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Summer course: FAST.0150.
Sustainable Agri-Food Production and Supply Chain Management

Sustainability, Its Importance and Application to the Agri-Food Business

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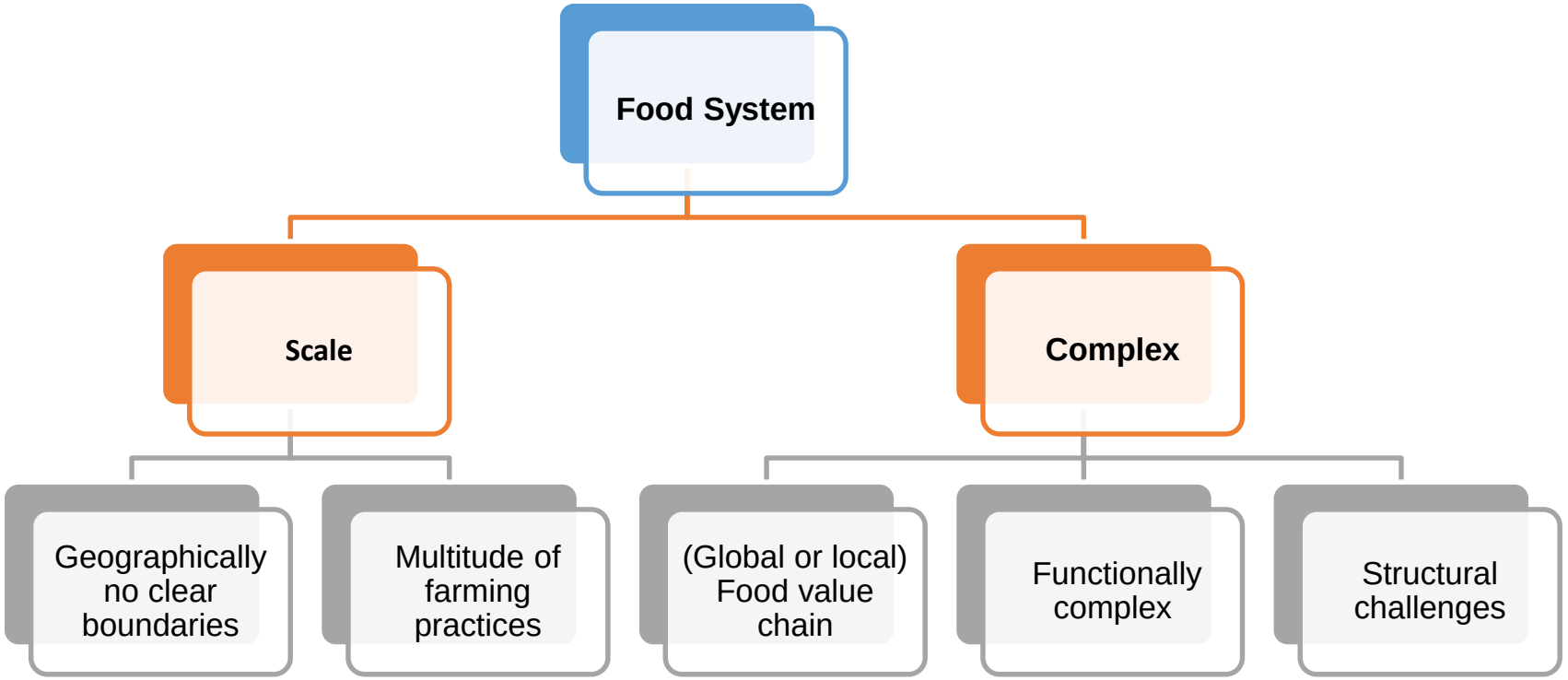
Topic: *ERASMUS-JMO-2021-MODULE*

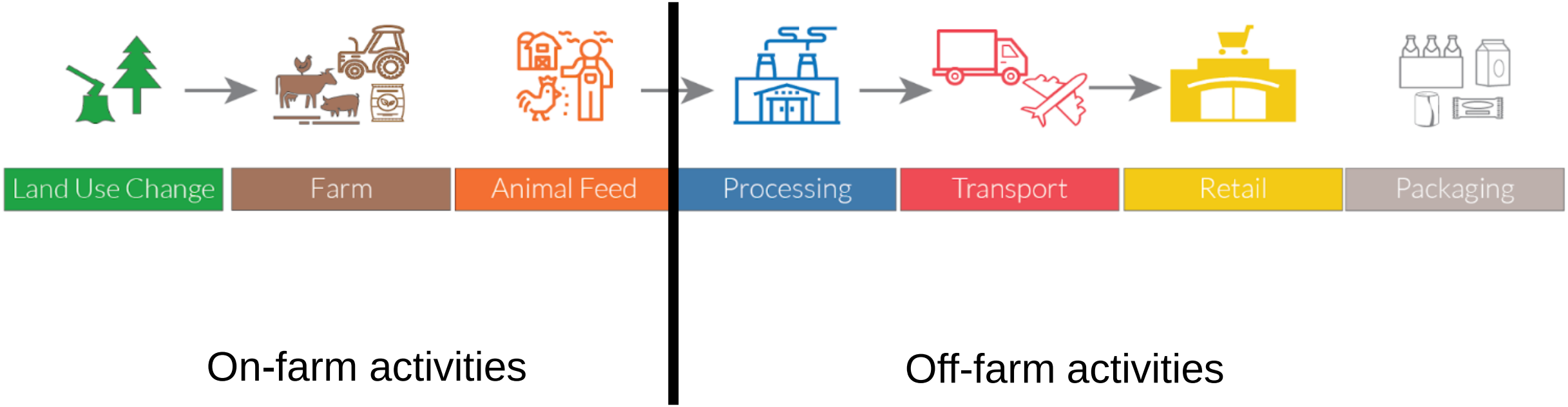
Global Food System

"The food system is a **web of activities** that involves **people** and **food activities** like production, processing, transport , consumption of food, and waste . This web of activities also involves decisions like food choices and resource investment."



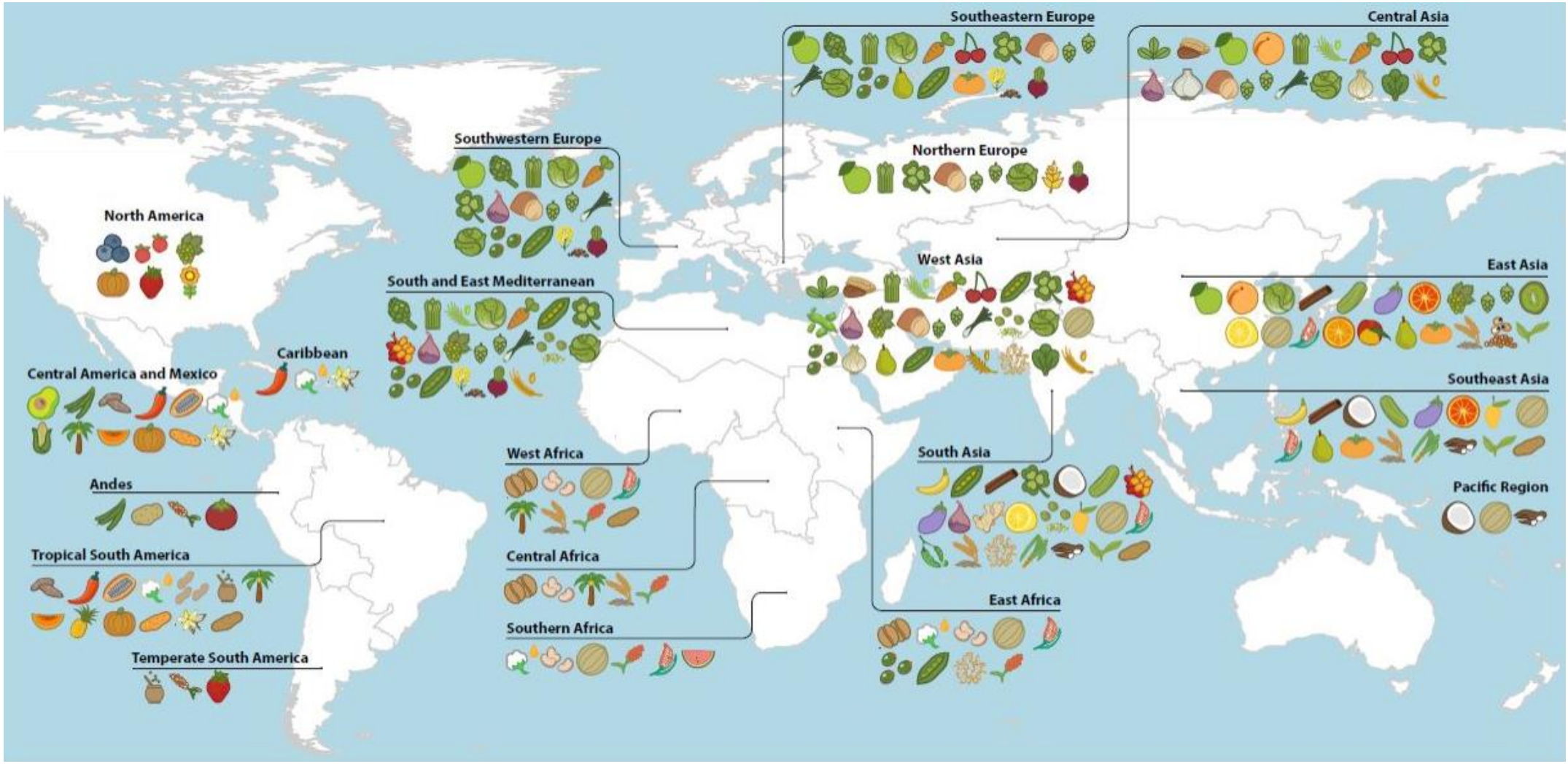
Food Value Chain

A food value chain (FVC) consists of all the **stakeholders** who **participate** in the coordinated **production** and **value-adding** activities that are needed to make **food products**.



