Earth Observation for Agriculture

International trends & developments

Earth observation applications

Business development

Capacity building

0. Introduction

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HCP international:
consulting, marketing of earth observation

Project director EOPOWER:
project for promotion & capacity building of earth observation applications

Sequence:

- General assessment of the state-of-the-art of earth observation
- Major trends and developments in the application field
- Description of earth observation solutions
- Assessment of market potential for earth observation solutions and marketing instruments
- Capacity building for successful application of earth observation solutions

Earth Observation helps you:

save money

save lives

save the environment

Earth observation applications

- On the verge of reaching new user communities
- These new user communities need to be involved
- Weakest link / last mile aspects are important
- Marketing needed: promotion & capacity building

Life cycle of products & services

Initialization

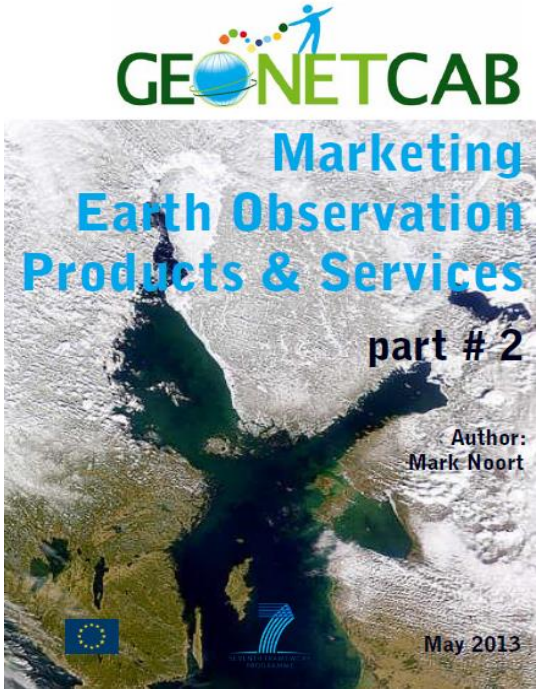
System analysis & design

Rapid prototyping

System development

Implementation

Post-implementation



Scope

In relation to crop farming and livestock farming, the term "agriculture" may be defined as:
the art and science of growing plants and other crops and the raising of animals for food, other human needs, or economic gain

Focus on:

- **Growing** plants and other crops (including pasture),
- **Transportation** of agricultural produce to the market,
- Derived products and services related to agriculture with a distinctive geospatial component, such as (re-)**insurance**, monitoring of compliance with agricultural **policies** and regulations and other forms of (risk) **management**.

Assessment of business & funding opportunities

- Categories of agricultural products & services
- Life cycle phase of product or service
- Regional context, level of technological & economic development
- Optimum marketing mix

1. International trends & developments in agriculture

Dimensions to characterize farmers' operations

1. **Type of agriculture**: *crops, livestock, fishery/aquaculture, forestry.*
2. **Purpose / goal of agricultural activity**, *such as subsistence farming, market- oriented farming or a mixture of subsistence and market-oriented farming.*
3. **Property structure and means for engagement in agricultural activities**: *human, financial and social/cultural capital employed, such as ownership of and access land and means, tenancy arrangements, credit facilities, government policy and subsidies (e.g. sharecropping, cooperative farming, communal lands, etc.).*
4. **Technology level**: *low, medium, high (e.g. precision agriculture is part of high level technology).*

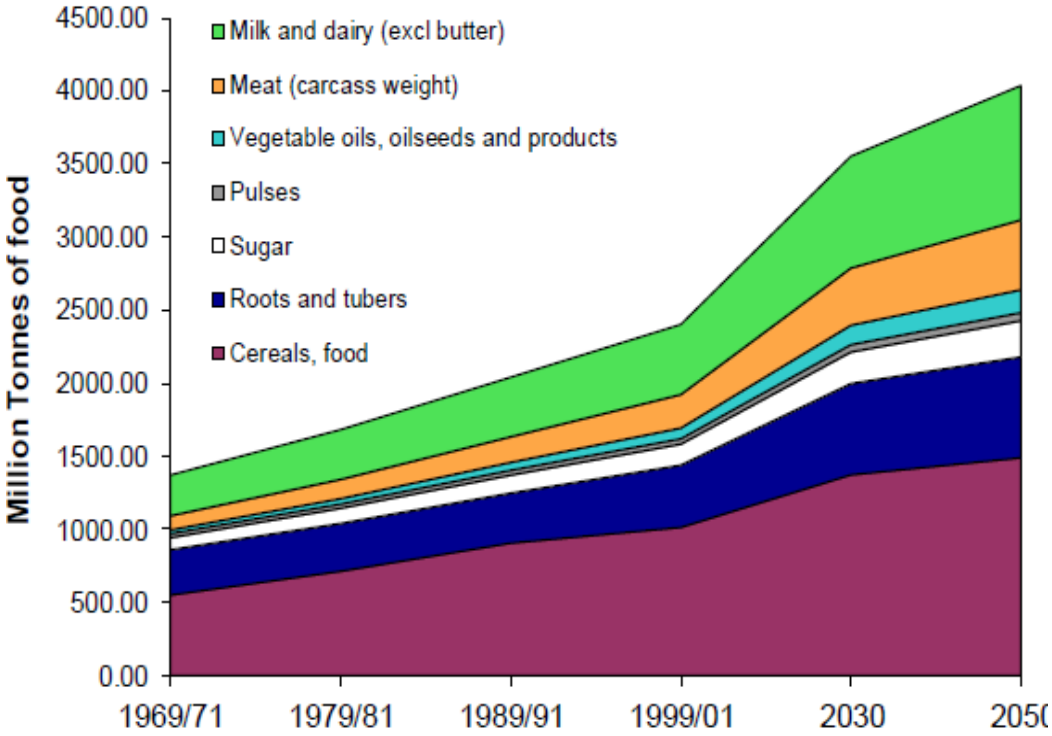
Issues & trends in Agriculture

- **Food security** and **increased production** and **productivity**;
- Adaptation to and mitigation of the effects of **climate change**;
- **Empowering local communities,** bridging the rural digital divide;
- **Food prices** and **markets**;
- **Risk management** (including insurance).

Drivers

- The increasing world population,
- Environmental factors (including climate change),
- The availability of water resources,
- Increasing urbanization and growing middle class population -> increased consumption and changing consumption patterns
- Land management (land as a scarce resource).

- Population growth ↑
- Protein consumption ↑
- Global warming ↑
- Energy crops ↑
- Food prices ↑
- Land & soil quality ↓
- Available land & water ↓
- % Rural population ↓



World food production must rise by 50% in 2030 to meet increasing demand Source: FAO/UN, 2008

Food security & increased production / productivity

- Food security in terms of avoiding hunger and undernourishment;
- Food security in terms of increased demand: production and productivity should go up;
- Food security in terms of sustainable management of natural resources;
- Food security in terms of increased resilience with respect to the effects of climate change and disasters / pests;
- Food security in terms of conflicting interests: biofuels may lead to more income for the farmer, but also to higher food prices in general.

More information:

Sustainable agricultural productivity growth and bridging the gap for small family farms (for G20; 2012)

World agriculture towards 2030/2050 – the 2012 revision (FAO; 2012)

Food and water: analysis of potentially new themes in water management - future trends and research needs (FutureWater; 2010)

Solutions sustainable agriculture and food systems – Technical report for the post-2015 development agenda **(UNSDSN; 2013)**

More information:

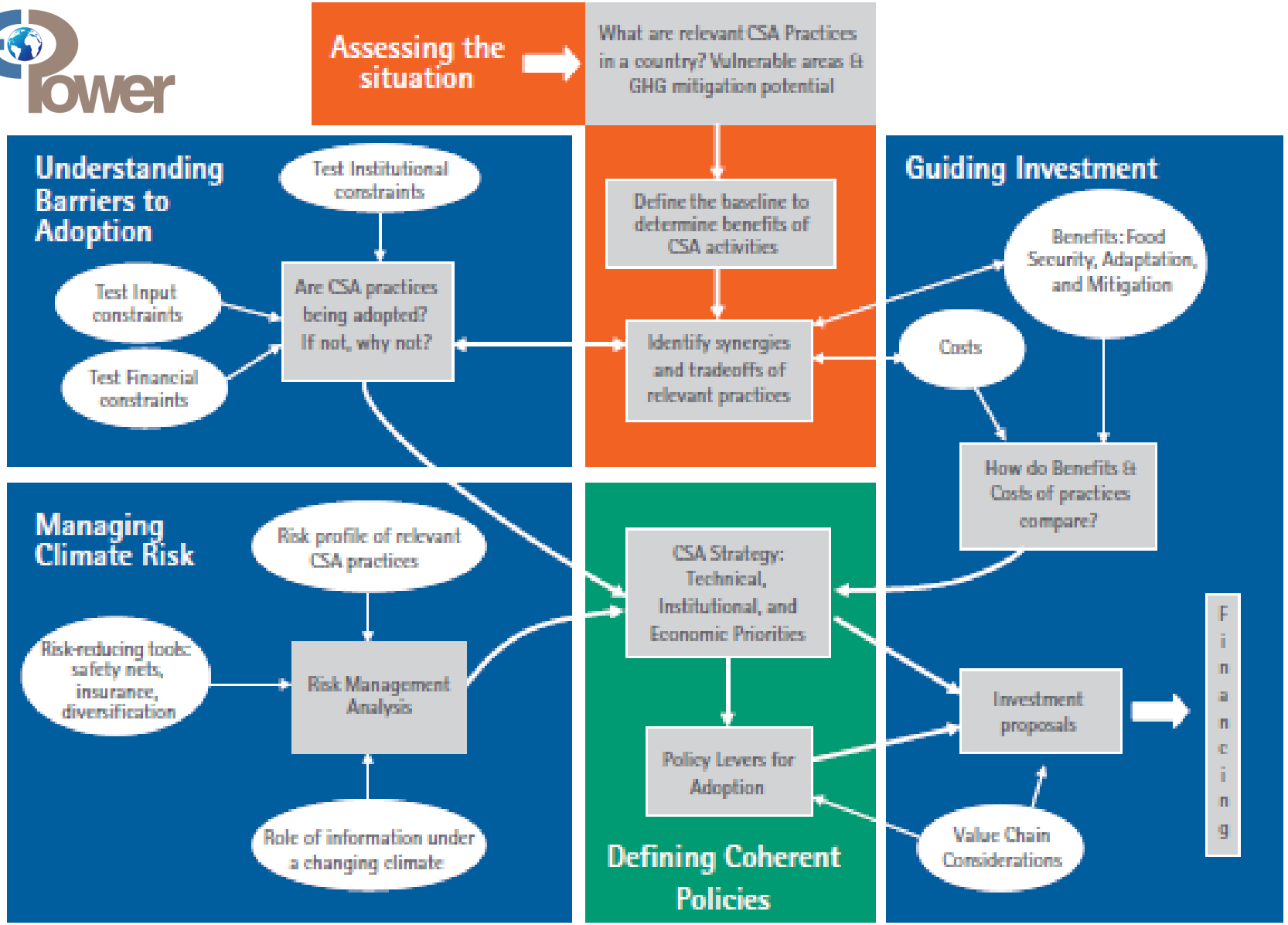
The state of food insecurity in the world
economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition
(IFAD, WFP, FAO; 2012)

Agricultural outlook 2015 – 2024
highlights **(OECD, FAO; 2015)**

The state of food and agriculture
investing in agriculture for a better future **(FAO; 2010)**

Climate change

- Climate will likely be substantially warmer in most parts of the world;
- Water availability for agriculture will be reduced;
- More extreme weather events will occur (prolonged drought, heavy rainfall, heat waves, frost, etc.);
- Danger of pests and diseases will increase.



