IAgrE Landwards Conference 2019
Can *Big Data* lead to Smarter Farming?
Wednesday 30th October 2019,
Peterborough Suite, East of England Events Centre,
Peterborough

Internet of Things (IoT) for Agriculture

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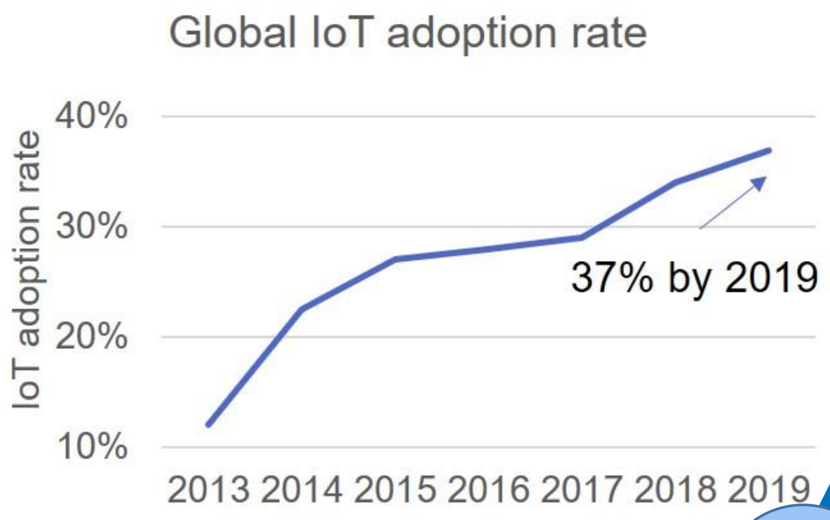
The views expressed are those of the author alone and do not necessarily reflect the views of Harper Adams University or other institutions

Towards an IoT for Agriculture – Overview



Source: IDTechE

The long transition – 1998 MIT to now – long tails of a sigmoid growth curve

Initial IoT Concept

Initial concept predicated on RFID (10 cent tags) and ubiquitous tagging of things

Evolving IoT Ecosystem

IoT Initialising imperatives

Emerging IoT Technology & Data Services

Intern
Agri-Th
IoA

Future –
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Specification and Implementation of IoAT/IoFT GOVERNANCE – A crucial but absent foundation addressing Food Security and Planetary Boundary issues

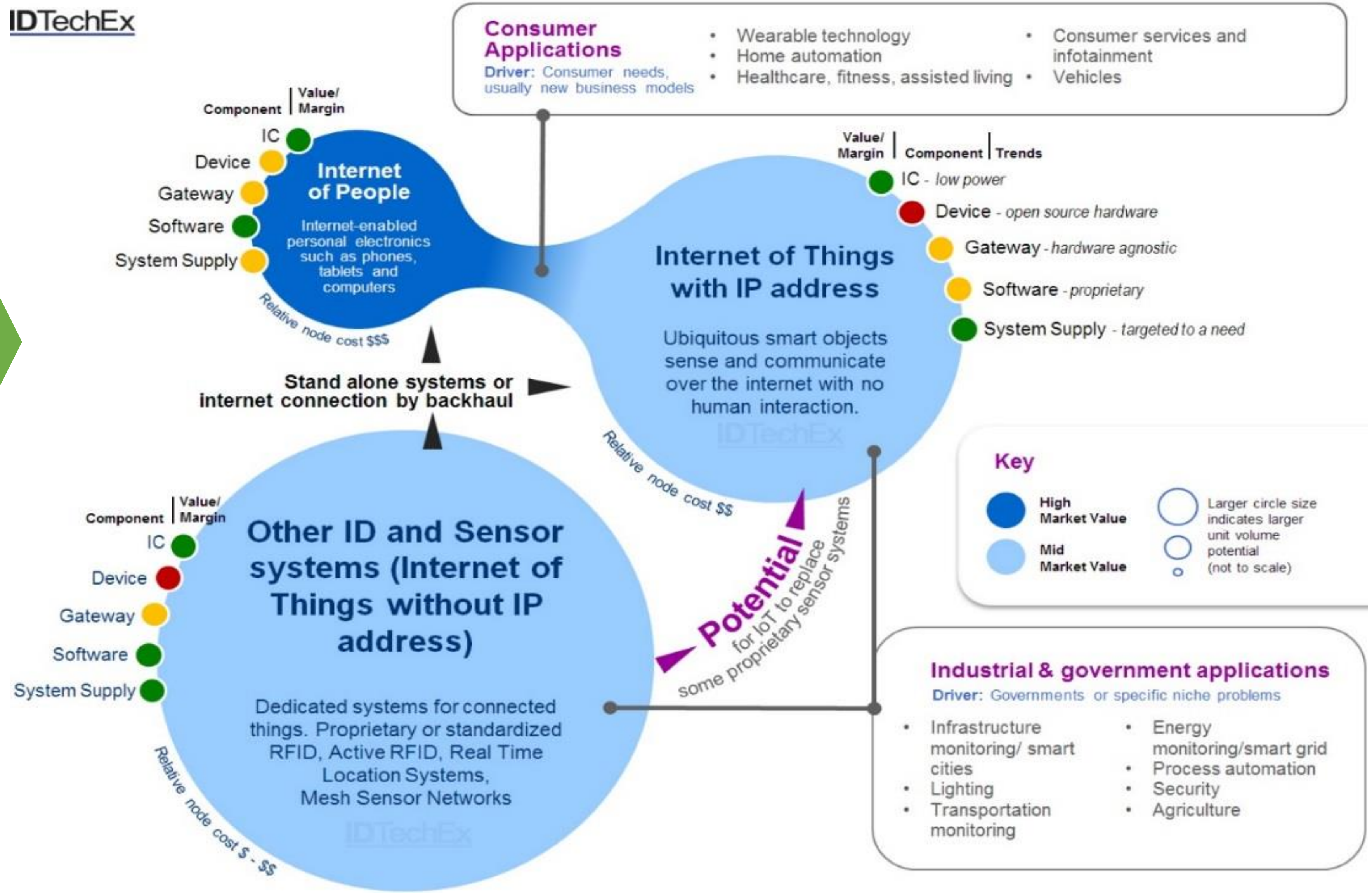
UK Government Animal and Plant Health Science Strategy