(Kaplinsky and Morris. 2000; FAO.2014)

Global Food Regions

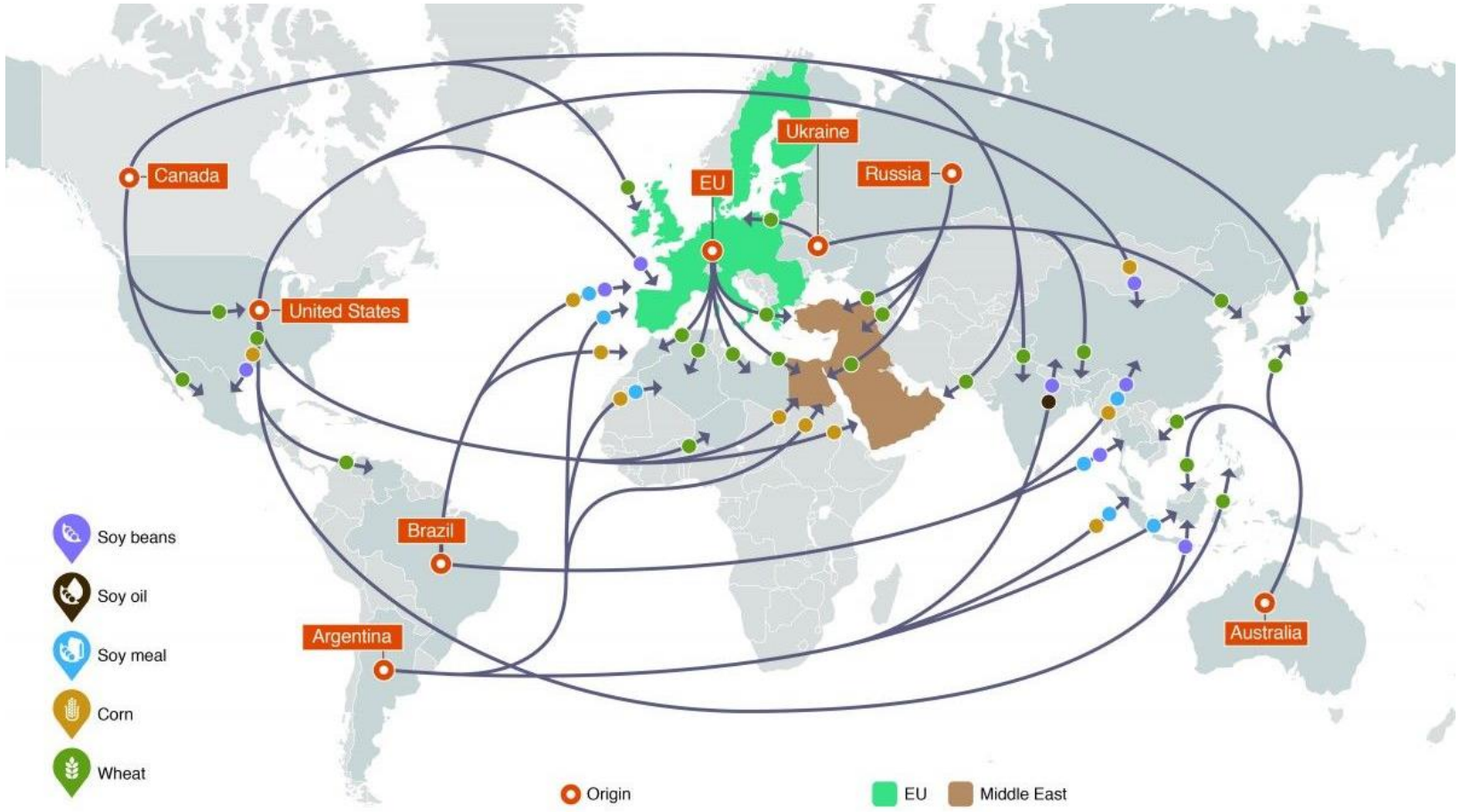


(Khoury et. al. 2016; https://blog.ciat.cgiar.org/origin-of-crops/)

Food Culture and Trade

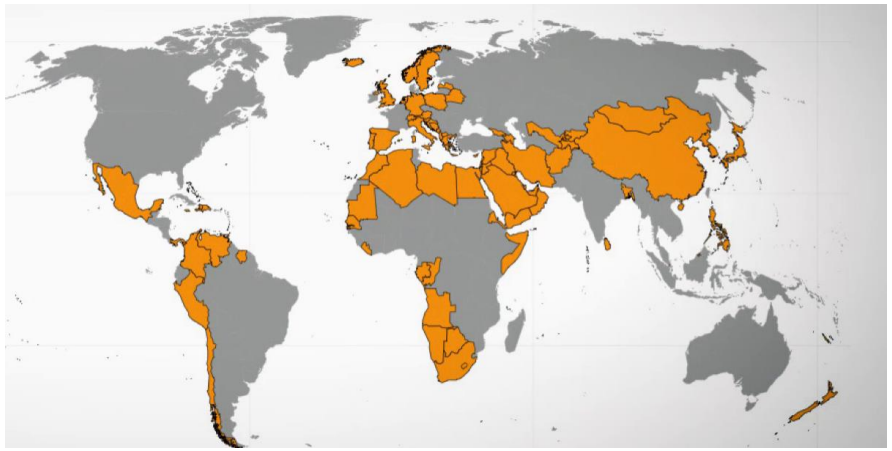
https://ngmdb.usgs.gov/gmna/

Food Trade and Flow



(Khoury et. al. 2016; https://blog.ciat.cgiar.org/origin-of-crops/)

Food Trade (e.g., Cropland)



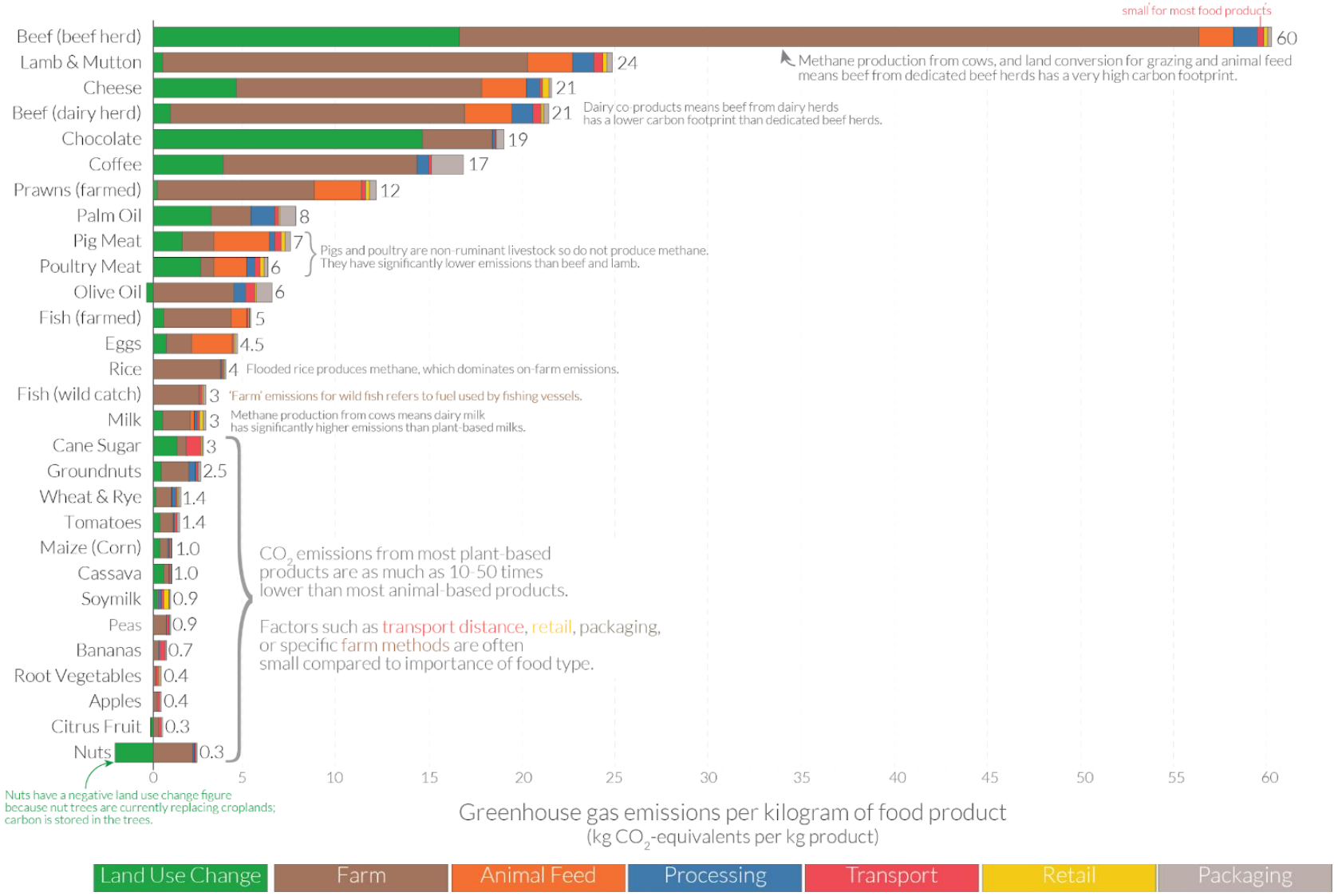
Cropland importers (102 countries)