A framework for developing a climate-smart agriculture strategy and investment proposals (FAO; 2012)

More information:

Climate change and food security:
a framework document **(FAO)**

The state of the world's land and water resources for food and agriculture - managing systems at risk **(FAO; 2011)**

Water-food-energy nexus: towards a widening of the water agenda (FutureWater; 2013)

More information (2):

Climate-smart agriculture - increased productivity and food security, enhanced resilience and reduced carbon emissions for sustainable development **(World Bank; 2011)**

A growing interest 2 - climate and economic impacts on the plant sector **(IGES; 2012)**

Uses and limitations of observations, data, forecasts, and other projections in decision support for selected sectors and regions (NASA; 2008)

Empowering local communities

- Local communities as drivers to increase production and productivity in vulnerable areas to achieve food security;
- Sustainable management of natural resources at the local level;
- Reduce post-harvest transportation and storage losses;
- Accessible, timely and affordable information on food prices and markets for farmers;
- Support to risk management in the form of (index-based) insurance schemes.

More information:

Sustainable agricultural productivity growth and bridging the gap for small family farms (for G20; 2012)

Smallholder certification in biomass supply chains – guidance manual **(CREM; 2013)**

Smallholder farmers can feed the world (IFAD)

Foodie – Open data for agriculture
article on information tools for farmers **(Foodie project; 2014)**

More information (2):

The new harvest
Agricultural innovation in Africa **(Juma; 2011)**

e-Sourcebook ICT in agriculture
Connecting smallholders to knowledge, networks, and institutions **(World Bank; 2011)**

Guide for regional integrated assessments: handbook of methods and procedures (AgMIP; 2013)

The transformational use of information and communication technologies in Africa (World Bank, African Development Bank; 2014)

Food prices & markets

- Improve physical market infrastructure and transport to and from markets;
- Improve market transparency;
- Improve market institutions;
- Sustainable management of the whole value chain: include costs of externalities;
- Increase resilience of vulnerable farmer and consumer communities.

More information:

Agricultural policy monitoring and evaluation 2013
OECD countries and emerging economies **(OECD; 2013)**

Agricultural value added services (AgriVAS; 2011):
market entry toolkit

Spatial patterns of food staple production and marketing in South East Africa: implications for trade policy and emergency response (MSU; 2009)

Risk management

- Improved prediction capability for detecting possible calamities;
- Improved early warning systems and general information provision on agro-meteorological conditions;
- Improved physical protection against extreme events;
- Sustainable management of natural resources;
- Insurance schemes for risk coverage.

More information:

The landscape of micro-insurance in Africa 2012
(Munich Re; 2012)

Weather index-based insurance in agricultural development
a technical guide **(IFAD; 2011)**

Rainfall variability, food security and human mobility
an approach for generating empirical evidence
(UNU-EHS; 2012)

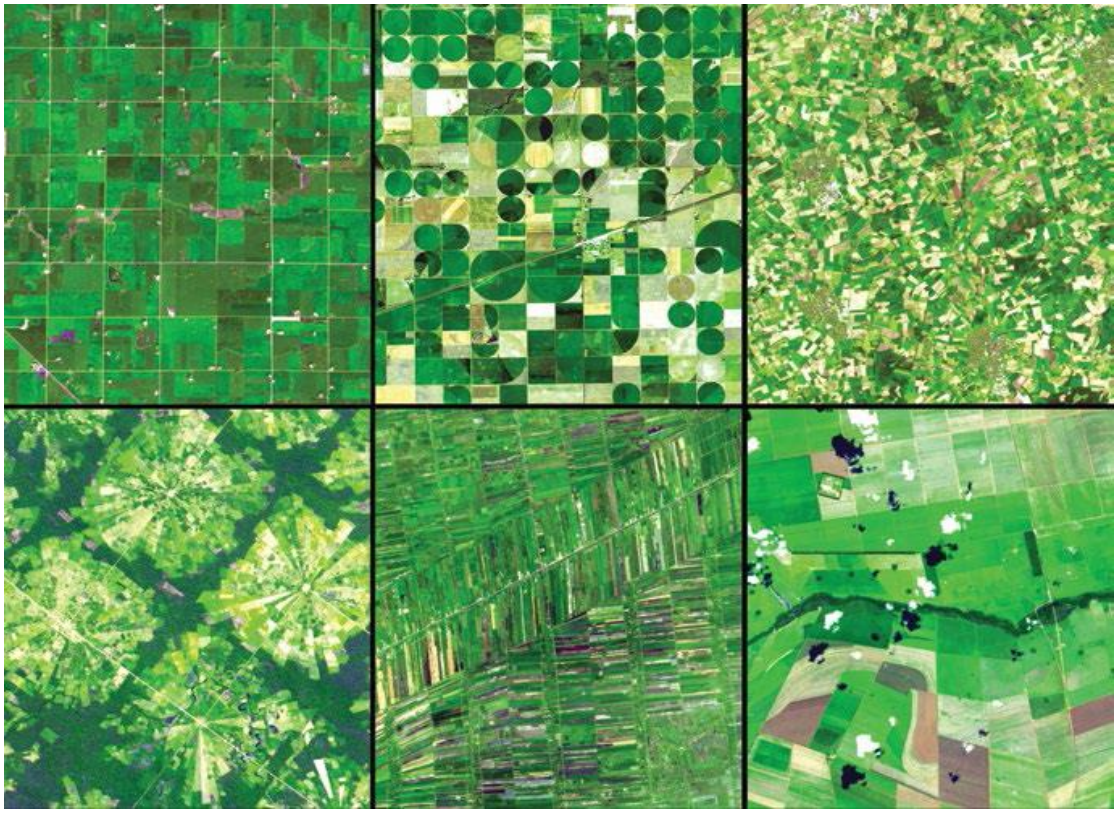
2. Earth observation applications

Earth observation for agriculture

Three levels of interaction within a country:

- **Country level**
  focusing on policy, research and innovation;
- **Agro-ecological zone or watershed level**
  focusing on extension services and management of regional resources;
- **Farm level**
  focusing on advice and income optimization.

Earth observation for agriculture



Remote sensing images showing agriculture patterns (Geospatial World)

Country level: earth observation contribution

- **Agricultural knowledge and information systems**: *parcel identification and measurement, geo-statistics and crop identification, field survey, subsidy and policy monitoring and control,*
- **National crop and yield monitoring**,
- **Transport infrastructure and transport to market** *(food chain management),*
- **Land rights**,
- **Market information**.

Example agricultural information systems



Agricultural parcel (blue) one single crop group from a single farmer;
farmers' block/plot (red) one single or several crop groups from a single farmer;
and physical block (yellow) one single or several crop groups from one or several farmers.
(GeoCAP, JRC)

Agricultural information systems

- Parcel identification and measurement, geo-statistics and crop identification, field survey, subsidy and policy monitoring and control. Combines data and information on land use, land administration, crop monitoring and agro-ecological zones for better decision making;
- Earth observation improves accuracy, enables more frequent and better monitoring, coverage of large (not easily accessible) areas and facilitates integration of information;
- Cost estimate:
  total cultivated area 100 – 120 k€ / country, mapping of different crops and parcels 1.5 -2.5 € / km^2;
- Main challenges: cost, capacity, data access;

Examples:

GeoCAP (European Union):
digital land parcel identification, parcel area management, land cover type, compliance monitoring

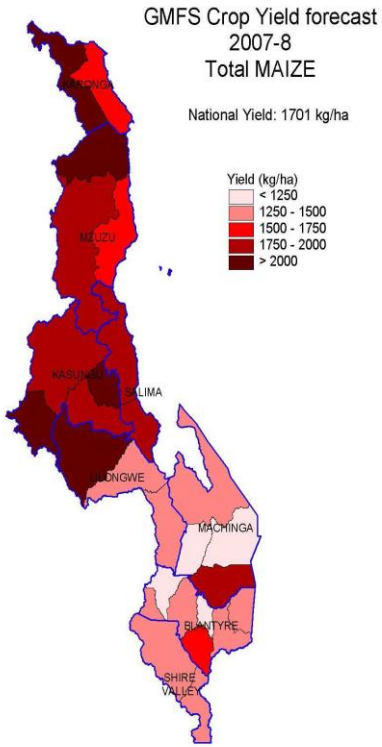
USDA (USA):
information system(s) for compliance and regulatory use, cropland data, soil modelling, etc. based on common land units

SICA (Colombia):
design, monitoring and tracking of coffee farming activities

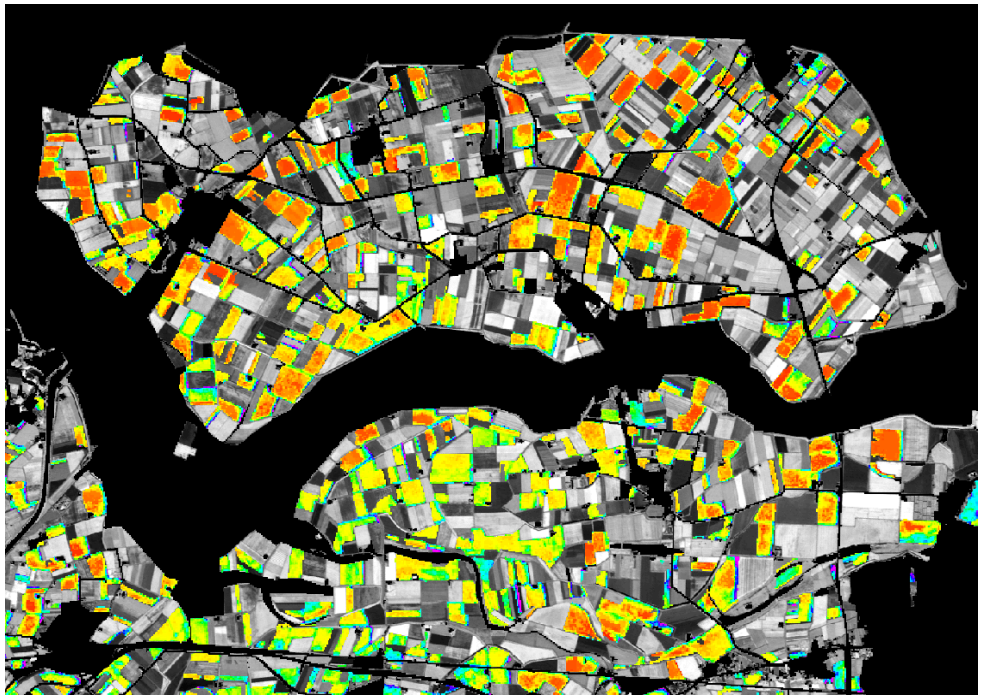
SOMABRASIL (Brazil):
system for agricultural observation and monitoring

Technical report on improving the use of GPS, GIS and remote sensing in setting up master sampling frames (2015)

Example crop and yield monitoring



Maize crop yield forecast 2007
Source: Service operations report Malawi 2007 – 2008 (GMFS, 2008)



Field scale wheat yield in the Netherlands (blue: 9 ton/ha, green: 8 ton/ha; yellow: 6 ton/ha, red 4 ton/ha)
Source: eLeaf

Crop and yield monitoring

- Distinguishes between agricultural land and non-agriculture land, different crop types, assesses crop growth in comparison with historical data, predicts yields (including early warning for possible food shortages);
- Earth observation improves accuracy, enables more frequent and better monitoring, coverage of large (not easily accessible) areas and facilitates integration of information;
- Cost estimate: total cultivated area 100 – 120 k€ / country, mapping of different crops and parcels 1.5 -2.5 € / km^2, early warning crop health 200 – 300 k€ / continent (with 10-day updates), yield prediction 70 – 100 k€ / 2 – 3 crops / 100,000 km^2;
- Main challenges: cost, capacity, data access;

Examples:

GEOGLAM: *GEO global agricultural monitoring, connected to G20 AMIS*

GIEWS: *FAO's global information and early warning system*

GMFS: *global monitoring of food security, developed through a sequence of ESA and EC-funded projects (latest is SIGMA)*

FEWSNET: *US system for food security early warning (USGS, USAID, USDA)*

FOOD-SEC (MARS): *EU system for monitoring of food security and many national systems: China, Argentina, Canada, Ukraine, South Africa, Australia, USA, India, Russia, etc.*

Examples (2):

