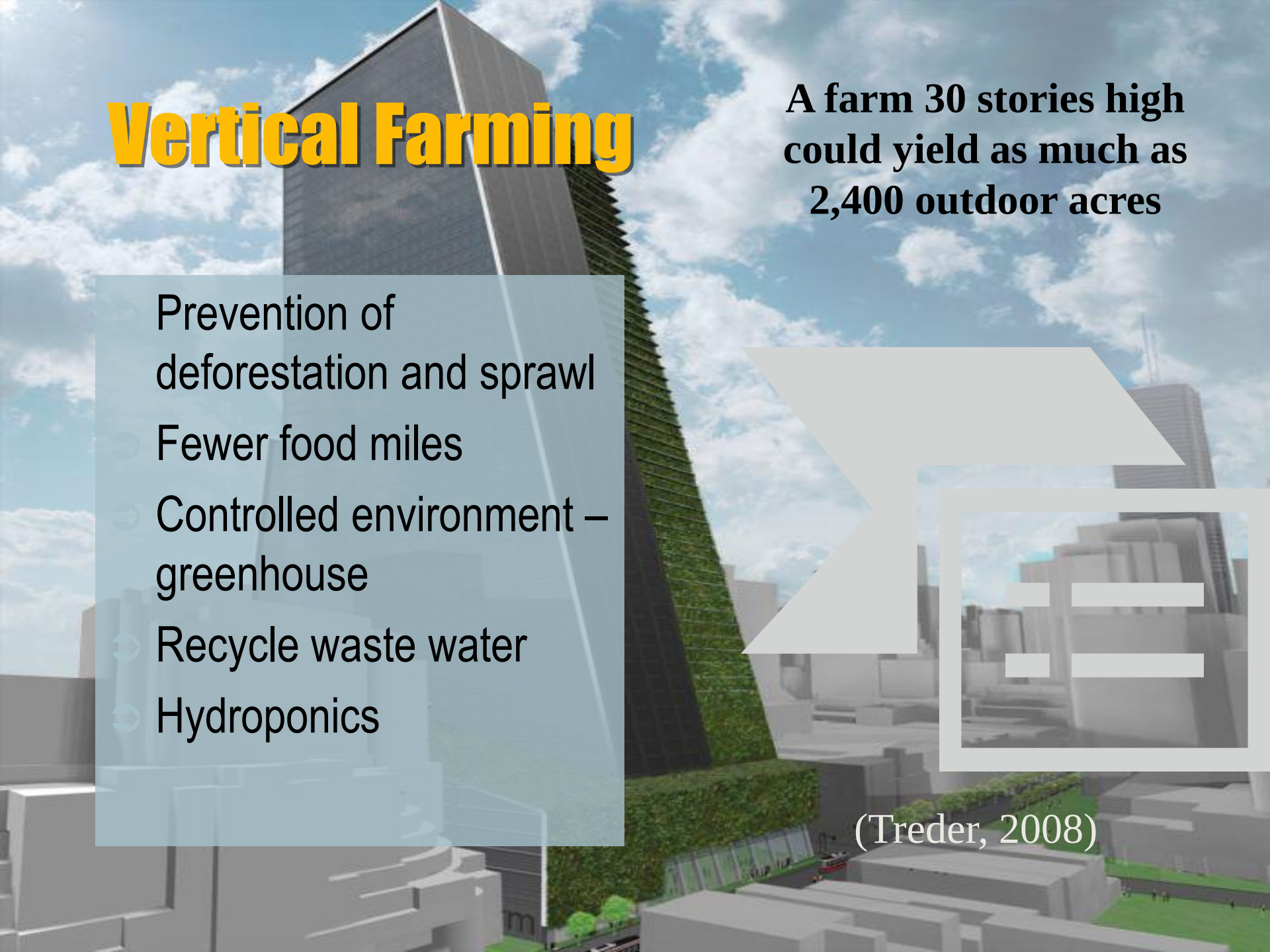
Hydroponics - method of growing plants using mineral nutrient solutions, in water, without soil.