Cropland Exporters (26 countries)

Cropland exchange (34 countries)

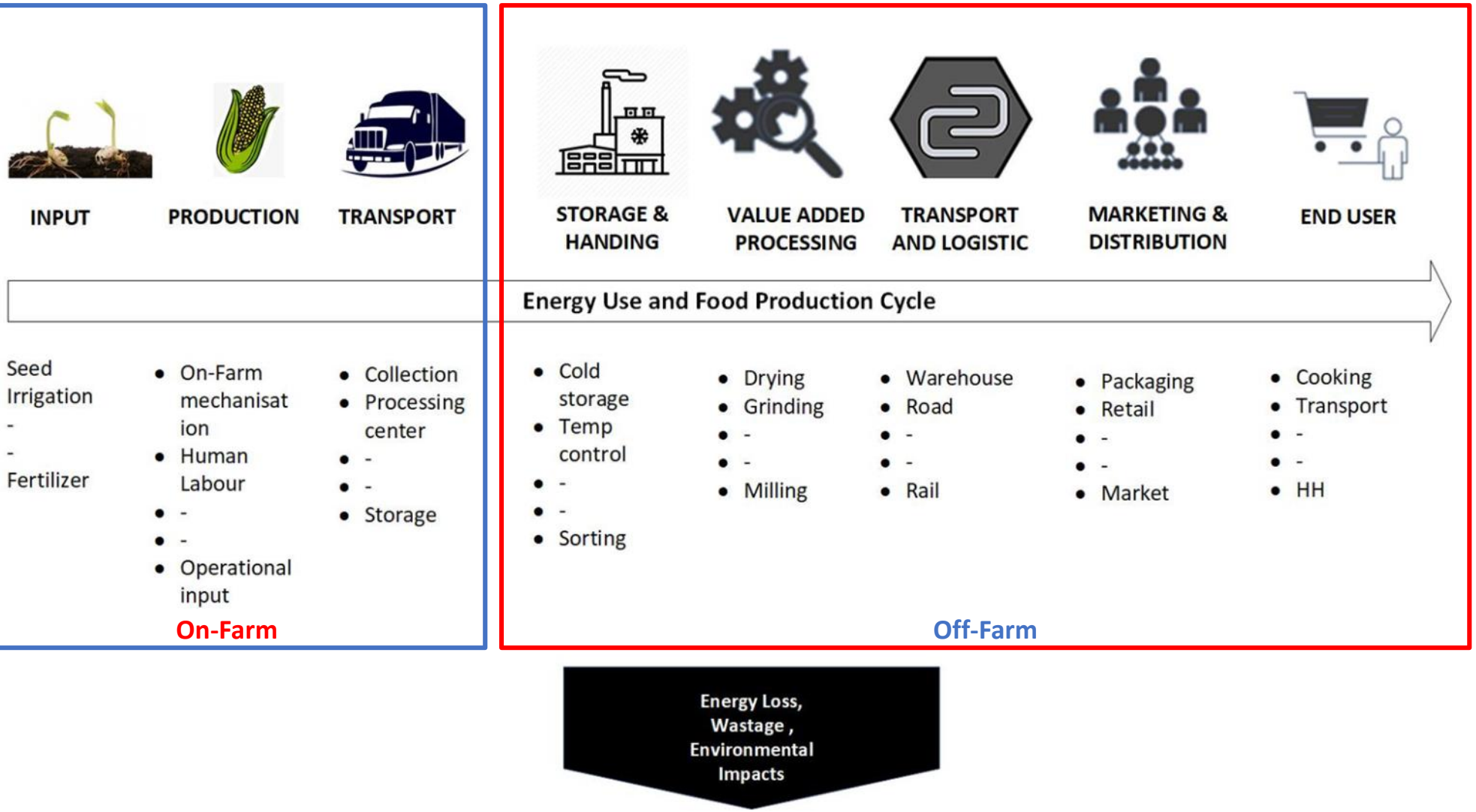
(http://opentranscripts.org/transcript/mapping-evolving-food-systems/)

GHG Emissions



(Poore, J., et al. 2018)

Constituent Parts of Agri-Food Value Chain

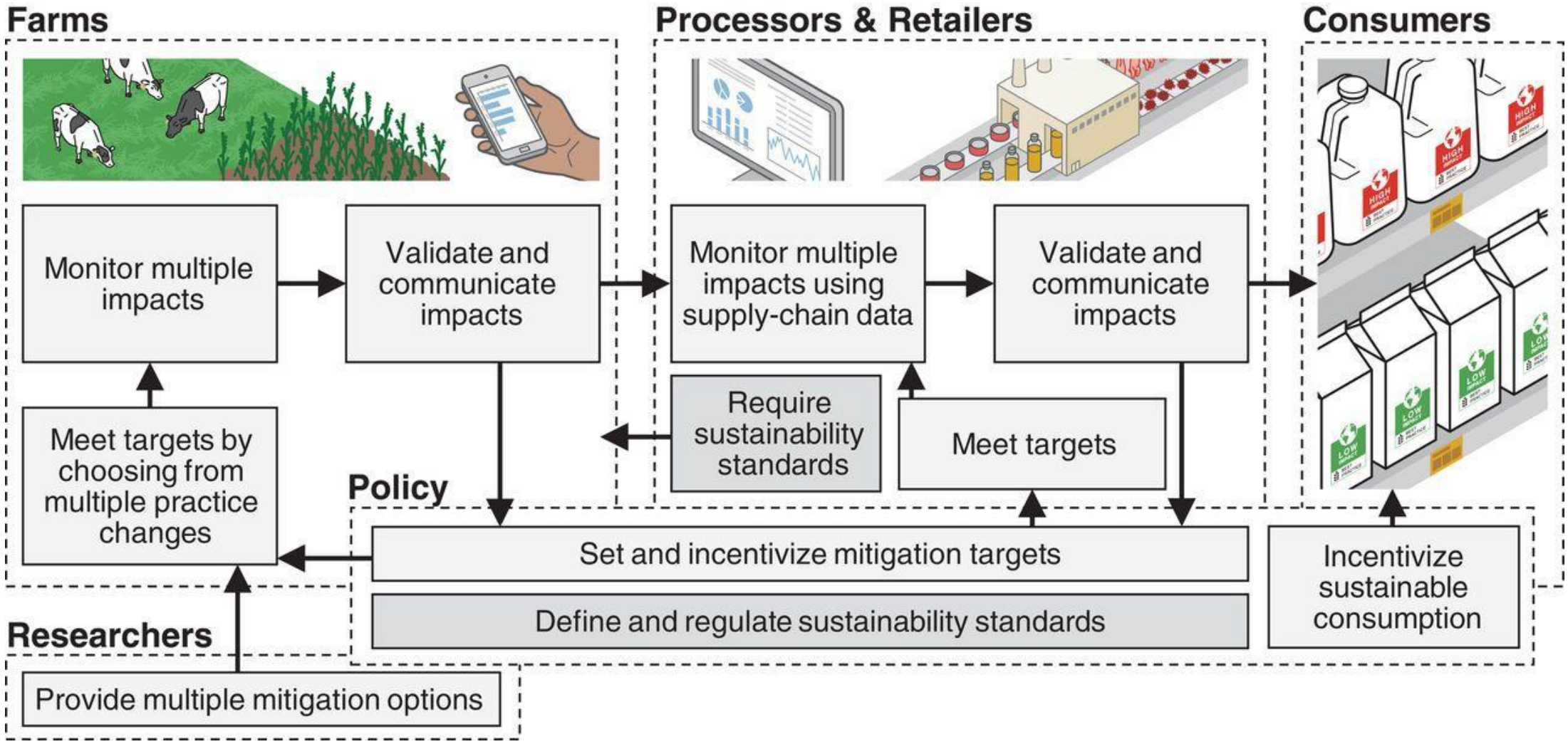


Agricultural Technologies in Agri-Food Sector

The emergence of industry 4.0 has set the basis for a broad spectrum of digital technologies in the Agri-Food sector. These digital technologies help agri-food communities to find solutions to existing or emerging challenges and help food value chain to maintain compliance and improves visibility of the end product . Presently most of user use one or two digital technologies and its services usually provided by digital platform.