Workshop to develop proposals for “Internet of Agri-Things” for the understanding and management of crop and livestock diseases: 19-20 November 2015

2017 Last of
Science & Innovation Audit – ICT, A crucial but absent foundation

Towards an IoT for Agriculture – Emergent Ecosystem

Evolving IoT Ecosystem



With permission from IDTechEx

Towards an IoT for Agriculture – Initialising Imperatives

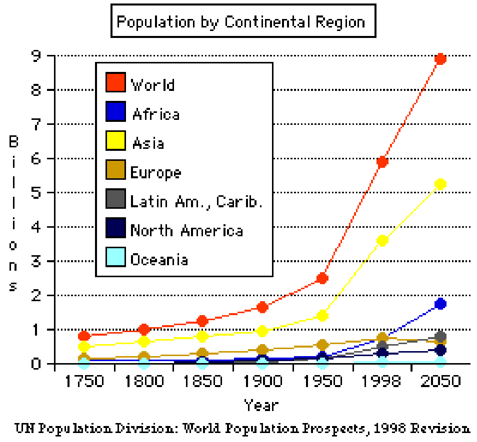
Farming Challenges & Needs

Wherein the concept twenty years on?

- **Significant developments in technology** – communications, sensing, low power ID devices, gateway hardware, systems support.
- **Significant developments in internet and web services**, including developments with regard to cloud computing, big data, machine-to-machine communications, AI…

- **But still no clear IoT specification for agriculture?** - largely process support applications with Internet access – important, but not realising the full potential of the IoT concept.
- **Also lacks Governance…**
- **Specification and Governance could allow more effective accommodation of national and global challenges – specifically relevant to agriculture and primary food production**

IoT for Agriculture – Tackling Global Challenges



Responding to the Growing World Population and Food Security

- 50% increase in global food demand by 2050
- Exacerbated by the needs to avoid adverse impacts upon the environment, climate change and use of resources

Responding to the Critical Demands of Climate Change / Planetary Boundaries

- Nine critical boundaries, even more socio-economic factors.
- Exacerbated by the needs to avoid adverse impacts upon the environment, climate change and use of resources

Applying the precision principles across the farming modalities

- New era being driven by need and by opportunity not only in Livestock, Arable and Horticulture, but also integrated Urban and Aquaculture, and their associated service and supply chains

Urban Outreach and Smart City Farming

- Exploiting potential for Integrated Ecosystem Food & Energy Production
- Extending the concept of Smart City living

Innovation for productivity and sustainability – The Totally Connected Farm

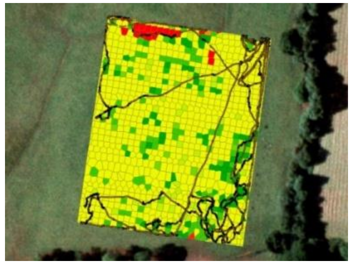
- Innovation in use of resources and environmental response
- Incremental innovation through continuous process improvement
- Systems engineering innovation and the importance of standards

IoT for Agriculture – Global Challenges – Precision Farming

Precision Farming – **Global Importance in securing future food supplies** - **already worth £1 billion to the UK economy**

Precision Farming

The global needs translate to national, regional and individual farming needs, with prospective solutions focused upon:



- **Intensification and phenotyping**
- **Sustainability**
- More effective use of **identification, integration and exploitation of foundational science**
- Improving production through **process enhancement** and development based upon profound understanding of precision and precision economics
- **More effective management**
- **More effective and efficient use of resources**
- **More effective use of radical, beneficially disruptive, information technologies and automation (including robotics) – (10’s % improvement and fast return on investment)**
- **Innovation for productivity and sustainability**

IoT for Agriculture – Global Challenges – Food Security

Food Security – World facing an unprecedented challenge to accommodating a 50% increase in global food demand by 2050.