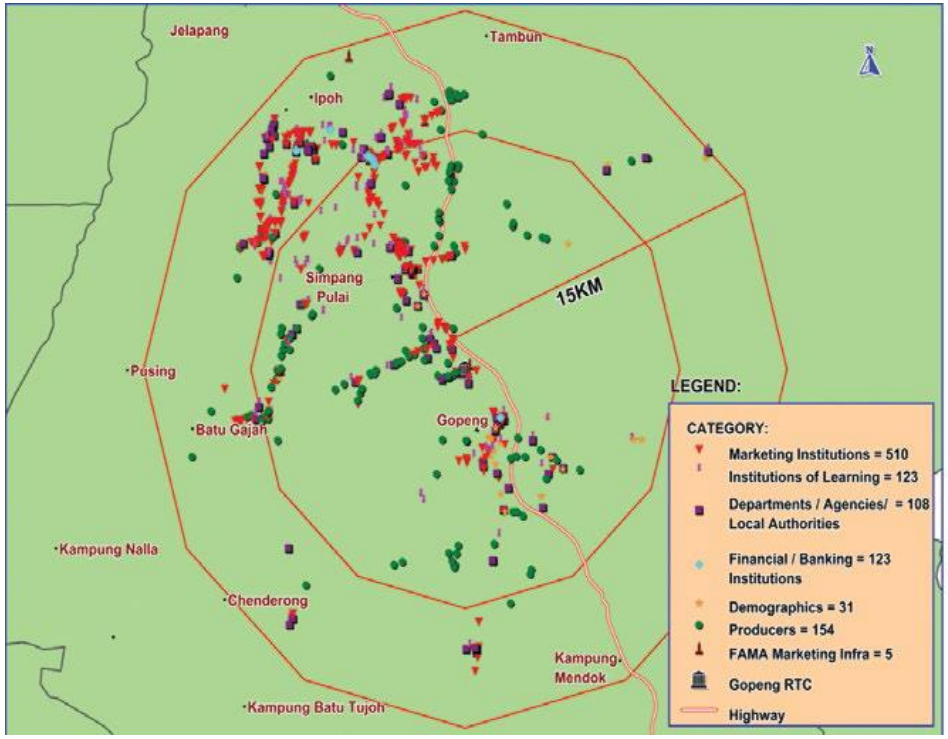
Advances in remote sensing of agriculture: Context description, existing operational monitoring systems and major information needs **(Atzberger; 2013)**

South Africa national agricultural monitoring (SAGEO; 2014)
Presentation on national crop and yield monitoring

More presentations on various crop and yield monitoring systems:

http://swfound.org/events/2013/international-meeting-on-food-security,-earth-observations-and-agricultural-monitoring/

Example market access



Map of plot locations in relation to markets and extension services (profiling study, Malaysia)

Market access

- Analyses the opportunities and constraints for optimum market access of agricultural produce, supports decision making for planning and improvement of infrastructure, storage and market facilities;
- Earth observation provides the base layer for spatial information analysis (including crowd-sourcing) and monitoring of agricultural activities (crop growth and land use change);
- Cost estimate: see agricultural information systems and crop monitoring
- Main challenges: infrastructure, institutions.

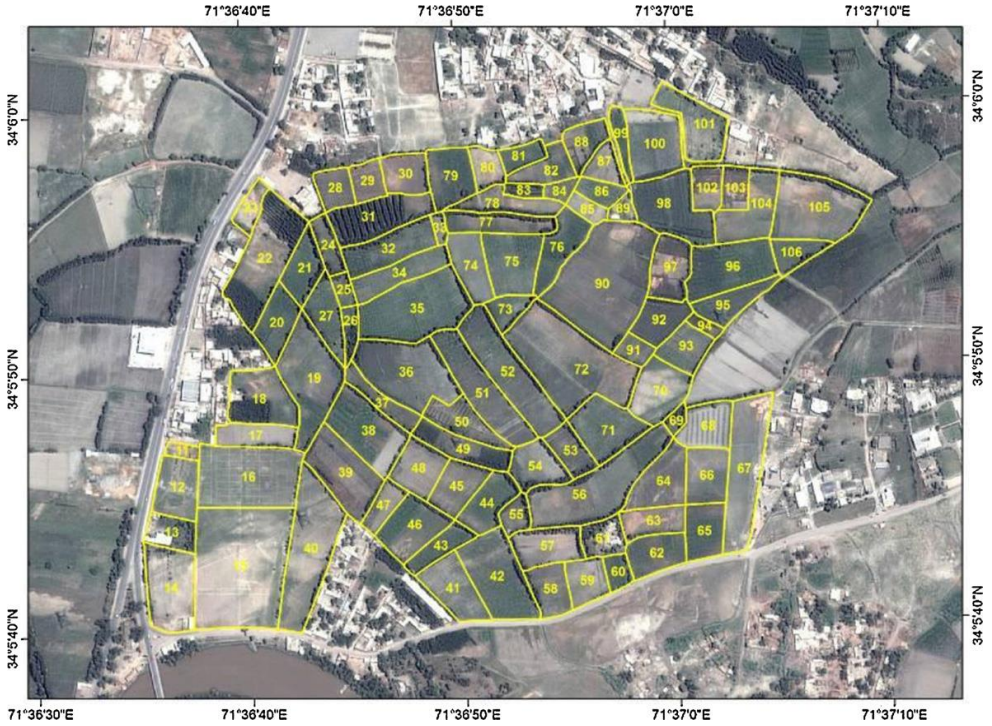
Examples:

Many products and services are in development, usually based on satellite navigation, information dissemination with mobile phones and crowd-sourcing.

CHEETAH:

Chains of Horticultural Intelligence; towards Efficiency and Equity in Agro-Food Trade along the Trans-Africa Highway, an ESA-award winning initiative that develops an intelligent app to reduce post-harvest losses and to improve (labour-intensive) road work.

Example land rights



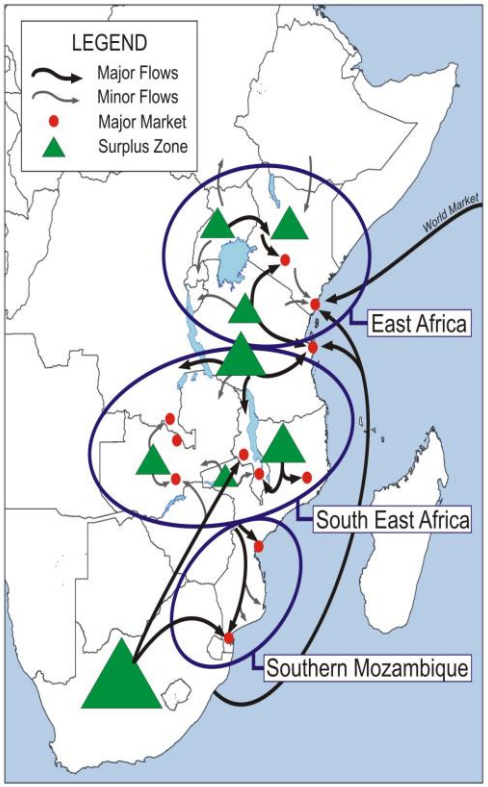
Digitised parcel boundaries on QuickBird HRSI in Zormandi area

(Source: First experiences using high-resolution imagery-based adjudication approach in Ethiopia (WB))

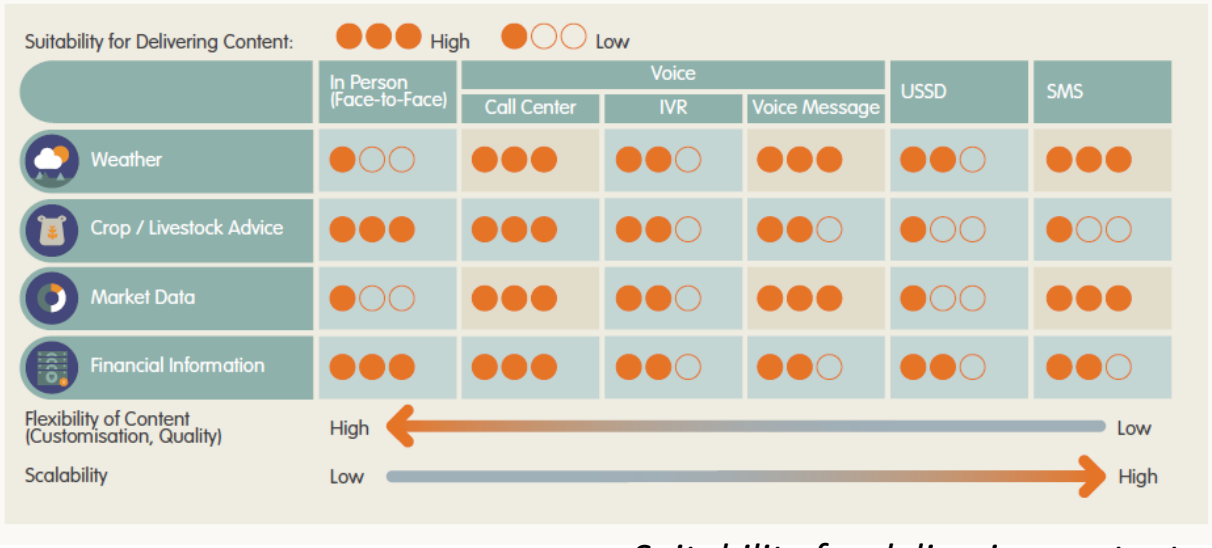
Land rights

- Determines land ownership and land rights to provide a secure basis for farming operations and access to credit;
- Earth observation provides the base layer for community participation in determining land ownership and (communal) rights and mapping the results. The information is easier to interpret and more up-to-date than conventional maps.
- Cost estimate: see toolkit on urban management, land administration and spatial data infrastructures.
- Main challenges: transparency, institutions.

Example market information



Maize Market Sheds in Eastern and Southern Africa
Source: Unscrambling Africa: Regional Requirements for Achieving Food Security (MSU, 2010)



Suitability for delivering content
Source: AgriVAS market entry toolkit

Market information

- Timely and accurate information on commodity prices and markets helps the farmer to improve decision-making with respect to selling and crop selection;
- Earth observation provides the base layer for spatial analysis of market information.
- Cost estimate: on case-by-case basis.
- Main challenges: communication, business model.

Examples:

Harvest Choice
data harmonization (assembling heterogeneous datasets)
+ data distribution (new ways of collecting and distributing spatial data).

Agro-ecological zone / watershed level: earth observation contribution

- Site evaluation
  (sustainable land use, suitability analysis),
- Regional crop and yield monitoring,
- Water management,
- Weather prediction.