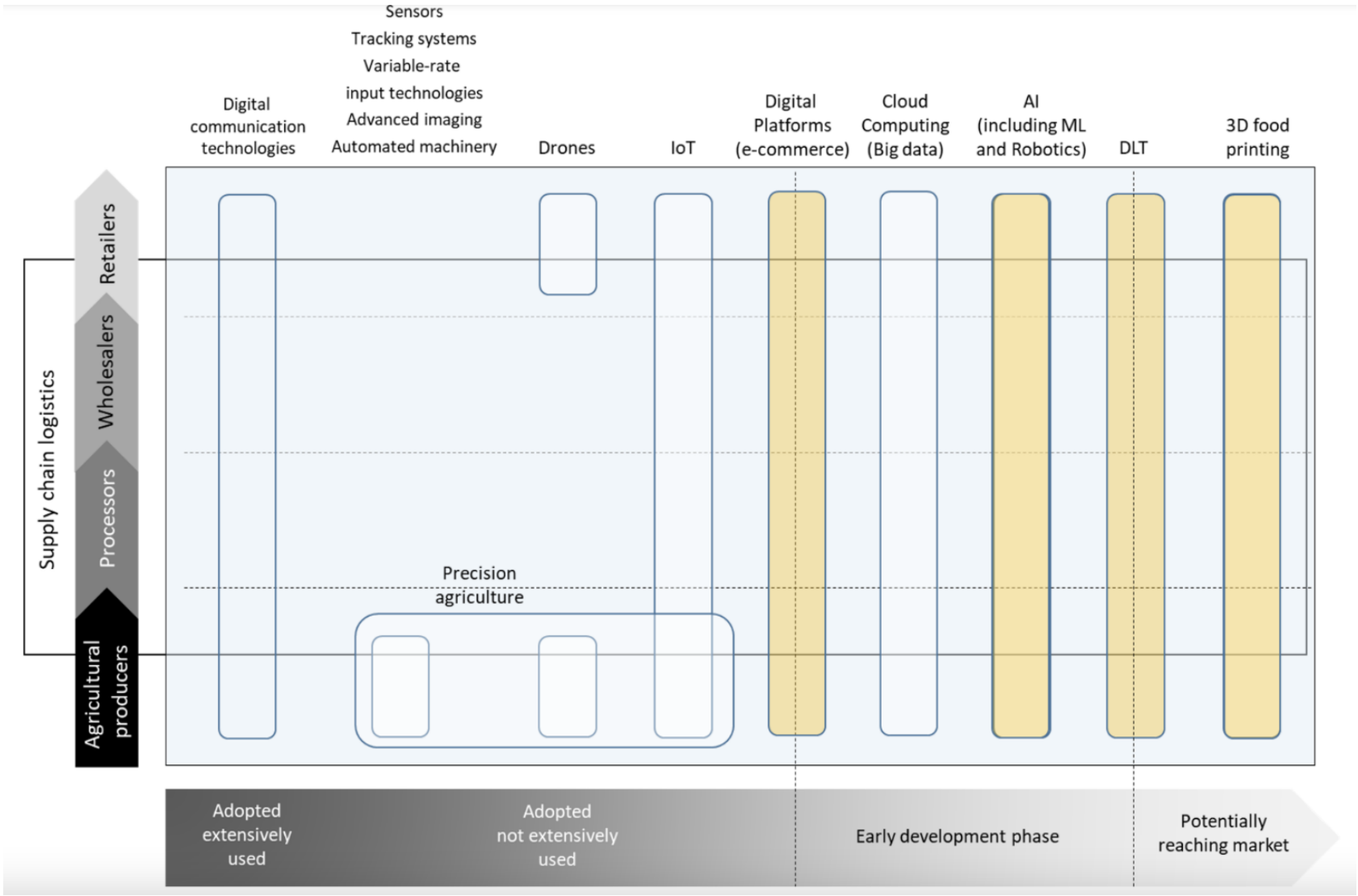
(Poore et. Al. 2018)

Role of Digital Technology in FVC



(Poore et. Al. 2018)

Examples of AgriTech in Agri-Food Sector



- Farm management decision
- Agri-food production
- Track and Trace

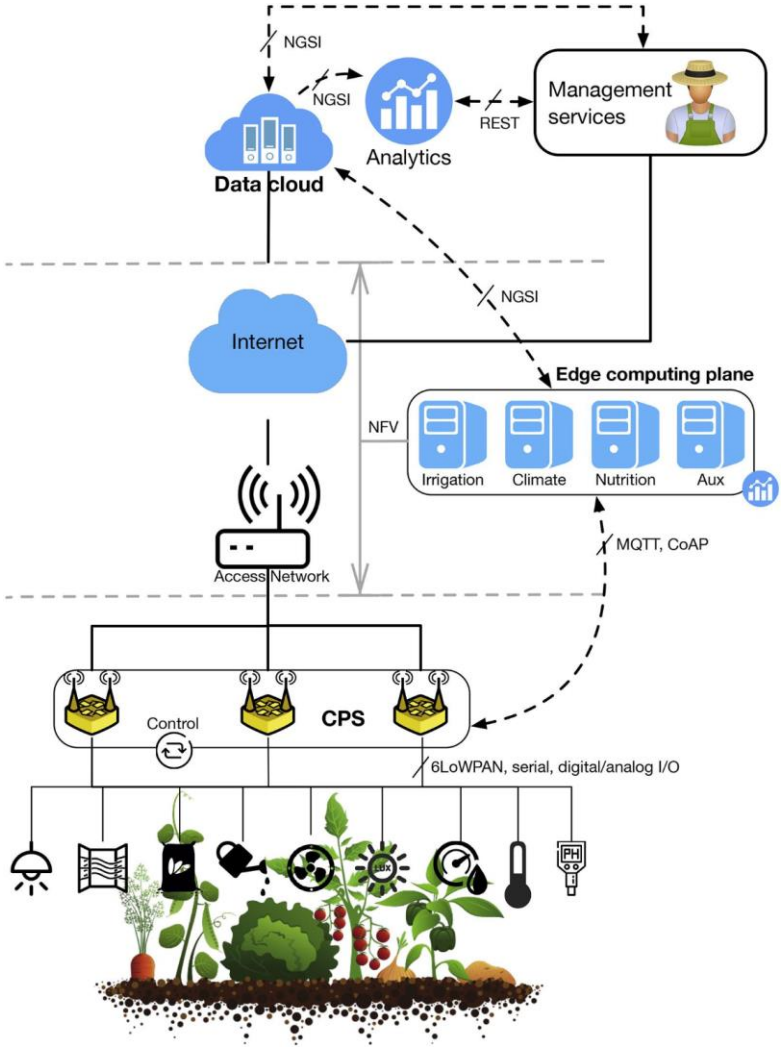
(FAO, 2020)

AgTech: Smart Farming

EU-funded IoF2020 project

- Smart farming practices makes agricultural farms and fields more efficient.
- Smart farming practices is a combination of emerging technologies like:
  - Software solutions,
  - Optimization devices, and
  - Process automation tools.

Examples of AgTech in Smart Farming



Data analytics and smart management layers

- A set of web services with a user friendly graphical view to monitor and control the main functions of the system.

Edge computing layer

- Set of virtualized control modules in the form of NFV nodes.

Sensor layer

- Deployment of various sensor in the farm and linked to remote data server.

(Zamora-Izquierdo et al., 2019)

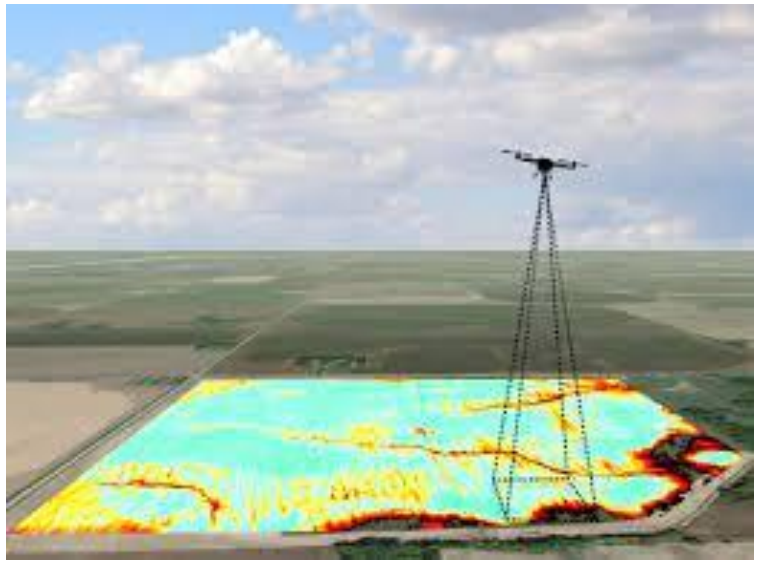
AgTech : Precision Farming

DJI agricultural drones

Farming tractor plowing and spraying on field

- Precision Agriculture is based on observing, measuring and responding to inter and intra-field variability in crops.
- It is based on the GPS, GNSS system, UAV and sensor technologies.
- These technologies map various actions of farming management actions such as cultivation, seeding, fertilization, herbicide application, and harvesting.