(Beddington, J (2011) The Future of Food and Farming, Foresight Report. Food and Agriculture Organization of the United Nations – FAOSTAT – FAO Statistical Database)

Food Security

The global needs translate to national, regional and individual farming needs, with prospective solutions focused upon:

A Five Step Plan*:

- **Controlling the agricultural footprint**
- **Improving the yields of existing farmland**
- **More effective and efficient use of resources**
- Shifting diets away from meat
- Reduction in food wastage

- Also – **Distribution, coupled with efficient track and traceability**

*** Foley. J A et al., (2011) Solutions for a cultivated planet, Nature, 478, 337-342, Oct 2011**

IoT for Agriculture – Global Challenges – Planetary Boundaries

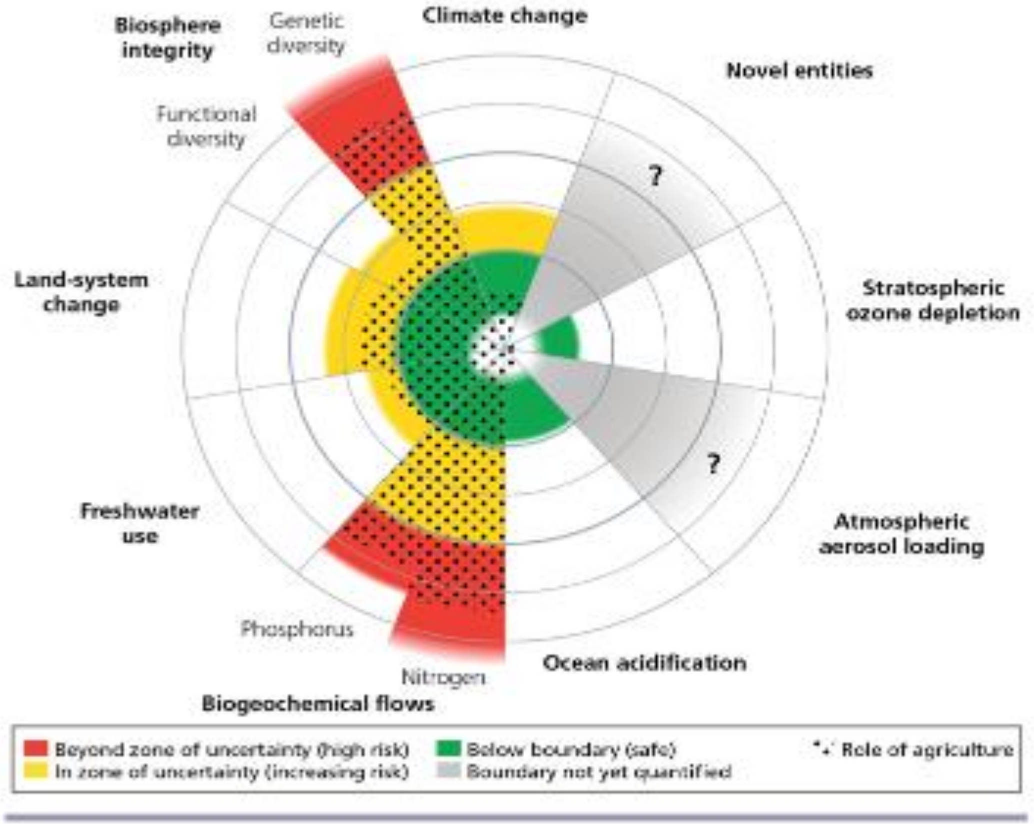
Planetary Boundaries – Global Importance

Planetary Boundaries

The global needs translate to national, regional and individual farming needs to consider:

- Climate change
- Land usage
- Water usage
- Bio-geochemical flows
- Biodiversity