Example site evaluation

Examples of reference parcels super-imposed on aerial orthoimagery
(colours correspond to different land cover types)
(GeoCAP, JRC)

Site evaluation

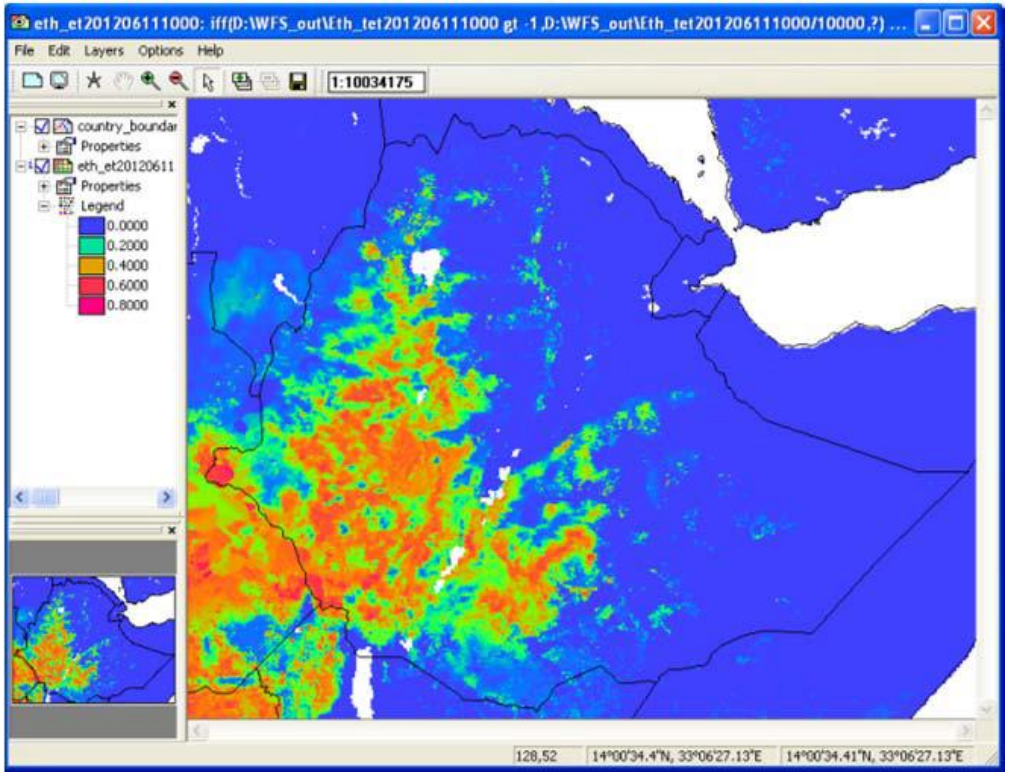
- Analysis and modelling of agro-climatic data, biomass and yield data, soil suitability to achieve optimum and sustainable use of agro-ecological zones;
- Earth observation provides the input for modelling and analysis: land cover, land use change, crop identification and monitoring, water resources, soil mapping and climate modelling with more accuracy, wider coverage and higher frequency than conventional methods.
- Cost estimate: on case-by-case basis (costs of crop monitoring + modelling).
- Main challenges: cost, capacity, data access.

Examples:

Global Agro-Ecological Zones (GAEZ)
initiative of IIASA and FAO for assessing agricultural resources and potential. A model is developed for sustainable utilization of land resources, agricultural development and food security that can be used as baseline for elaboration of local models and plans.

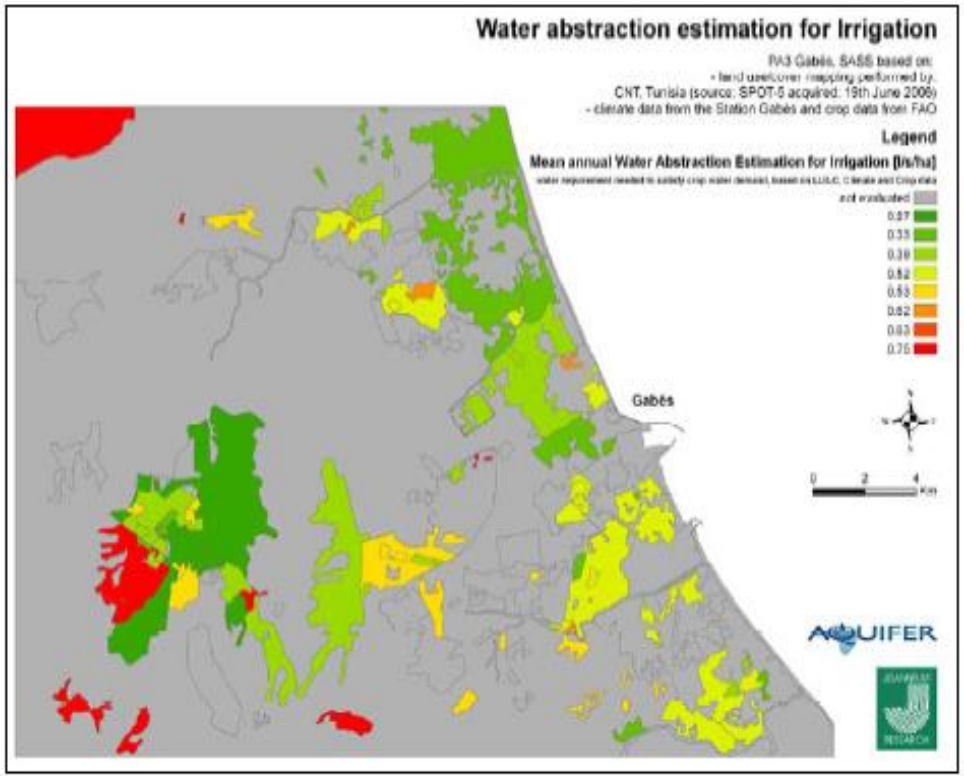
Remote sensing of soils (University of Zurich; 2014)
Description of state of the art of remote sensing of soils: soil mapping, remote sensing products, opportunities and limitations.

Example water management (1)



Example evapotranspiration Ethiopia
Source: GEONETCast presentation (ITC, 2012)

Example water management (2)



Mean annual water abstraction estimation for irrigation as amount of water needed to satisfy crop demand, Gabes area, Tunisia, 2006.

Source: Application of satellite remote sensing to support water resources management in Africa (TIGER, 2010)

Water management

- Mapping of water resources, analysis and modelling of water quality, water resources and water use to achieve sustainable water management
- Earth observation provides higher accuracy, wider coverage and more frequent monitoring of water use for agriculture (evapotranspiration), water quality and availability of water resources. Earth observation serves as base layer for hydrological modelling (digital elevation models and determination of surface roughness).
- Cost estimate: on case-by-case basis, mapping of water resources 0.75 € / km^2.
- Main challenges: capacity, account for real cost of water.

Examples:

JCRMO (Spain):
irrigation water needs

ORMVAG (Morocco):
evapotranspiration, irrigation management

Agricultural Catchments Programme (Ireland):
water quality protection, fertilizer advice, soil analysis

eLeaf (the Netherlands):
evapotranspiration, water management

More examples:

Cost and benefits of satellite-based tools for irrigation management (Vuolo et al.; 2013) *overview and cost-benefit analysis of EO for irrigated agriculture in Austria*

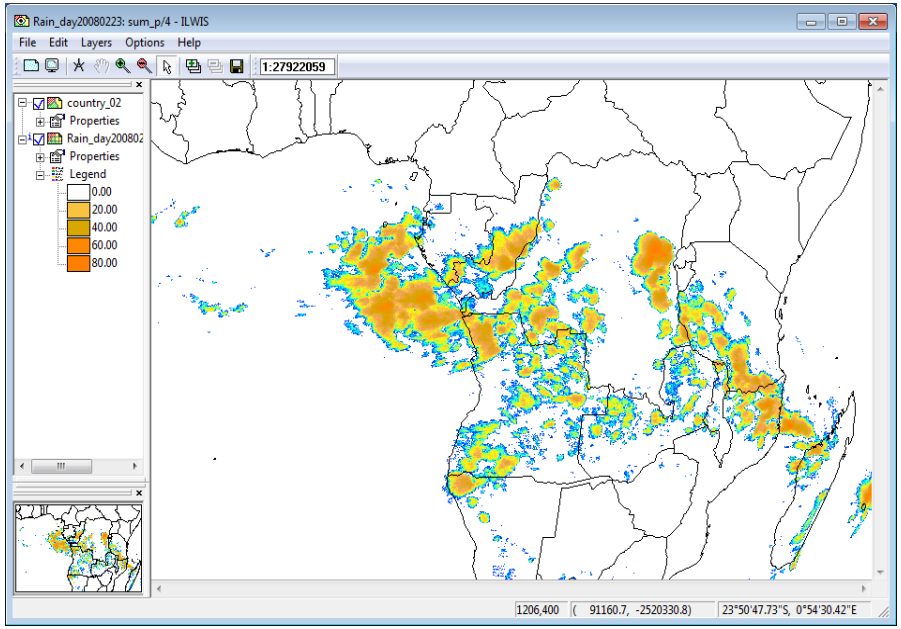
Landsat and water (USGS; 2014) *case studies of the uses and benefits of Landsat imagery in water resources*

Remote sensing for field scale monitoring of crop productivity and crop water consumption: Possibilities and limitations (UNESCO-IHE; 2015) *presentation on the SEBAL tool and FruitLook, including cost-benefit estimates*

Coupling VIS/NIR observations for crop characterisation and agro-hydrological model in irrigation management (IRRI-EYE; 2015) *presentation on practical application of EO for irrigation management*

Managing irrigation from space (TOPS; 2013) *presentation on mapping crop water requirements with satellite observations and CIMIS data in California*

Example weather prediction



Precipitation calculated over Central Africa for 23-02-2008
Source: GEONETCast - DevCoCast application manual (ITC, 2012)

Satellite dish installed at National University of Rwanda
Source: GEONETCast presentation (ITC, 2012)

Weather prediction

- Weather prediction assists planning of farming operations, such as sowing, irrigation and harvesting. Weather prediction is also crucial in early warning for extreme events and climate modelling for adaptation to and mitigation of the effects of climate change.
- Thanks to earth observation and progress in modelling (numerical weather prediction) weather forecasts have improved considerably and can provide quick, accurate and up-to-date information to the farmer.
- Cost estimate: most information derived from satellite images is available free-of-charge, processing and delivery is not.
- Main challenges: timely and accurate information provision to farmers.

Examples:

GEONETCast:

worldwide information dissemination system by which satellite and in situ data, products and services are transmitted to users through communications satellites. Receiving stations use low-cost, off the shelf technology. Information includes climate, weather, agriculture, air quality, disasters, and more. No internet connection required.

Copernicus:

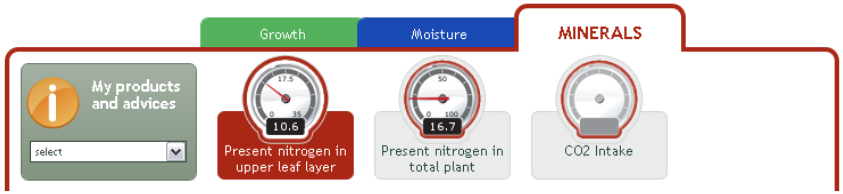
space-based weather prediction, nowcasting and forecasting of atmospheric parameters at global and regional scales and re-analysis of weather parameters at various temporal resolutions.

Farm level: earth observation contribution

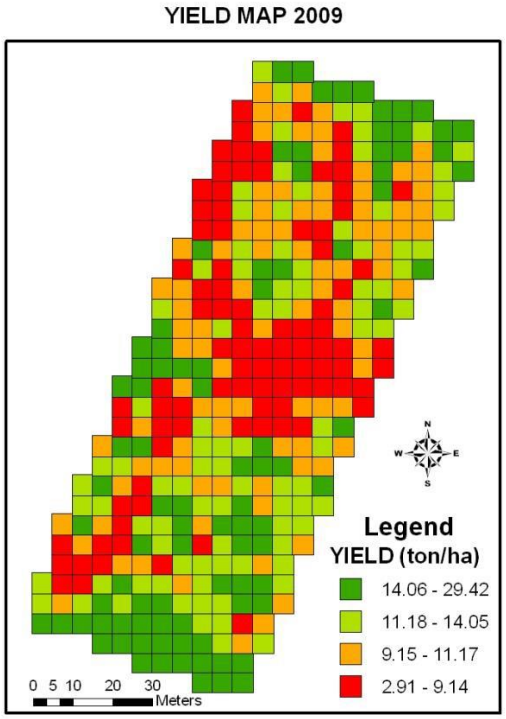
- **Farm site evaluation**,
- **Precision agriculture**: machine guidance, precise planting and harvesting, fertilization advice, yield monitoring, water management advice,
- **Pest management**,
- **Weather prediction**: temperature, rainfall (amount, geographical distribution, intensity, timing), extremes (rainfall, drought, wind, hail, etc.).