Examples of AgTech in Precision Farming



Using satellite technology to collect crop data

Control traffic farming

Precision livestock farming

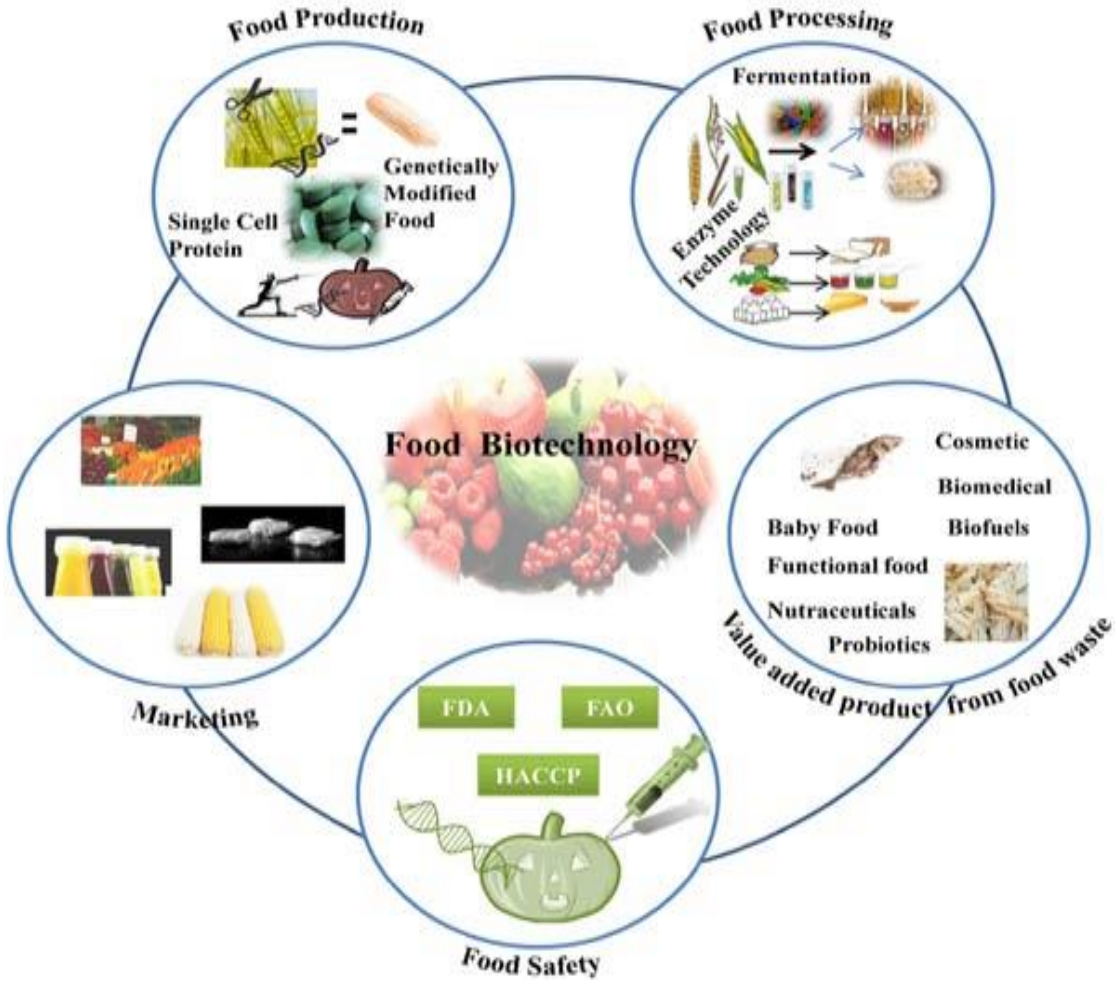
AgTech: Robotics and Automation

https://foodtank.com

https://civileats.com

Advanced robotics, automated machinery and drones are crucial to increase the efficiency of agricultural production in the future. A new generation of precision robotic manipulators can locate and identify produce, select and pick it based on their size and degree of ripeness.

AgTech: Biotech



Biotech in agri-food sector develop microbial products for remediating soil pollutants, improving soil fertility and increasing agricultural yield under stress conditions. Biotechnological techniques including conventional plant breeding, plant tissue culture, and modern genetic engineering.

(Dash et al. 2016)

AgTech: Track and Trace

- The food supply chain is dynamic and complex. Track and Trace helps to ensure that the necessary checks have been performed as required and products are not sitting in an uncontrolled environment.
- Traceability is the ability to track any food through all stages of production, processing and distribution. Some of the common track and trace technologies in the food supply chain operations includes:
    - Barcodes
    - Radio Frequency Identification (RFID) devices
    - Wireless sensor networks (WSN)
    - DNA barcoding
    - Blockchain

(Dash et al. 2016)

Track and Trace: Barcodes

- The Universal Product Code (UPC) barcode is one of the most popular way to store food data digitally. The UPC barcode consists of 12 numeric digits that are uniquely assigned to each trade/food item.
- Every region or country maintains a database that holds the record of these trade/food items along with the unique UPC, which are capable of storing the following data: the type of product, size, manufacturer and country of origin of the food item.

Advantages

- Simple,
- Economical, and
- Offer exact traceability

Disadvantages

- Reading needs a line of sight,
- Unreadable if damaged,
- Scanner can only read one label at a time, and
- Hard to attached more environmental information

Track and Trace: Radio Frequency Identification (RFID)

The RFID system consists of a tag (transponder) which is attached to the product during transit (at batch or item level). The tag then communicates wirelessly (via radio waves) with a reader (transceiver) and its reader makes the information about the product available to the operator (via computer, handheld via Android or iOS platform).

Advantages

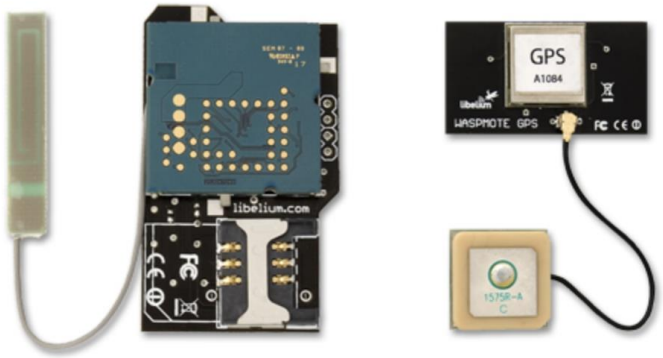
- No line of sight needed in reading,
- Can read and write tags,
- Higher data rate and larger memory size, and
- Reversible tags and it can can read many tags simultaneously

Disadvantages

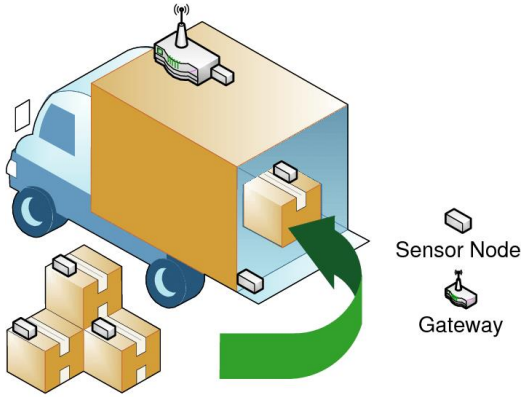
- Need to rely on reader for data collection,
- Tag cannot initiate communication
- No cooperation among the devices,
- Limited capability, and
- Costly

Track and Trace: Wireless Sensor Networks

Wireless sensor networks consist of tiny devices referred to as sensor nodes that are battery-powered and equipped with sensing devices, a data processing unit and a communication unit. These sensor monitor physical or environmental conditions, and pass their data through the network to a main location.