Also socio-economic factors, circular and doughnut-economy issues

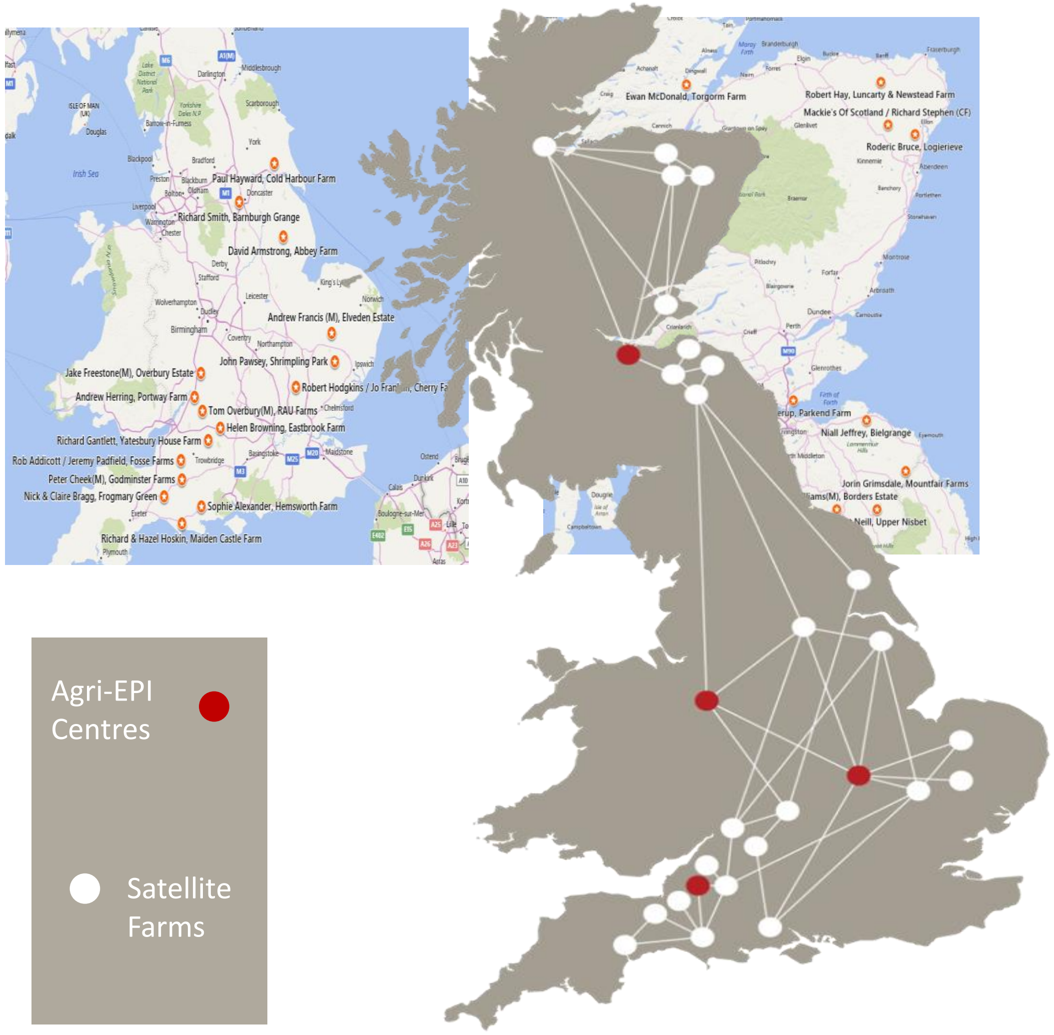


Source: Campbell, B. M., et al., (2017). Agriculture production as a major driver of the Earth system exceeding planetary boundaries. *Ecology and Society* 22 (4):8.

National Climate Emergency – not just about emissions – Requiring radical **engineering** solutions platform, accommodating future support needs.