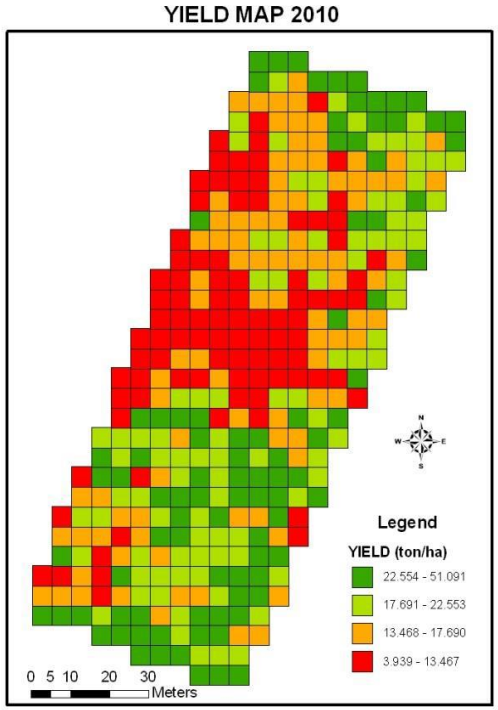
Example precision agriculture (1)

Source:
MijnAkker, Netherlands
&
FieldLook, Ethiopia
(eLeaf 2012 & 2013)



Example precision agriculture (2)





Vineyard yield map and comparison 2010 and 2009

Source: Fountas

Precision agriculture

- Machine guidance, precise planting and harvesting, fertilization advice, yield monitoring, water management advice.
- High-resolution earth observation provides accurate information with high frequency that serves, after processing, to reduce fertilizer input, increase efficiency of water use, etc.
- Cost estimate: 10 -15 € / ha.
- Main challenges: affordability, cloud cover.

Examples:

Although most geospatial applications for precision agriculture are based on satellite navigations and GIS, there are quite a number of products and services offered (or in development) by commercial EO-providers, such as

- **Digital Globe (AgroWatch)**
- **Blackbridge**
- **Airbus Defence & Space (FarmStar)**
- **eLeaf (FieldLook)**
- **Cropio**
- **MicroImages (TNTmips)**
- **IRRI-EYE**

etc.

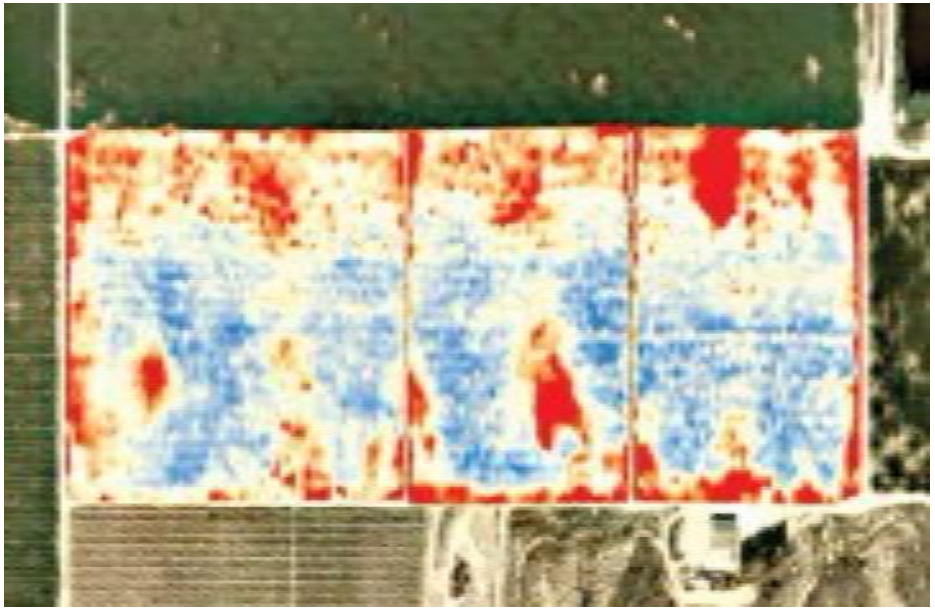
Examples (2):

Precision agriculture: An opportunity for EU farmers – Potential support with the CAP 2014 – 2020 **(JRC; 2014)**

Overview of precision agriculture technology and applications, stakeholders and policy instruments

Example pest management

“FieldCopter” used to monitor crop health
(AeroVision, sponsor: EC/ Galileo)



Water stress in a vineyard in Spain (AeroVision)

Pest management

- Early recognition and treatment of pests, plagues and other diseases / deficiencies.
- Earth observation provides clues about crops possibly affected by diseases. Due to the high repetition time and resolution required, UAVs may offer a better alternative (in terms of remote sensing solutions). In special cases, such as locust plagues, earth observation is instrumental for early warning.
- Cost estimate: on case-by-case basis.
- Main challenges: affordability, timing, accuracy.

Examples:

APHIS (USA):
USDA animal plant health inspection service

EMPRES (FAO):
emergency prevention system for desert locusts, monitoring of desert locusts activity in 30 countries.

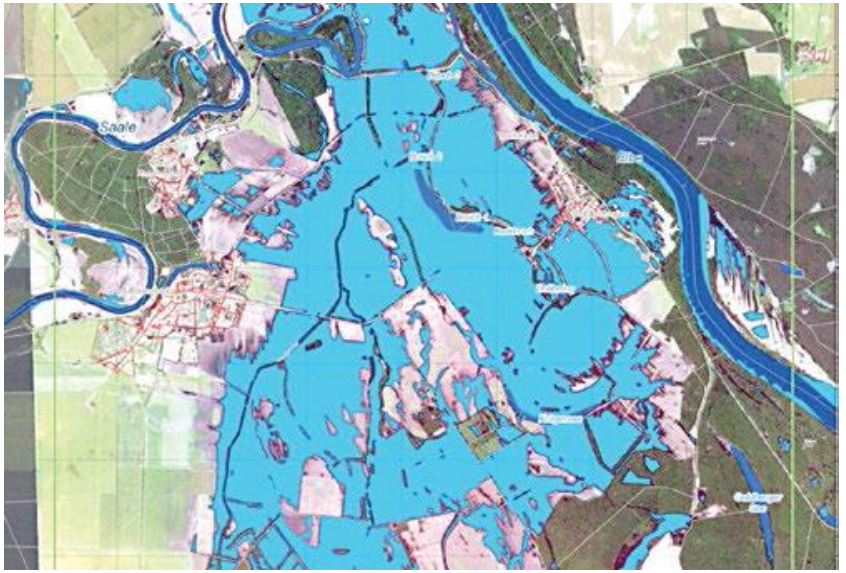
FieldCopter (Aerovision and others):
EU-sponsored pilot project that tests a multi-sensing approach (satellites, UAV, etc.) to detect growth deficiencies, diseases and pests and water shortage.

Agricultural insurance: earth observation contribution

- **Plot identification**,
- **Crop identification**,
- **Crop monitoring**,
- **Yield estimation**,
- **Loss event monitoring and verification**,
- **Risk assessment**,
- **Insurance product indicators**
  (precipitation, evapotranspiration, NDVI, etc.).

Example agricultural insurance

Pre-flood situation in the agricultural area around Breitenhagen, Germany (source: Munich Re)



Flood on the River Elbe in the agricultural area around Breitenhagen in Germany in June 2013. The flooded area is shown in light blue, and the reference water level in dark blue (source: Munich Re)

Insurance

- Insurance against extreme events and/or reduced yields is an important safety net for farming.
- Earth observation helps reduce costs in assessing risk and monitoring and verification. Index-based insurance, where pay-out is a based on performance of a single or a small number of parameters, earth observation can play a key role.
- Cost estimate: 10 – 20 € / ha for smallholder farmers in Africa is an acceptable range for premiums.
- Main challenges: acceptance, business model.

Examples:

FESA (EARS):
the food early solutions for Africa offers a framework for index-based insurance for small farmers, based on evapotranspiration.

Many national (mainly conventional) agricultural insurance schemes, where earth observation is used for verification and compliance monitoring.

There are also many index-insurance pilot projects for small farmers, based on earth observation, with different parameters, such as rainfall, NDVI, evapotranspiration, in cooperation with the World Bank, Munich Re, Swiss Re, etc.

Growth potential for earth observation

- **Precision agriculture: increase yields and productivity**.
  Main clients: commercial large-scale agri-businesses.
- **More detailed agricultural information systems, including monitoring and control.**
  Main client is government.
- **Applications that increase the efficiency of resource use, such as water, fertilizer or fuel**.
  Clients are both individual farmers and (local) government.
- **Applications that are related to market information: geospatial component of rapid information exchange about prices of agricultural products** .
  Main clients: farmers and traders.

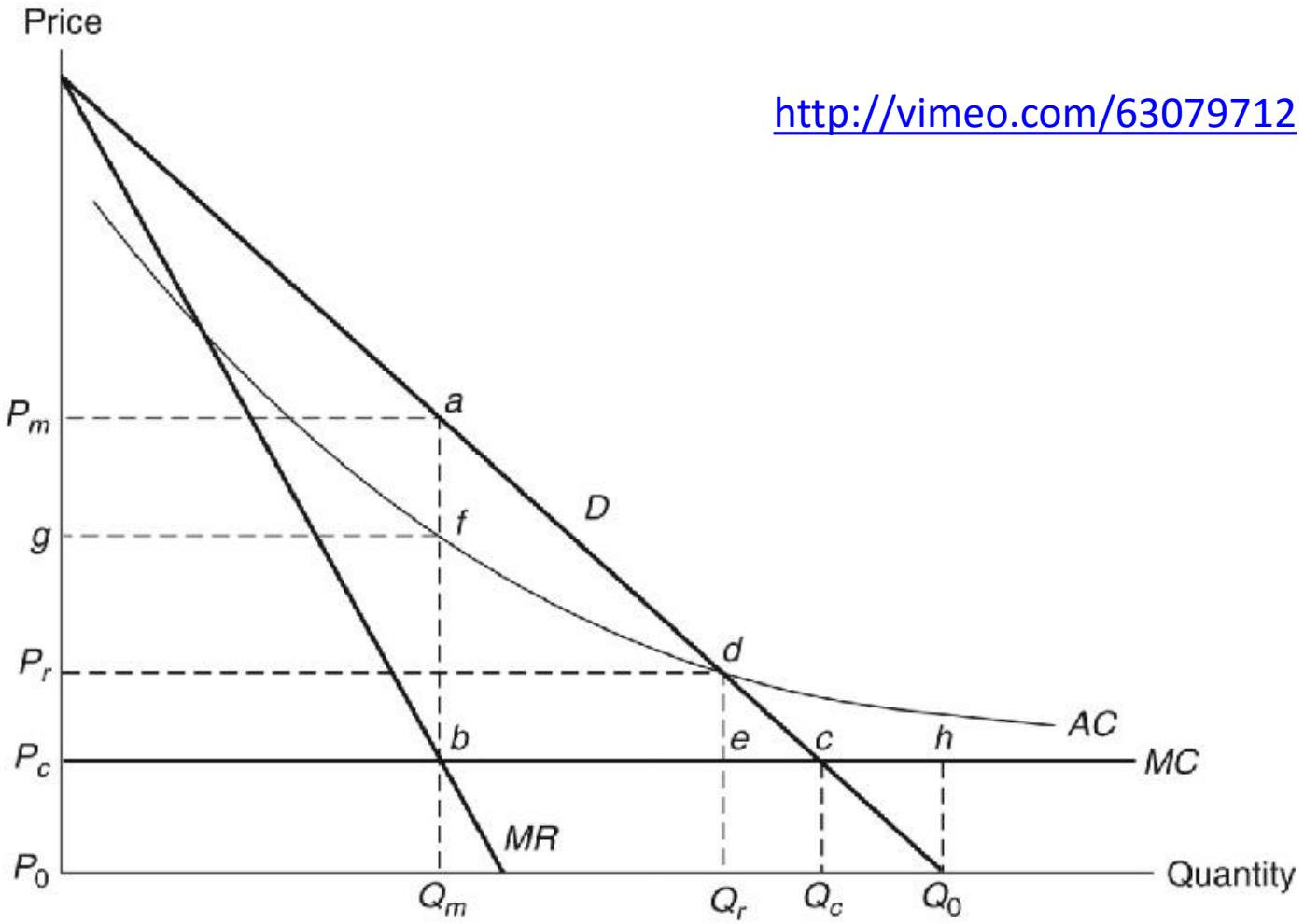
3. Business development

Why is marketing / promotion of earth observation needed?