Waspmote GPS and GPRS/3G modules



Advantages

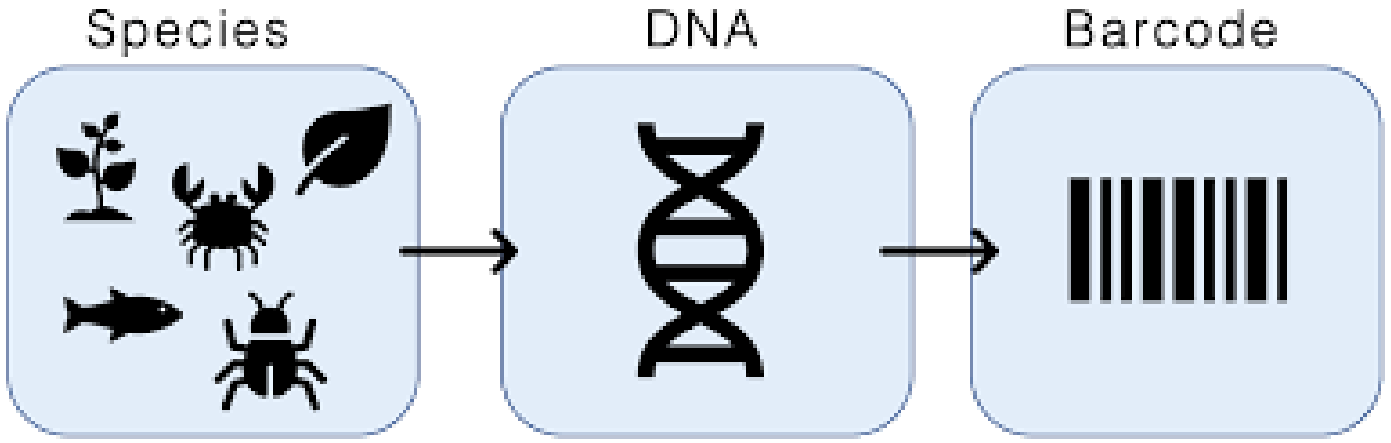
- network setups without fixed infrastructure,
- Suitable for non-reachable places,
- Implementation pricing is cheap,
- Easy to accommodate new devices, and
- Can be accessed by using a centralized monitor

Disadvantages

- Reduced security,
- Lower speed as compared to a wired network,
- Complicated to configure,
- Easily troubled by surroundings,
- Unable to control propagation of waves, and
- Cost

Track and Trace: DNA Barcoding

- DNA barcoding is a molecular based system, which allows scientists to identify particular species, by comparing short genetic markers in the specimen DNA with reference sequences.
- Current application of DNA barcoding could be found in the seafood, meat, edible plants, dairy products and processed foods for the identification and traceability purpose .



https://en.wikipedia.org/wiki/Algae_DNA_barcoding

Advantages

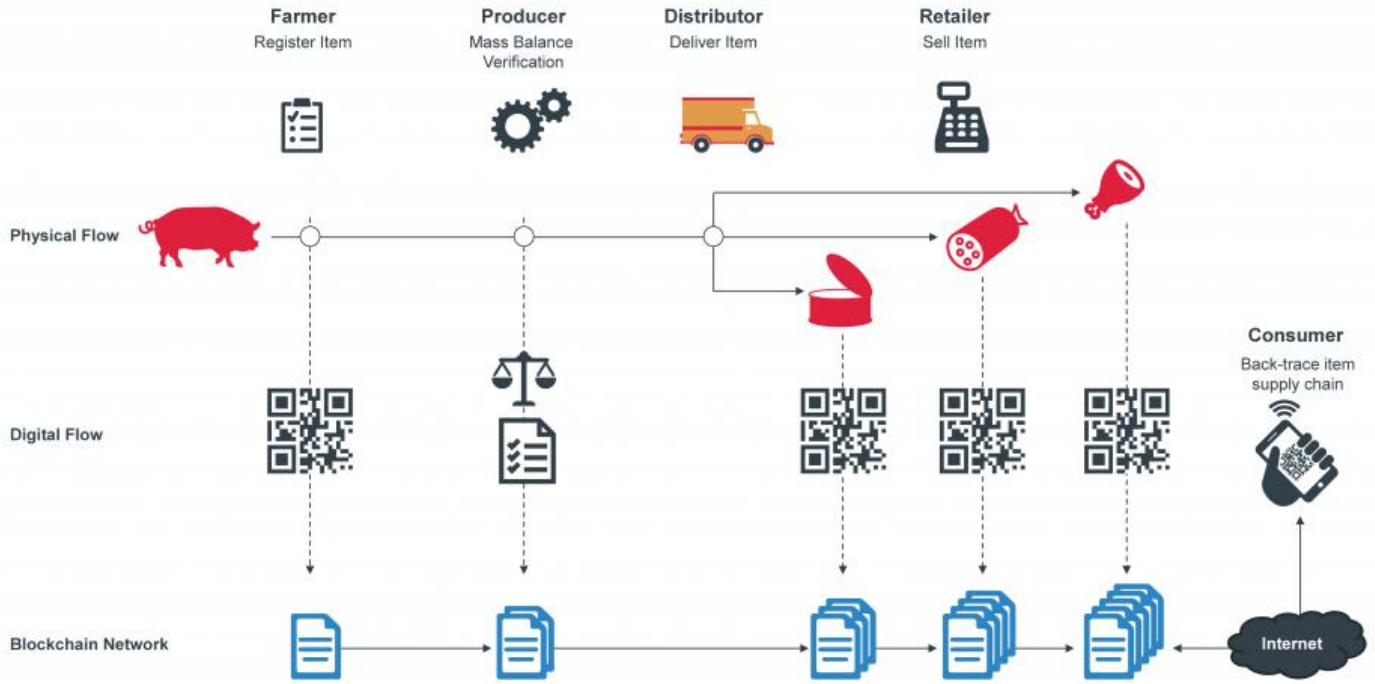
- Reliable method,
- Small amount of biological samples needed,
- Applicability for all life stages,
- Differentiation among phenotypically alike species, and
- Can be accessed by using a centralized monitor

Disadvantages

- DNA-extraction,
- Sample condition, and
- Dependency on a single region of mitochondrial DNA

Track and Trace: Blockchain Technology

Blockchain technology (BCT) supports a robust information system that removes the risk of ‘single point of failure’ due to its distributed nature and ensures the integrity of information.



(*https://sodio.tech*)

Advantages

- Distributed ledger
- Immutability of records
- Peer-to-peer exchanges:
- Differentiation among phenotypically
- Computational logic
- Can be accessed by using a centralized monitor

Disadvantages

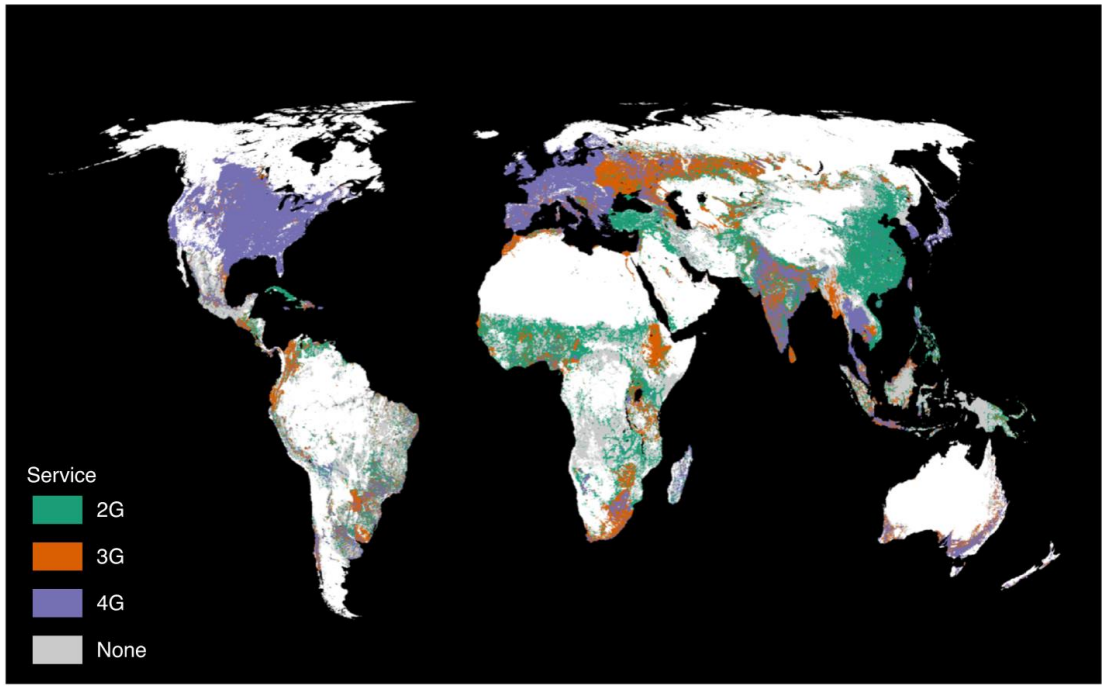
- Still in exploration stage
- Infrastructure and technical limitations
- Integrity of the shared data
- Scalability
- High energy cost