AGRIEPICENTRE
Engineering • Precision • Innovation

Centres and Satellite Farms as an ideal platform for IoAT Implementation

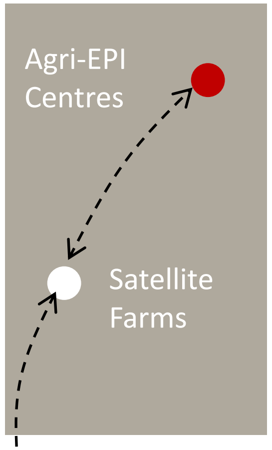


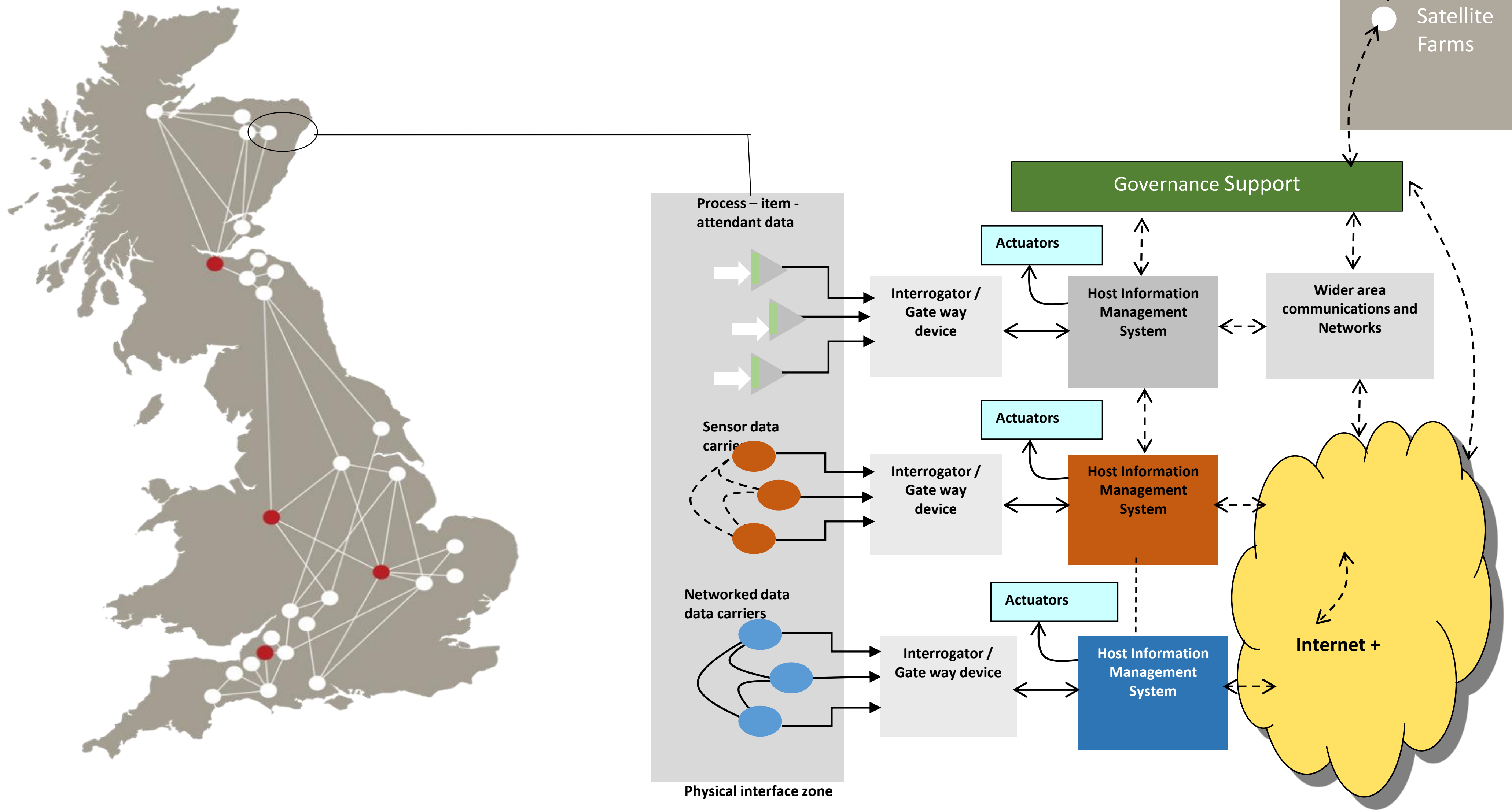
Tackling global challenges requires a well-defined National IoT for Agriculture with Governance

Needs may be considered to include:

- An agriculturally-specific, industry-supported, network specifications
- Open-systems approach for ease of construction and scalability
- Object Identification protocols and standards
- **Data identification**, open source and proprietary ownership
- Communications protocols and associated standards
- IoT Protocols and associated standards
- **Challenge Data**, systems and cyber security
- **Governance infrastructure….**