Aquaponics : a closed – loop system



- ⇒ Fish are feed
- ⇒ Waste water from tanks is pumped to the roots of the plants
- ⇒ Microbacteria convert to useful nutrients
- ⇒ Nutrients fertilise the plants
- ⇒ Plants purify the water
- ⇒ Water is pumped back into the fish tank

Vertical Farming



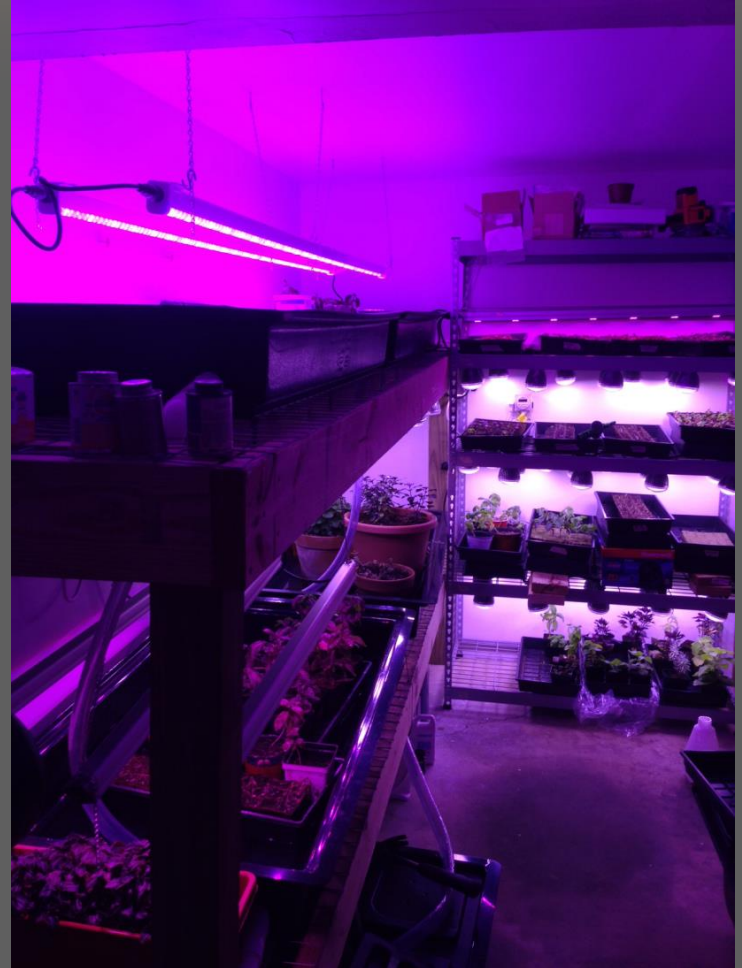
**A farm 30 stories high
could yield as much as
2,400 outdoor acres**

- Prevention of deforestation and sprawl
- Fewer food miles
- Controlled environment – greenhouse
- Recycle waste water
- Hydroponics

(Treder, 2008)

UK's 1st vertical farm

- ➔ Intelligent Growth Solutions – built at the James Hutton Institute in Scotland
- ➔ Total Controlled Environment Agriculture (TCEA), growing environment controlled : light, temperature, humidity, nutrition and even air composition
- ➔ Enables the grower to produce consistent, high quality crops all year round.



A Seawater Vertical Farm



Seawater Vertical Farm

- ⇒ Seawater for irrigation of crops
- ⇒ 'Pod-like' sky gardens
- ⇒ Just a concept for Dubai at present.....
- ⇒ Look it up!



Suggested Self Study

- ⇒ Investigate ways in which technology can solve the world's water shortage problem:
 - Agriculture
 - What of education?
- ⇒ Does the global water crisis limit progress towards sustainable development?.....
- ⇒ Investigate the potential of vertical farming in creating sustainable agriculture for the future.