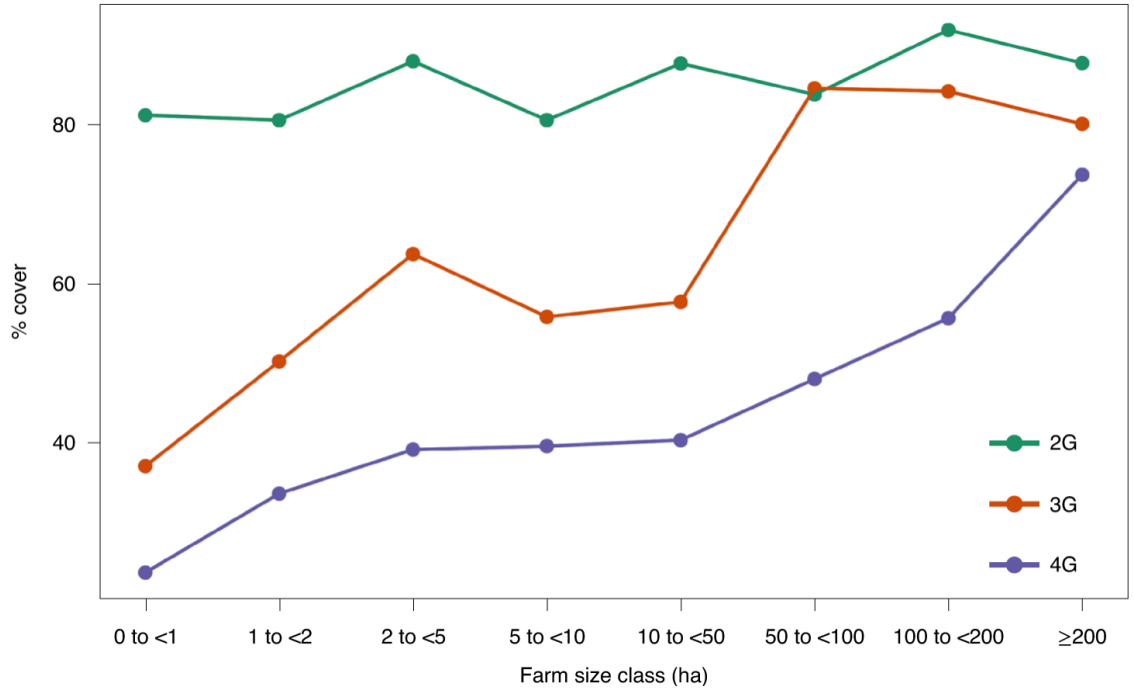
Digital Transformation of Agri-food System and FVC

Essential conditions that must exist for the use of digital technologies and digital transformation of the agri-food sector and the food value chain.

- Availability, connectivity, and affordability internet coverage
- Supportive policies, programmes and ICT education for digital strategies
- Legal infrastructure for regulation and trust, and
- ICT Standards

Internet Coverage: Availability, Connectivity, & Affordability





Mobile services coverage across global croplands (Till 2018)

- Only 24–37% of farms of <1 ha in size are served by third or fourth generation services, and
- About 74–80% of farms of >200 ha in size.

(Mehrabi et al. 2021)

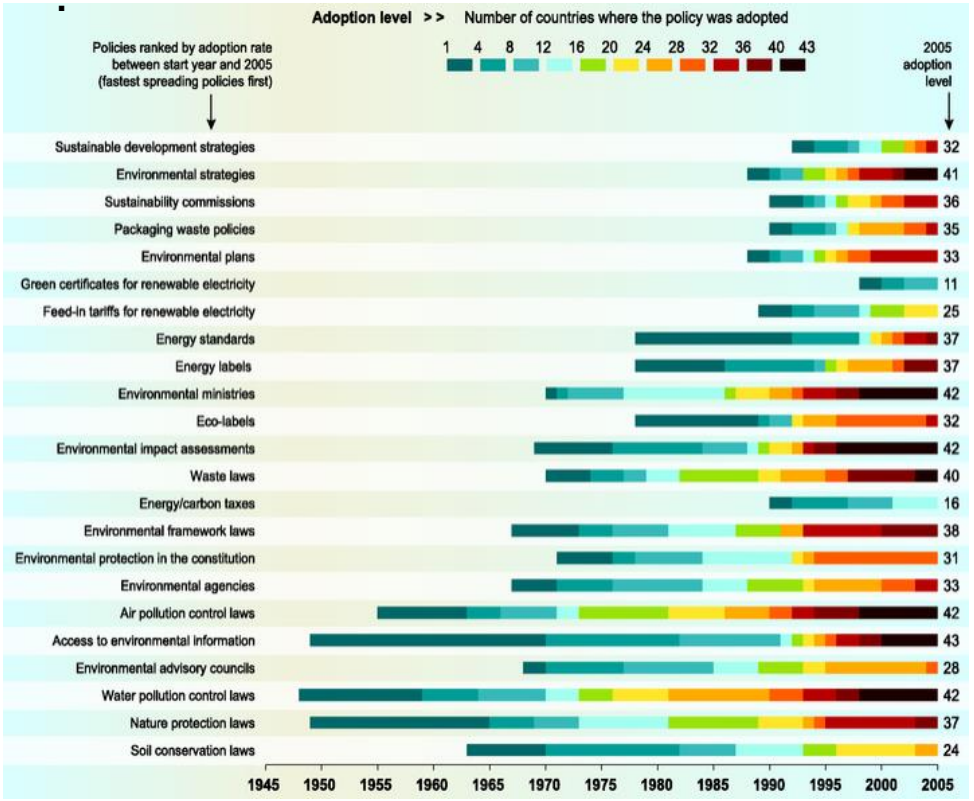
Supportive Policies & Programmes for Digital Strategies

Production, processing, distribution and consumption of food, and their impacts, fall under a wide range of policy areas and instruments at different spatial scale:

Global level:

EU level:

Environmental policies intake in OECD and EU state :

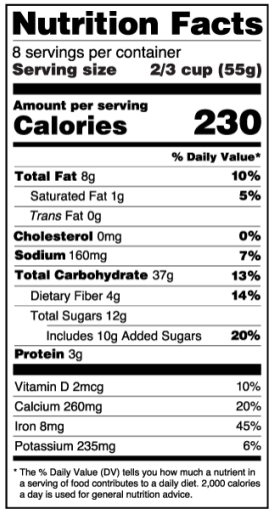


(Busch PO. and Joergens H.,2005)

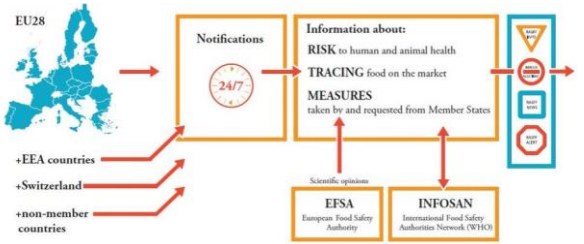
Legal Infrastructure[I]: International Initiatives

Organisation

Initiatives



1. The serving size now appears in larger, bold font and some serving sizes have been updated.
2. Calories are now displayed in larger, bolder font.
3. Daily Values have been updated.
4. Added sugars, vitamin D, and potassium are now listed. Manufacturers must declare the amount in addition to percent Daily Value for vitamins and minerals.



Legal Infrastructure [II]: Regulation & Schemes

National/ State level

EU

- **Directive**
- **Regulation**

- **Opinion**
- **Assessment**

USA

Integrated approach to food safety 'from farm to fork'

Protecting the consumer from exposure to unsafe and unwholesome food products

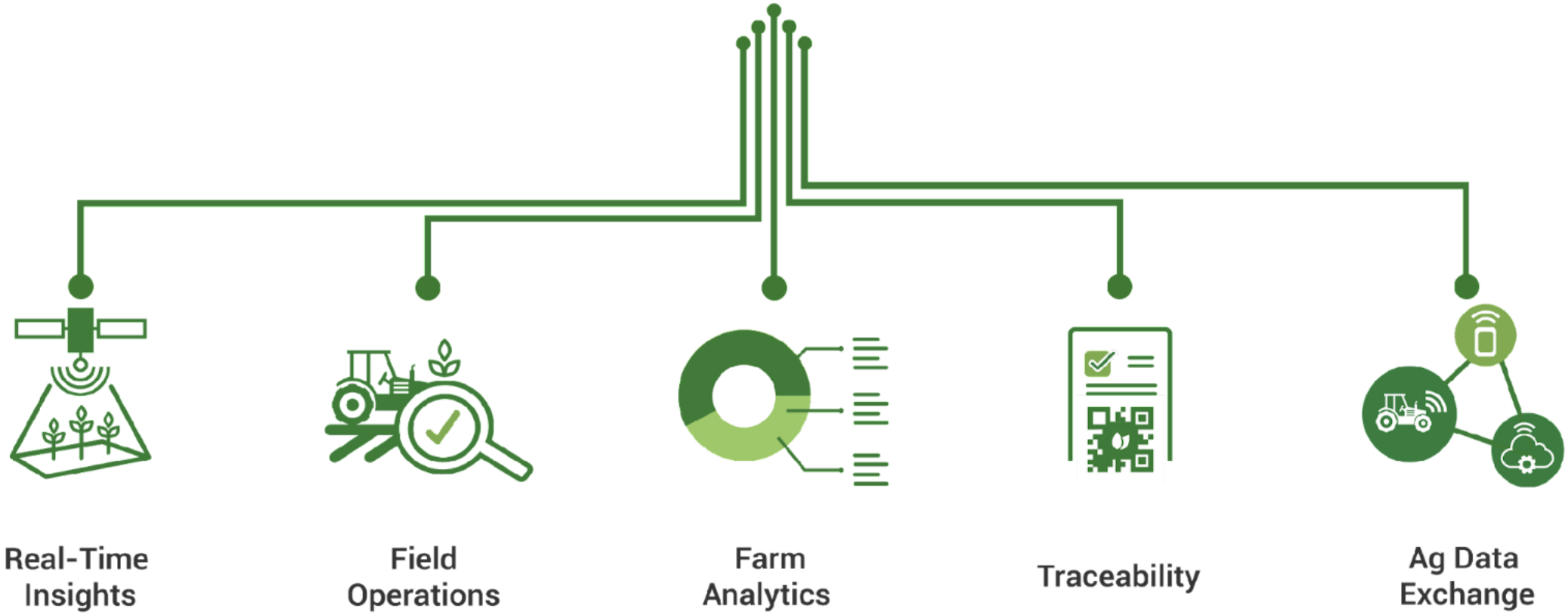
Regulation/ directives/ Law

Regulation/directives
Regulation 178/2002 (GFL [30])
Regulations 1829/2003 and 1830/2003: GMO package
Allergen labelling requirements included in Directive 2000/13
Regulation 1924/2006 Nutrition and health claim
Regulation 1169/2011 Food information to consumers

Federal/State Act
Federal Food, Drug and Cosmetic Act
Federal Meat Inspection Act
Poultry Products Inspection Act
Food Quality Protection Act
Public Health Services Act

Need of ICT Standards

- **Real time exchange of information and data across food value supply chain**
- **Data governance process for regulatory compliance**
- **Consistent and informed omnichannel consumer experience**



(www.agrivi.com/)

ICT Standards [I]: Electronic Data Interchange

Electronic Data Interchange (EDI) is the process of using computers to exchange business documents between companies.