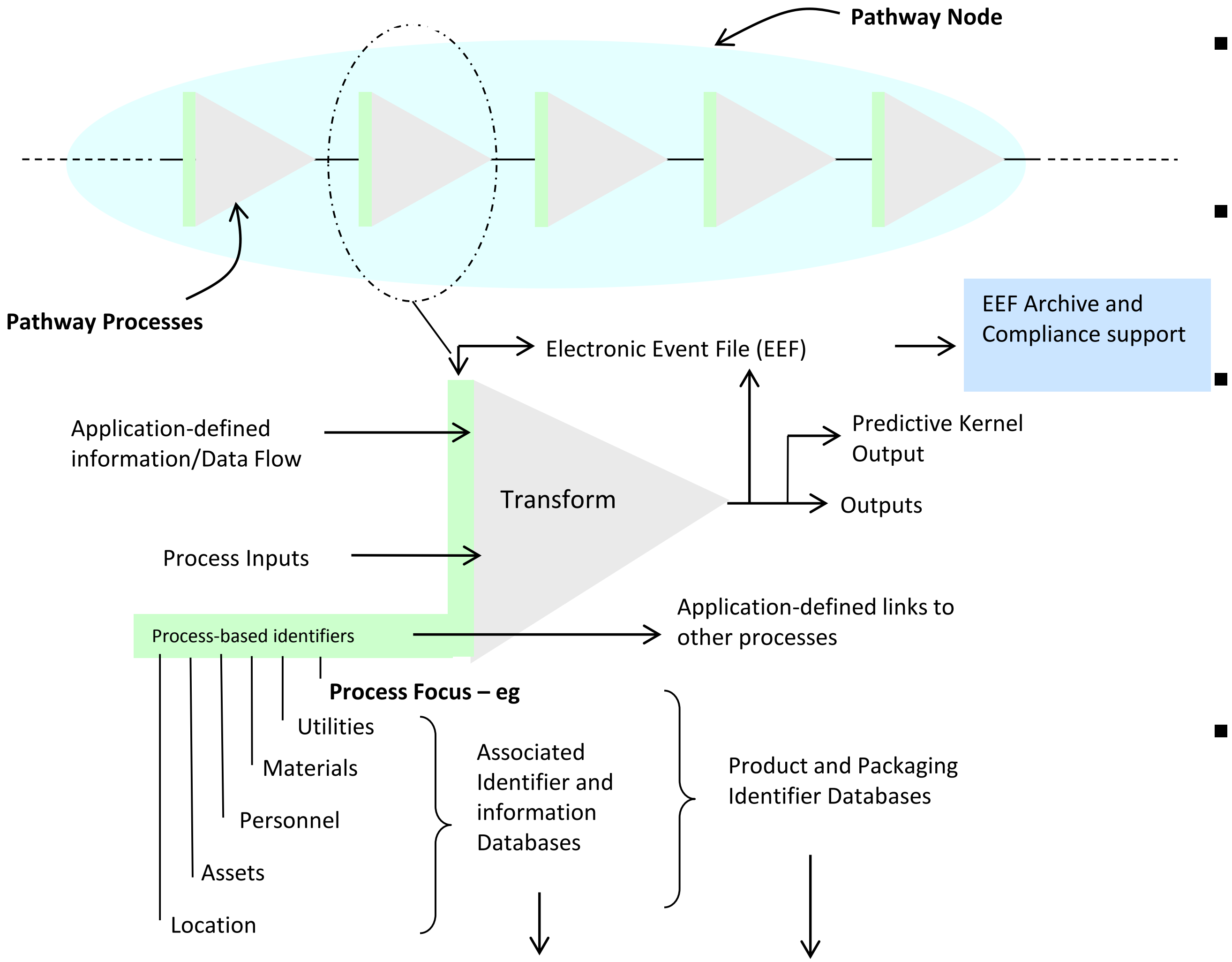
Satellite Farms as a Test-Bed for IoAT Implementation





IoT for Agriculture – Global Challenges – 'Big Data' Issues

Increasing Data ('Big' Data) and Needs an Extended ICT Infrastructure



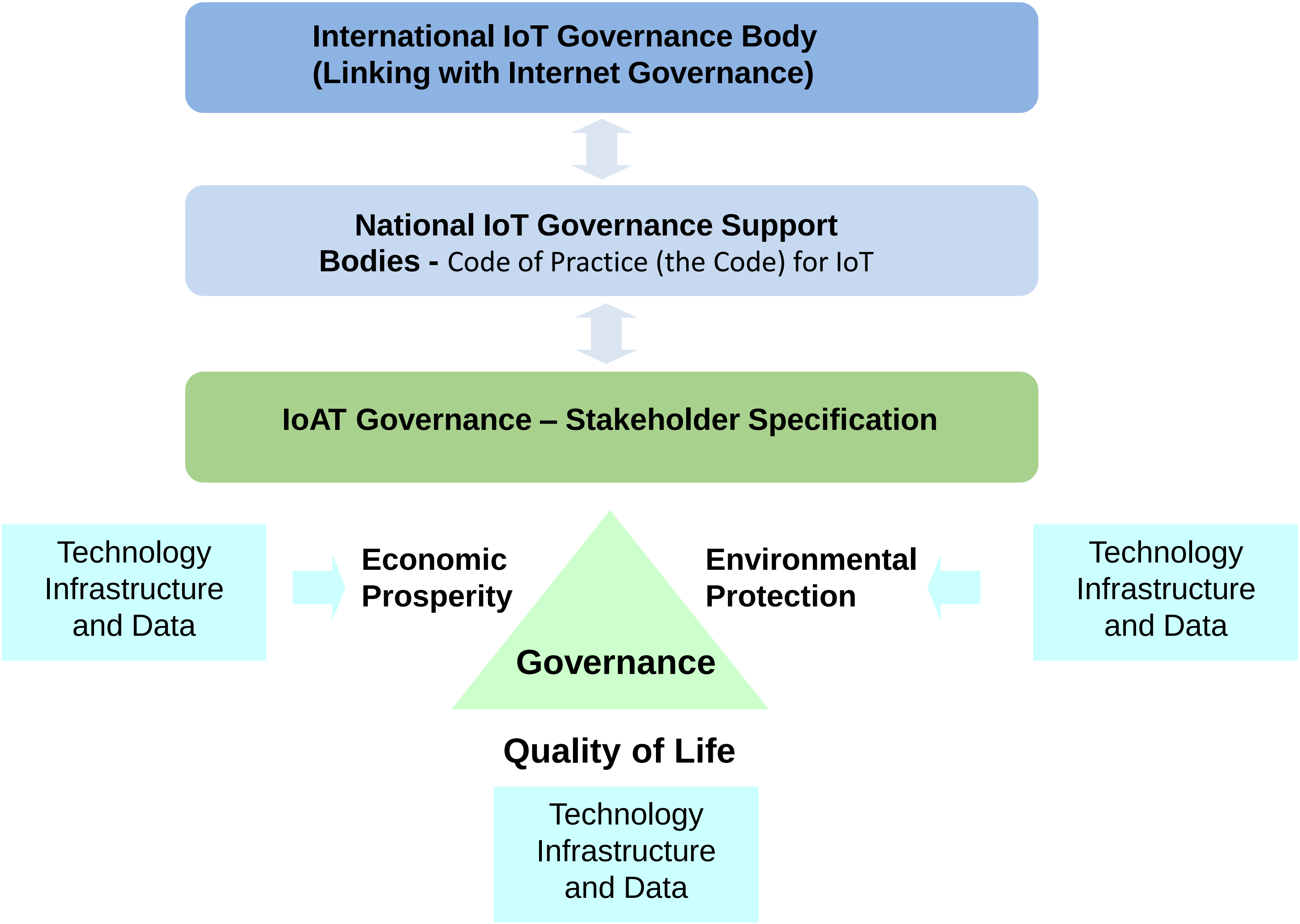
- **The Big Data approach** requires less, but complementary dependence on the strictures of the causality-focused standard scientific method.
- **The approach utilises vast quantities of data to achieve by-proxy correlations** that can assist in developing the foundations for Precision Agriculture.
- **"Big Data Analytics"**, how the approach is now termed, provides the potential to catalyse a new revolution in agricultural production, presenting unprecedented opportunities for identifying associations between information and knowledge entities, often faster and with greater temporal significance than conventional small data analytics.
- **Using the data from multitude of sensors** embedded within fields, farm buildings, ground-machines, aerial vehicles and satellite platforms we can effectively inform predictive models that achieve insights and recommendations not previously possible.