- Public sector information (PSI)
- Externalities (environmental accounting & payment for ecosystem services)
- Global datasets, open access, data sharing, compatibility (GEO)

If public sector information is made available free-of-charge, demand will increase and, in the end, government revenue also, as companies will derive income from value-added products and services, and consequently pay more taxes (see figures in following slides).

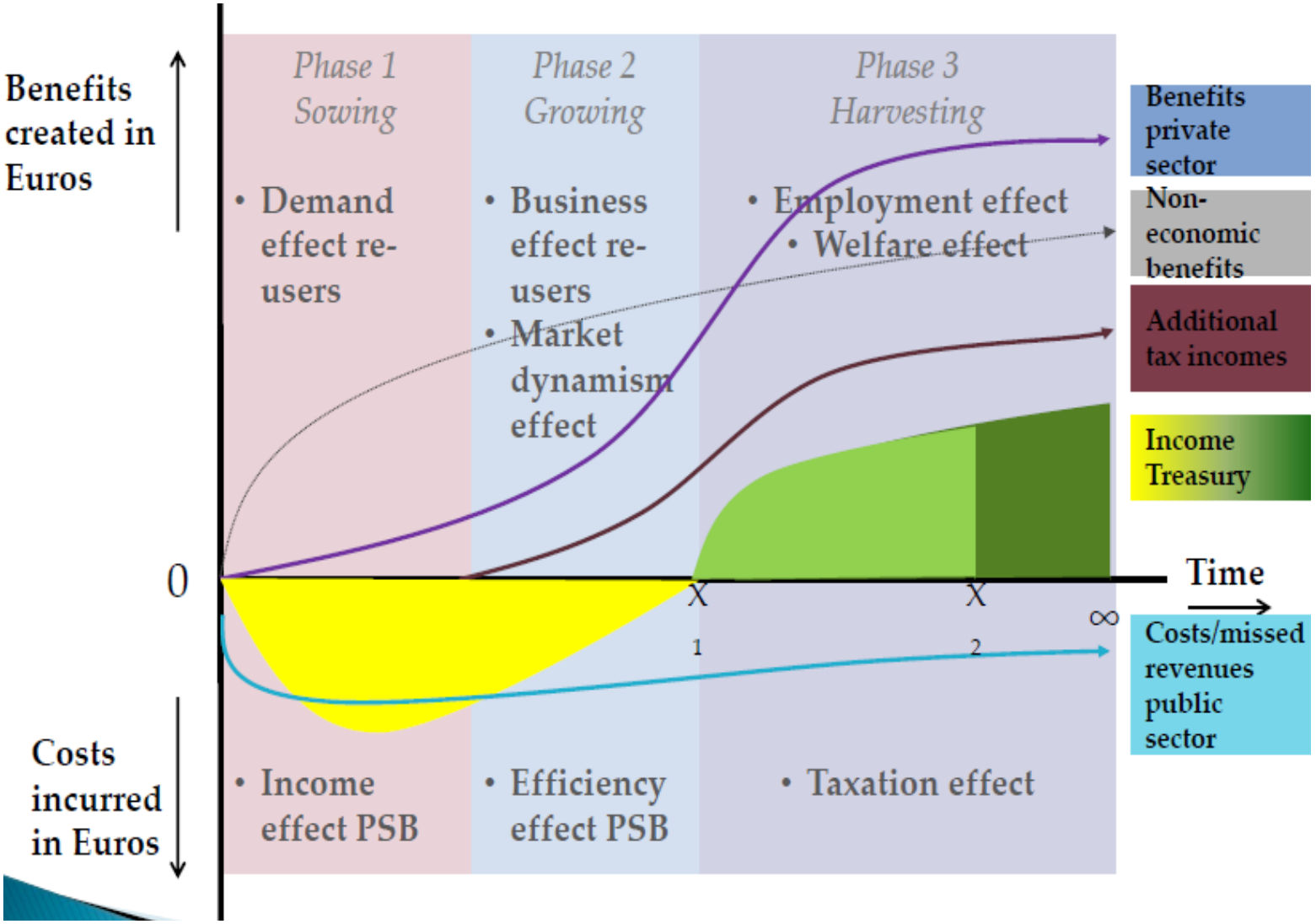
Supply & Demand Public Sector Information



http://vimeo.com/63079712

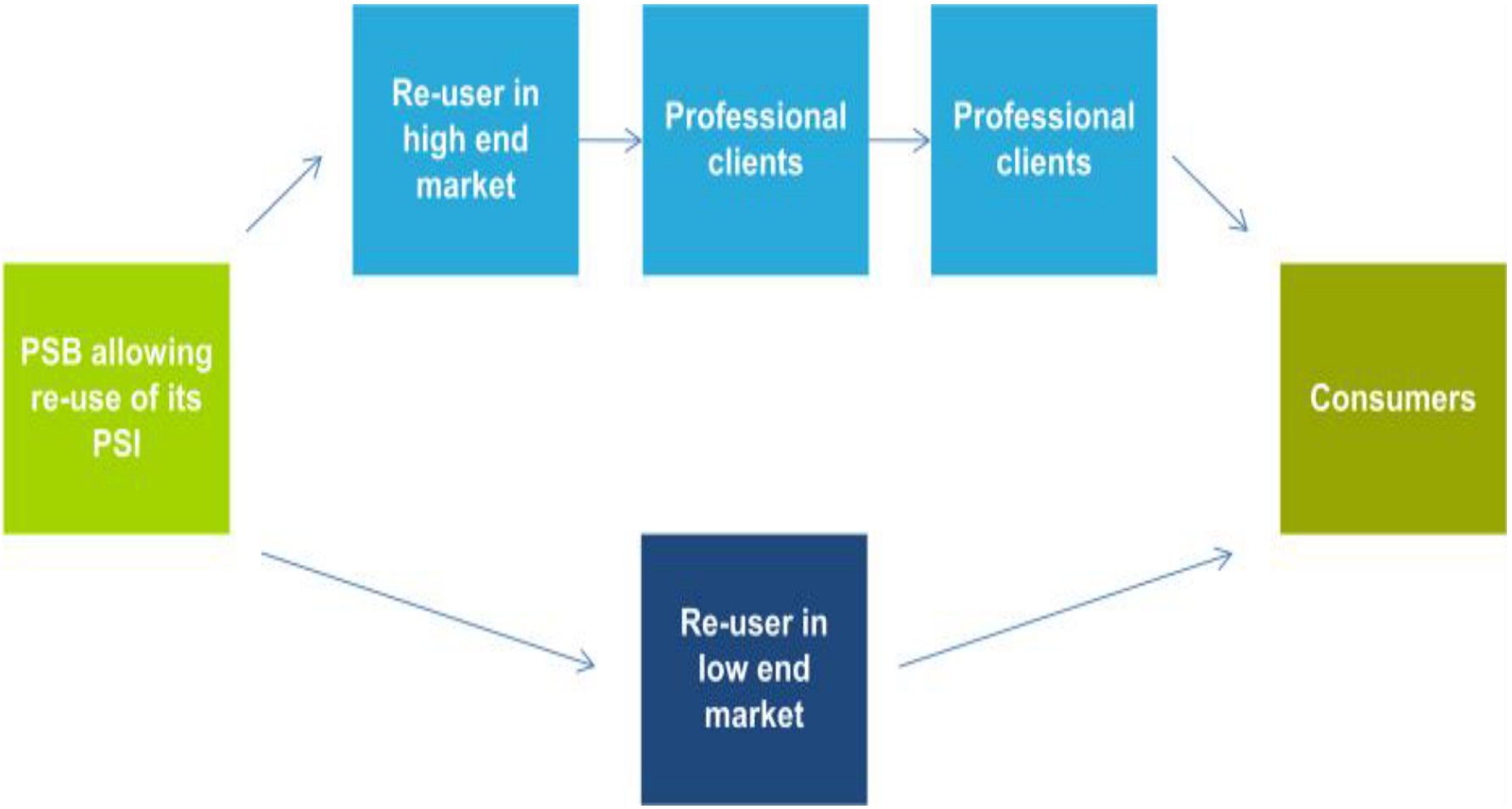
Source: About GMES and data: geese and golden eggs (Sawyer, de Vries 2012)

Cost-benefit Public Sector Information



Source: About GMES and data: geese and golden eggs (Sawyer, de Vries 2012)

Re-use of Public Sector Information



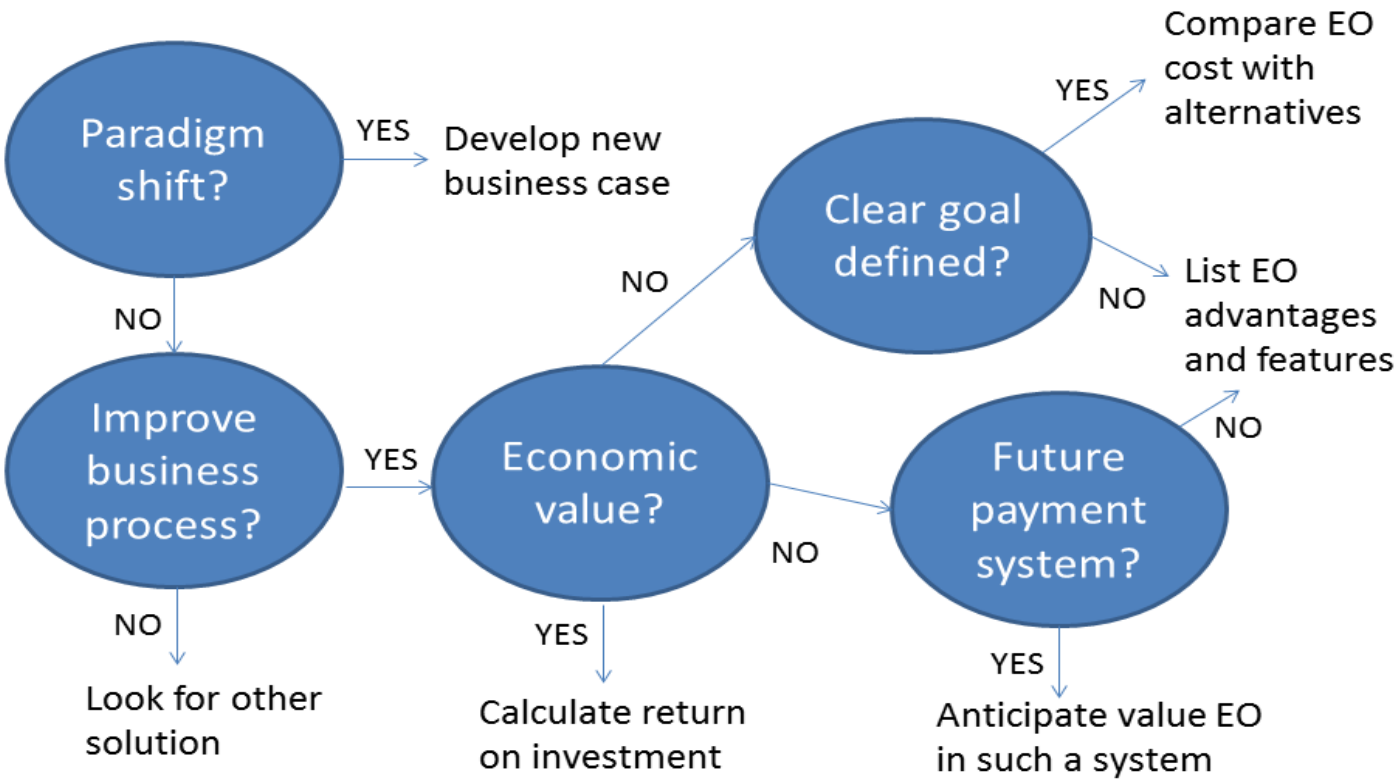
Source: About GMES and data: geese and golden eggs (Sawyer, de Vries 2012)

Most earth observation applications deal with so-called externalities, such as impact on the environment.
It is difficult to capture these in terms of conventional cost-benefit models.