Necessary components and tools for performing EDI:

- Trade Agreement
- Standard Document Format
- EDI Translation Management Software
- Communications Software
- Modem, VAN and Point-to-Point

Example:

- UN/EDIFACT [UN-recommended]
- ANSI ASC X12 (X12) [US standard]
- TRADACOMS [UK retail industry]
- ODETTE standard [European automotive industry]

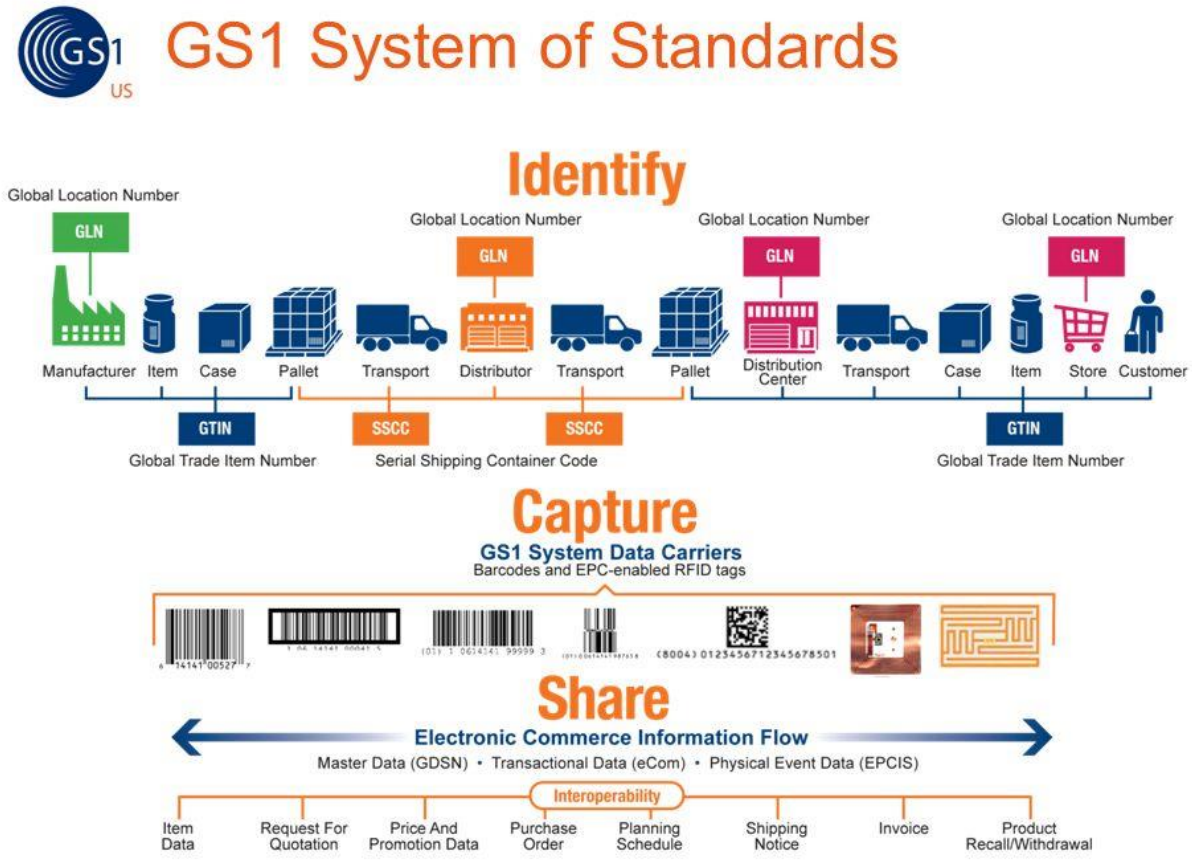
EDI technologies in the agri-food industry

(I Füzesi,2007)

ICT Standards [II]: GS1 System of Standards

GS1 represents a global standard (GS1 standard), a global system (the global identification system, GS1 System), and a global organization. It is responsible for establishing the standards of bar code and data exchange for the world's goods, and determine RFID standard by EPC global.

- Global food standard for traceability,
- Components of coding systems (EAN/UCC, EPC),
- Data carriers (bar code, RFID), and
- Data exchange (EDI, XML),



(gs1ae.org)

ICT Standards [III]: Popular Vocabularies

- Commonly used ‘general’ vocabularies (ontologies) describe terms to use to denote different kinds of data.
- This improves interoperability between different data sources.
- Built to achieve a ’Semantic Web’ (Web 3.0) in which internet data is machine-readable.
  - **Schema.org:** model designed to enrich webpages with ‘metadata’ (used by Google, Microsoft)
  - **Dublin Core:** abstract model to describe metadata (used by Facebook Open Graph)
  - **SKOS:** Specifications to support Knowledge Organization Systems

ICT Standards [III]: Popular Vocabularies

- Numerous ontologies are developed to cater to specific domains
- AgroPortal provides a repository for agronomy related ontologies
  - **AGROVOC:** Vocabulary about agriculture, provides multilingual support
  - **FoodOn:** Ontology describing food related concepts

Drivers for AgriTech uptake

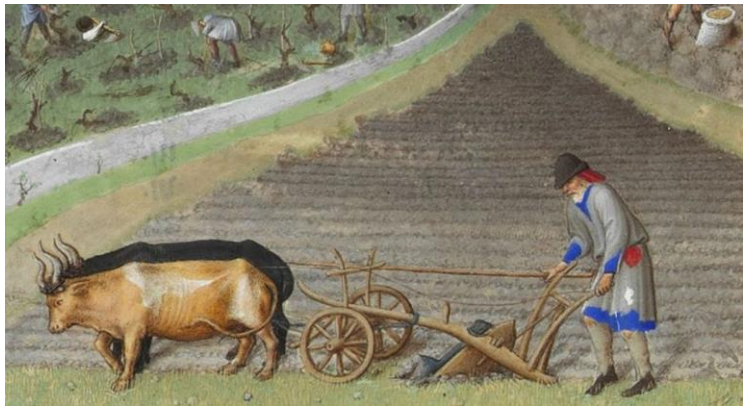
- Changing consumer preferences are impacting demand for food and fibre,
- Increased market risk due to global political shifts and volatility,
- Demographic changes are affecting the available workforces for agritech and adjacent sectors,
- Labour supply shortages are affecting the agritech and food sectors,
- Climate change is changing growing conditions for the food production, and
- Technology and business model innovations are evolving rapidly.

Barriers for AgriTech uptake

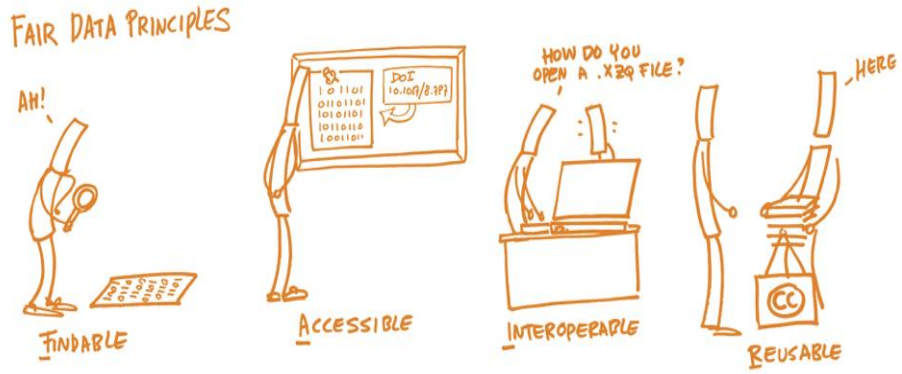
Cultural change
Willingness to engage with the AgriTech and cultural change across the entire Farm-to-Fork value chain

Legislation
Legislation and regulations need to keep up with the developments in AgTech

Data
Lack of Open and FAIR data



From: Limbourg brothers/public domain



Trust, Transparency, and Cost

Lack of trust among stakeholders (specially farmer),transparency and high cost of AgTech uptake.

Opportunities for AgriTech uptake

- Effective use of data
- Improving resource inputs
- Connecting food system and food value chain stakeholders
- Monitoring and compliance
- Policy evaluation and welfare programme

THANK YOU

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