A Data ('Big' Data) intensive future requires IoT-specific meta-data structures and governance to support global challenge solutions

IoT for Agriculture – Specification and Governance

Staged Approach to realising a framework for IoAT Governance:

- **Preparation** of IoT Statement of Purpose and Structure
- **Identification** of an IoAT Governance Stakeholder Group
- **Identification** and recruitment of a Legislator and Regional Legislators and the Governing Body
- **Legislator/Stakeholder agreement** on:
    - Regulatory approach
    - Agreement on IoT Statement of Structure and Purpose
    - On infrastructural requirements and policy for on-going consideration
    - Access to governance procedures and liaison with Internet governance developers
- **Legislator/Stakeholder agreement** and pursuance of governance and legal agenda on governance requirements.

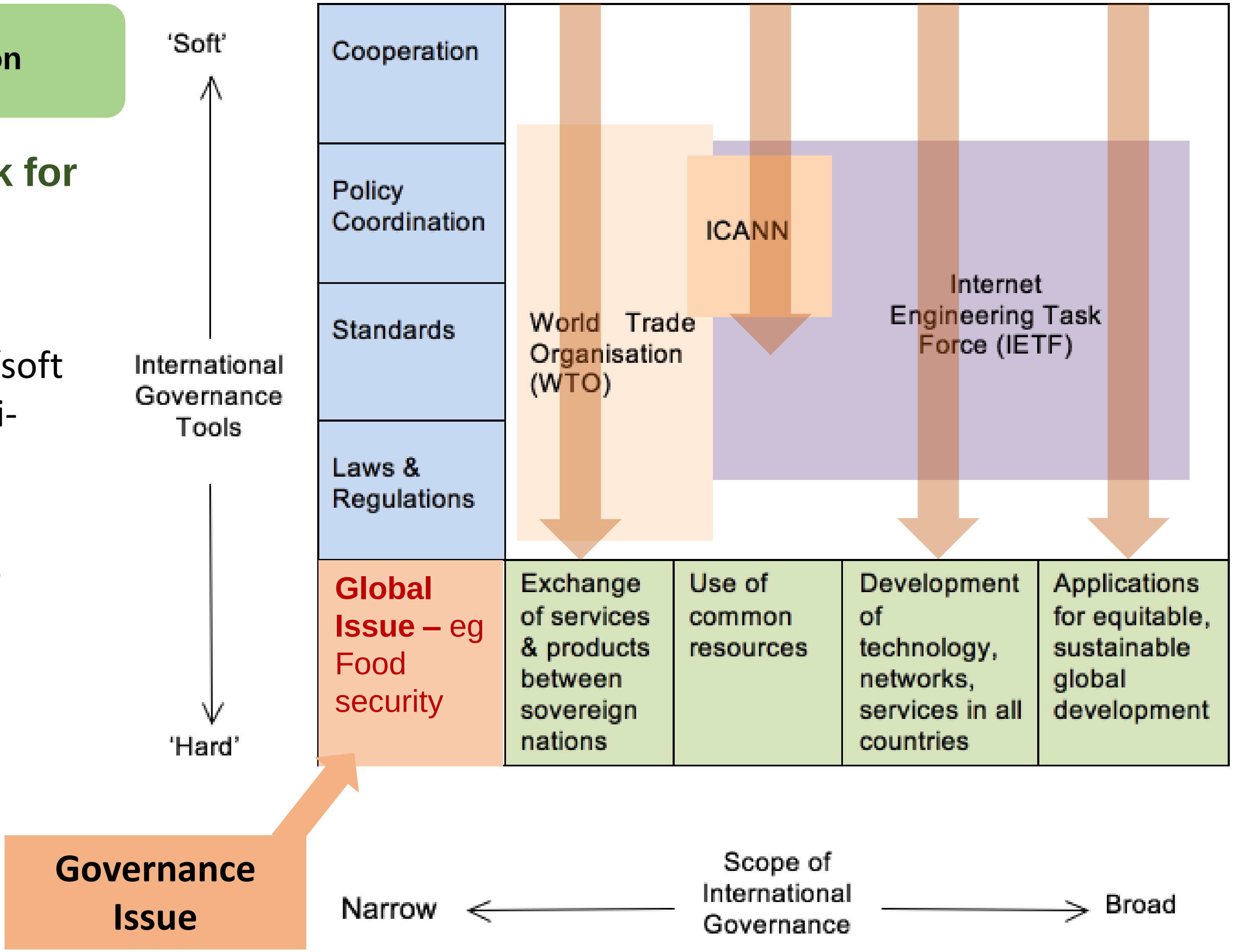


IoT for Agriculture – Specification and Governance – The International Dimension

IoAT Governance – Stakeholder Specification

Approach to extending the framework for IoAT Governance:

- **Recognising the tools** International specification and governance, including 'soft law' as a useful vehicle for deriving quasi-legal instruments for governance.
- **Recognising scope** for International specification and governance, relating to global challenges and associated issues, including **identified data streams.**
- **Recognising collaborative bodies** for addressing specification and governance requirements.



After MacLean, cited in Weber, R (2009)

IoT for Agriculture – Specification and Governance – The International Dimension

Illustrative addressing of issues…

	Requirement	Technical	Economic	Institutional	Policy	Legal
Issues relating to Structure	Security	Technical and design measures for IoT security	Cost of IoT security	Institutional measures for Security	Policy for IoT Security	Security laws
	Safety	Technical and design measures for IoT safety	Cost of IoT safety	Institutional measures for Safety	Policy for IoT Safety	Safety laws
	Energy conservation	IoT infrastructure considerations	Cost of conservation vs non-conservation	Energy footprints	International view on policy for conservation re International and IoT	Proposals for law
	Regulatory	Technical regulations	Economics of regulatory compliance	Institutional usage of regulatory information	Policy for monitoring, complying and exploiting regulations	Legal underpinning of regulations
	Standards	Technical standards	Economics of standards compliance	Institutional usage of standards	Policy for monitoring, complying and exploiting standards	Legal underpinning of standards

IoT for Agriculture – Specification and Governance – The International Dimension

Illustrative addressing of issues…

Issues relating to Operation and Usage	Identification Coding	Technical aspects of coding for identification – Resolver scheme	Cost of achieving and role out of an international resolver scheme	Institutional issues in take up and exploitation of a resolver scheme	Policy for use and management of an international resolver scheme	Legal issues in using and management of an international resolver scheme
	Privacy	Technology means for supporting privacy & Design for Privacy	Cost of privacy - social and economic Social Capital	Institutional measures for privacy	Policy for IoT privacy protection an design for privacy that goes well beyond RFID	Privacy and Data protection laws
	Ethical issues	Technology for privacy and ethical protection measures	Cost of non-protection of ethical and privacy issues	Institutional measures for defining an protecting privacy and ethical policy	Policy for ethical matters	Legal underpinning of ethical policy
	Cyber-crime	Technical measures to combat cyber-crime	Cost of cyber-crime	Institutional measures to combat cyber-crime	Policy for combating IoT cyber-crime	Legal framework for combating cyber-crime
	Intellectual property (IP)	IP for IoT novelty and innovation	Economic evaluation of IP potential	Institutional strategy for evaluating, protecting and exploiting IP	Policy for IP protection and exploitation	Legal underpinning for IP protection
	Performance Indicators	Technical features of indicators and indicators for technology function	Economics for performance measures	Institutional usage and management of performance indicators	Policy on the development and use of performance indicators	Legal considerations concerning performance indicators
	Developmental policy	Technology and technical considerations	Economics of development	Institutional factors impacting upon development	Policy structure	Legal underpinning of policy developments

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Any Questions?

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