To tackle this, the following framework for analysis of earth observation applications is developed:

Framework for analysis

Step-by-step benefit EO



Step-by-step analysis of the benefits of earth observation (source: GEONetCab, 2013)

Key questions

- Does the new application cause a paradigm shift?
- Is the current business or organization process improved?
- Does the application provide economic value that can be quantified?
- Is a clear measurable goal defined to which the earth observation application contributes?
- Is a future payment scheme or other economic mechanism foreseen in which the earth observation application fits?

Assessment of geospatial solutions

Rating of **characteristics** of geospatial solutions:

- fit-for-purpose
- comparative advantage
- complexity to user / ease- of-use
- elegance
- cost-benefit,
- sustainability
- resilience
- reproduction capacity / flexibility
- acceptance
- level of knowledge transfer required
- ethics, transparency, public accountability, objectivity & impartiality

Rating of **business environment**:

- **Willingness to pay** (by clients)
- **Embedding** (in organizational processes)
- **Openness** (transparency and ease of doing business, access to markets)
- **Institutions** (is the institutional environment conducive to doing business, acceptance of new solutions?)

Fit-for-purpose

An important, but often forgotten requirement:
Does the product or service do what it is supposed to do to solve a certain problem?

In other words: is it really a solution or just an attempt towards a solution?

- Quantitative: not applicable
- Qualitative (on scale of 1 to 5): based on description of what the EO solution actually does

Comparative advantage

What it does significantly better than other solutions to the same problem.

For earth observation usually the comparative advantages of greater accuracy, better resolution in time and space, comprehensive overview of large areas and near real-time information provision are mentioned as comparative advantages.

- Quantitative: calculation of degree in which the EO solution is better than alternatives
- Qualitative (on scale of 1 to 5): based on listing of comparative advantages

Complexity (to user) / ease-of-use

At all levels in the value chain the users (professionals and end-users) are able to work with the product or service.

- Quantitative: not applicable
- Qualitative (on scale of 1 to 5): based on user testimonials and user surveys

Elegance

Once you get the idea behind this product or service, you want to be part of the community that uses it.

This sense of belonging facilitates the formation of user groups that provide valuable feedback.

- Quantitative: none, or it should be the size of the user community
- Qualitative (on scale of 1 to 5): based on user testimonials and user surveys

Cost-benefit

The cost-benefit of the product or service is quantified and sufficiently attractive, also in the long-term.

- Quantitative: cost-benefit calculation
- Qualitative (on scale of 1 to 5): based on quantitative assessment

Sustainability

The product or service can be delivered when it is needed.
There is a long-term perspective that guarantees delivery.

Sustainability concerns the following aspects:

- ✓ Long-term data availability
- ✓ Availability of finance/funds to provide the solution continuously for present and future use
- ✓ Long-term institutional / governmental interest and support
- ✓ Long-term user interest for a solution that addresses real needs

- Quantitative: not applicable
- Qualitative (on scale of 1 to 5): based on sensitivity analysis of the EO solution

Resilience

In case of extremes or breakdown in the value chain, the product or service can still be delivered at an acceptable level. Alternatives (plan B) are available (and developed).

- Quantitative: cost-benefit calculation of plan B
- Qualitative (on scale of 1 to 5): based on risk analysis of the EO solution

Reproduction capacity / flexibility

The product or service can be easily applied or adapted for use in another region or another situation, while still providing the solution without (too much) extra cost.

- Quantitative: calculation of reproduction costs for application in other regions or situations; measurement of spreading of actual use
- Qualitative (on scale of 1 to 5): based on quantitative assessment and description of EO solution

Acceptance

The users intuitively get what the product or service is about and are interested. They accept it as a solution to their problem.

- Quantitative: none, or survey results about acceptance. After introduction of the solution: number of clients and/or users
- Qualitative (on scale of 1 to 5): based on user testimonials and user surveys

Level of knowledge transfer required

The training requirements for professionals and other users along the value chain are clear and associated costs and efforts are acceptable.

- Quantitative: cost and time required to get the users at the desired knowledge and skill level
- Qualitative (on scale of 1 to 5): based on knowledge transfer plans and evaluation of training activities

Ethics, transparency, public accountability, objectivity & impartiality

Application of Earth observation increases the level of objectivity and impartiality in decision-making processes, including conflict resolution. The application improves transparency and public accountability. It raises no ethical issues or if it does, as in the case of privacy concerns, these are resolved in a satisfactory way for all parties concerned.

- Quantitative: not applicable
- Qualitative (on scale of 1 to 5): based on user testimonials and user surveys

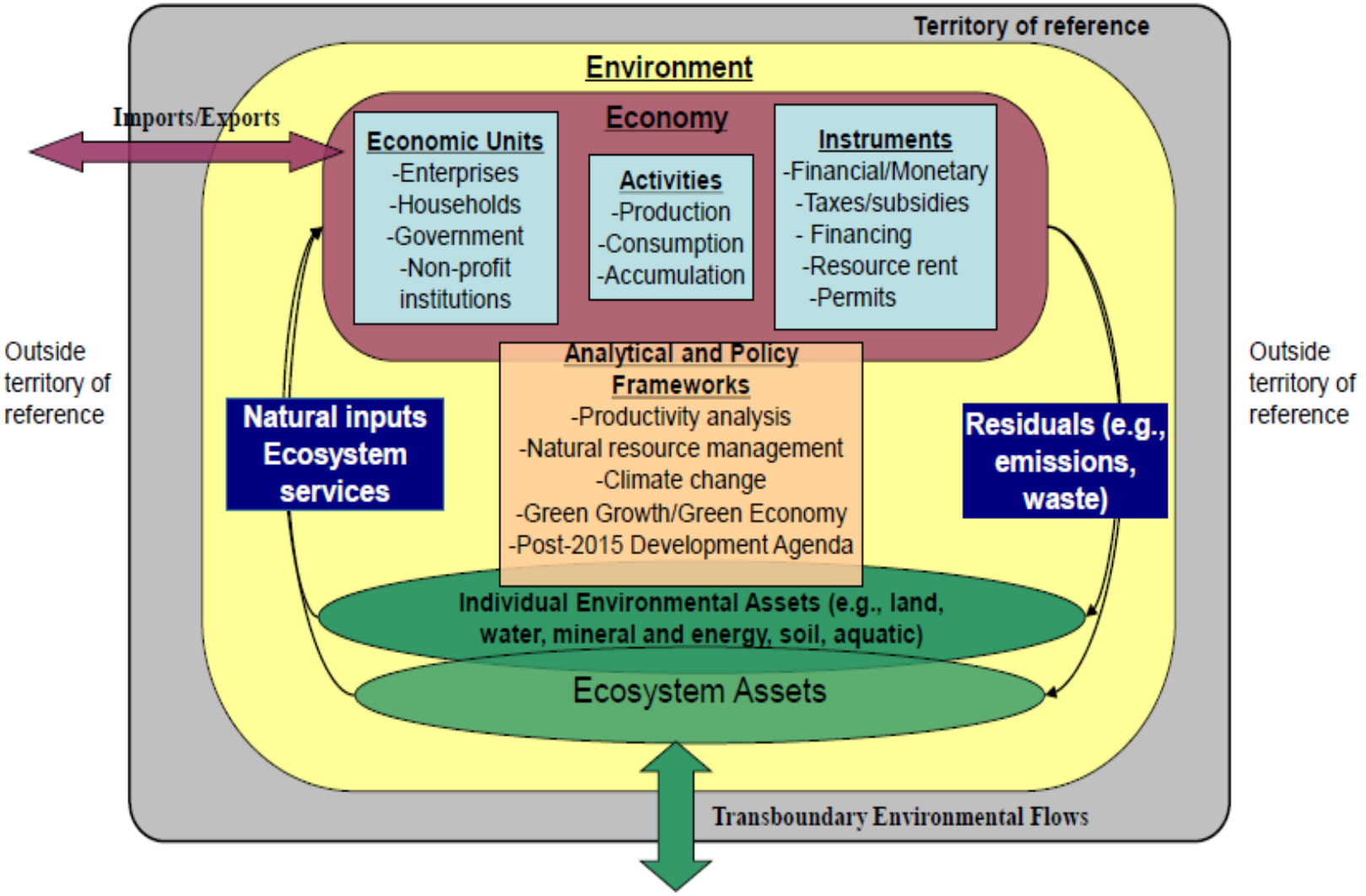
Several attempts have been made to introduce environmental accounting and to enlarge the sphere of the conventional economy to include and quantify impact on ecosystems.

The following slides give some examples:

Environmental accounting & payment for ecosystem services

- **SEEA:**
  System of Environmental-Economic Accounts
  (EC, FAO, IMF, OECD, UN, WB)
- **WAVES:**
  Wealth Accounting and the Valuation of Ecosystem Services (global partnership, led by World Bank)
- **TEEB:**
  The Economics of Ecosystems and Biodiversity
  (group led by UNEP)

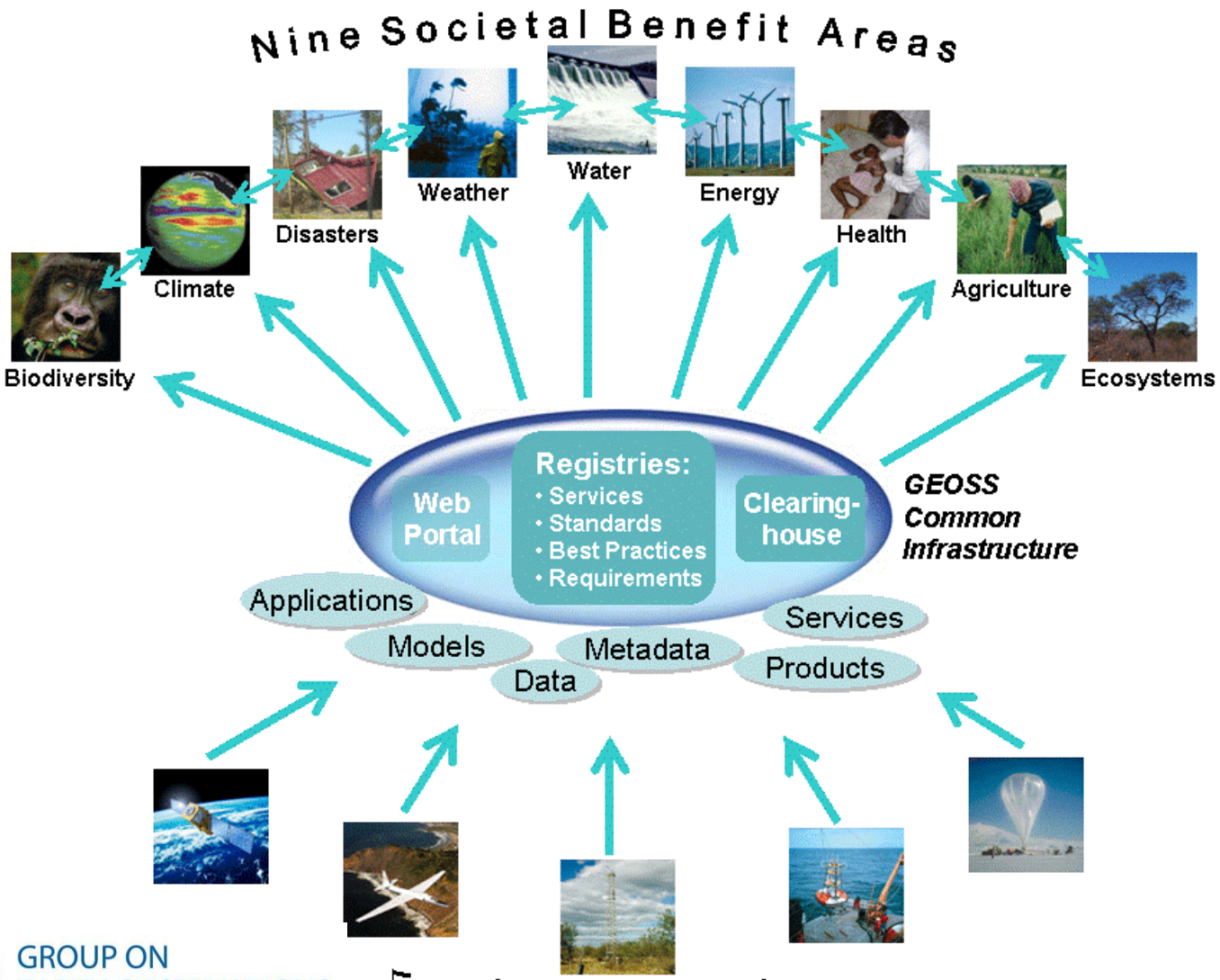
SEEA Conceptual Framework



Source: SEEA conceptual framework report (EC, FAO, IMF, OECD, UN, WB 2012)

For earth observation the work of the Group on Earth Observations (GEO) is essential to achieve the goal of a Global Earth Observations System of Systems (GEOSS), resulting in the shared GEO common infrastructure (GCI):

Group on Earth Observations



GROUP ON EARTH OBSERVATIONS

Marketing elements

- Customer value propositions
- Crossing the technology chasm
- Creating shared value
- Promotion tools

Customer value propositions capture the unique value of a product or services as perceived and appreciated by the customer.

Interestingly, they can differ completely from the features that the provider considers most important:

Customer Value Propositions

VALUE PROPOSITION	ALL BENEFITS	FAVOURABLE POINTS OF DIFFERENCE	RESONATING FOCUS
Consists of:	All benefits customers receive from a market offering	All favourable points of difference a market offering has relative to the next best alternative	The one or two points of difference whose improvement will deliver the greatest value to the customer
Answers the customer question:	"Why should our firm purchase your offering?"	"Why should our firm purchase your offering instead of your competitor's?"	"What is *most* worthwhile for our firm to keep in mind about your offering?"
Requires:	Knowledge of own market offering	Knowledge of own market offering and next best alternative	Knowledge of how own marketing offering delivers value to customers, compared with next best alternative
Has the potential pitfall:	Benefit assertion	Value presumption	Requires customer value research

Source: Customer value propositions in business markets (HBR 2006)

Buyer behaviour & motivation

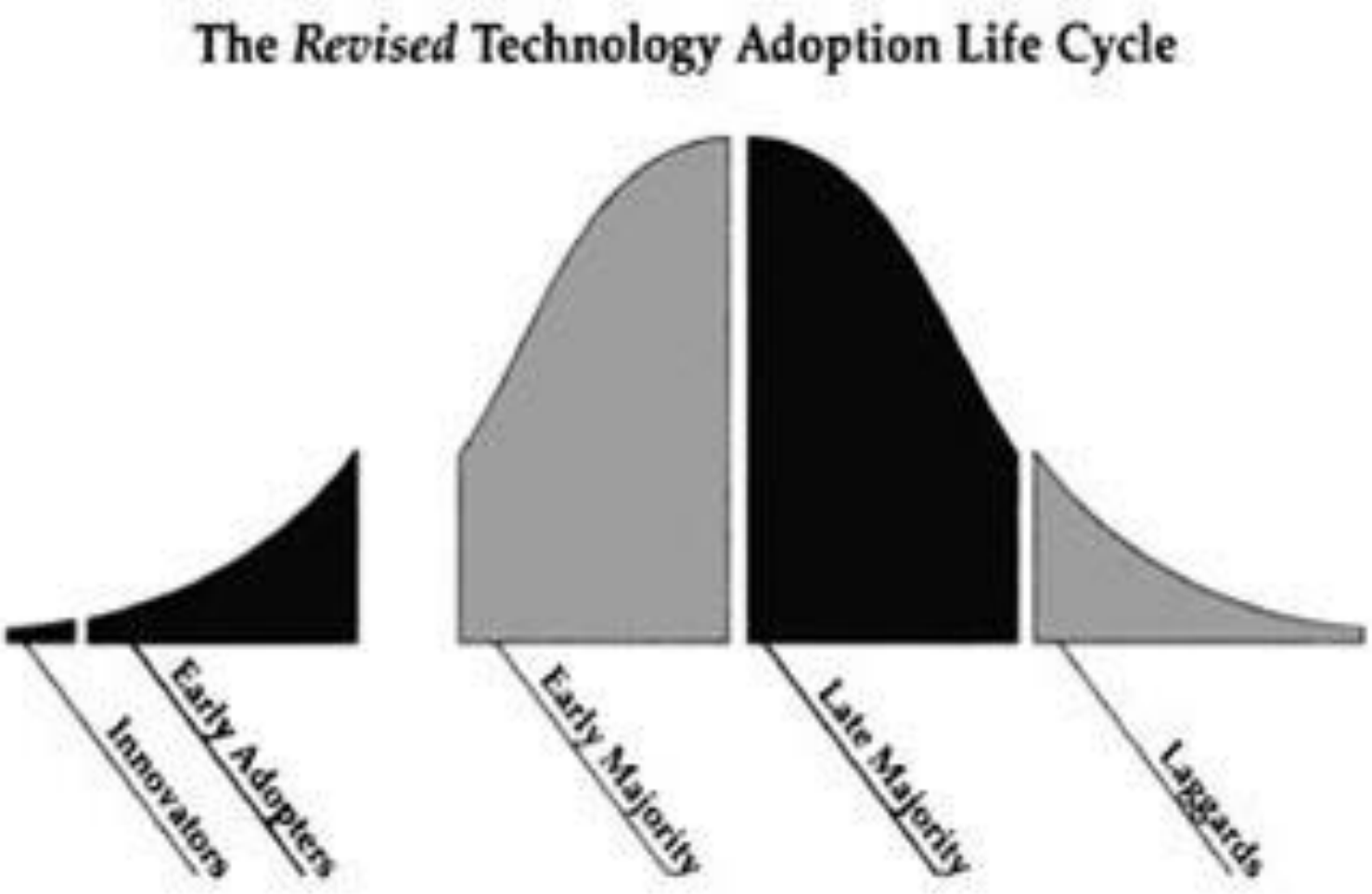
Type	Buyer behaviour	Motivation
Transactional sales	Intrinsic value buyers: "keep it cheap and easy to do business"	Understands the product Perceives it as substitutable Cost focus Resents time 'wasted' with sales people
Consultative sales	Extrinsic value buyers: "I don't know the answer: help me analyse and solve the issue	Focus on how the product is used Interested in solutions and applications Values advice and help Needs the sales person

Source: Rethinking the sales force (Rackham, de Vincentis 1999)

Even when customer value propositions are well captured and formulated, introduction of solutions that involve new technology will have to overcome some hurdles.

This is called “crossing the technology chasm”:

Crossing the technology chasm



Source: Crossing the chasm (Moore 1991)

Crossing the technology chasm

- Most clients of EO products and services belong to the early and late majority.
- They are pragmatists and are not prepared or willing to take substantial risk: the solution should work and be reliable.
- Once convinced, the pragmatists will be long-term clients.

Source: Crossing the chasm (Moore 1991)

More information:

Creating & delivering your value proposition
– managing customer experience for profit
(Barnes, Blake, Pinder; 2009)

Customer value propositions in business markets
(Anderson, Narus, van Rossum [Harvard Business Review]**; 2006)**

Rethinking the sales force:
refining selling to create and capture customer value
(Rackham, de Vicentis; 1999)

Crossing the chasm
– marketing and selling high-tech products to mainstream customers
(Moore; 1991)

Creating shared value is a key element of successful implementation of earth observation solutions.

To achieve this, in most cases earth observation applications have to be integrated into more general (business or organizational) processes:

Create shared value

Involves cooperation between:

- **Public sector**
- **Private sector**
- **Social sector**

Opportunity for earth observation (integrated) solutions:

- Integrate EO in general business / organizational process
- Integrate different EO (and GIS and navigation) functionalities

Based on all considerations dealt with in the previous slides, there are some practical approaches that can be applied in combination to promote earth observation applications:

Tools for earth observation marketing:

- Success stories (in non-technical language, feasible, replication capacity, sustainable)
- Marketing toolkits (international trends, earth observation examples, references)
- Pilot projects, innovation funds, quick-wins (demonstration that EO actually works)
- Promotion outside EO community (fairs, seminars, lunch-bag meetings, magazines)
- Resource facilities for reference and capacity building (distributed, but connected, in different languages)

Source: Marketing earth observation products and services (Noort 2013)

Business elements

Business elements:

- **Proposal writing**
- **Business procedures**

Proposal writing is an art in itself.

During the GEONetCab and EOPOWER projects templates have been developed for writing successful proposals:

Proposal outline

1. Introduction / relevance
2. Objective(s)
3. Activities
4. Output
5. Management & evaluation
6. Risk assessment
7. Time schedule
8. Budget

Annexes

(more detailed version in separate document,
see www.eopower.eu or www.hcpinternational.com)

Other guides that may be useful:

- Civicus: writing a funding proposal
- Michigan State University: guide for writing a funding proposal
- ESRI: writing a competitive GRANT application
- REC: project proposal writing

If you run a company, compete for assignments and manage projects, a structured approach towards responsibilities, tasks, implementation and documentation is needed.

The following business procedures may be helpful:

Business procedures

1. On acquisition
2. On offers
3. On negotiation
4. On contracts
5. On project management
6. On travel & deployment
7. On deficiencies & complaints
8. On internal organization
9. On finance

(more detailed version in separate document,
see www.eopower.eu or www.hcpinternational.com)

Again:

- **SHARED PROBLEM**
- **SHARED LANGUAGE**
- **SHARED SOLUTION**

4. Capacity Building

General

Marketing is promotion + capacity building.

Especially for the introduction of new technologies capacity building is important at all levels.

Capacity building is the instrument to increase self-sufficiency and make solutions work.

General references for capacity building, open data and success stories

GEO Portal: www.earthobservations.org

Capacity building resource facility www.geocab.org
compilation of tutorials, references, open-source software, etc.

Satellites going local: *share good practice* **(Eurisy handbooks)**
www.eurisy.org

Earth observation for green growth (ESA; 2013)

General references for capacity building, open data + call for proposals

Bringing GEOSS services into practice:
how to use data from the GEO portal and how to provide input
www.envirogrids.net

Science education through earth observation for high schools:
basic tutorials on all kind of subjects, including agriculture
www.seos-project.eu

Securing water for food: *call for proposals on innovative solutions*
securingwaterforfood.org

Copernicus briefs: *information on satellite applications for different topics*
http://www.copernicus.eu/main/copernicus-briefs

More references open data

Open data for sustainable development (World Bank; 2015)
description of the benefits of open data for a wide range of development goals, including the SDGs
http://pubdocs.worldbank.org/pubdocs/publicdoc/2015/8/904051440717425994/Open-Data-for-Sustainable-development-Final-New.pdf

Terms and conditions for the use and distribution of Sentinel data (European Parliament and European Commission; 2014)
standard stipulations related to free and open access to Sentinel data
http://www.demarine.de/lr/c/document_library/get_file?uuid=c5067655-b7ad-4d71-b07b-6111808f4abd&groupId=13521

Towards a thriving data-driven economy (European Commission; 2014) *policy document on the use of (open) data for a knowledge economy and society*
http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=6210

Capacity building resources for agriculture:

GEOGLAM www.geoglam-crop-monitor.org

AGRICAB (follow-up of DevCoCast and GMFS):
optical remote sensing, radar remote sensing, agro-meteorological modelling, food security information systems, product validation www.agricab.info

DevCoCast: *GEONETCast applications for agriculture*
www.devcocast.eu

e-Sourcebook ICT in agriculture (World Bank, 2011)

Remote sensing applications – chapter 1: Agriculture
(NRSC, 2010)

Capacity building resources for agriculture (2):

Use of active earth observation systems for agricultural monitoring

Monitoring and identification of crop areas using hyper temporal low resolution images **(ITC; 2015)**

3-day EOPOWER (self-study) course for professionals

http://menhir.itc.utwente.nl:5000/fbsharing/KGKOZXKU/

Further details:

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www.hcpinternational.com