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SUstainable developmeNT Smart Agriculture Capacity
« SUNSpACe »

Smart Farming Labs Architecture

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Document Description	The purpose of this document is a deliverable of results activities T2.1 to build the Architecture of Smart Farm Lab and T2.2 to connect Nepal Agro-Health-Tech centre with SUNSpACe Smart farming technologies. This task (T2.1) aims also to connect the smart farm lab with the social Business Incubation Centre of PA's Precise Agriculture (SOBICPA) in Thailand. Deliverable D2.1 aims to develop a Smart Farm Lab architecture which provides technology transfer interface between program and partner countries.

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Term / Abbreviation	Definition
AEC	Acme Engineering College
CMU	Chiang Mai University
CUB	Corvinus University of Budapest
HEI	Higher Education Institute
KEC	Kantipur Engineering College
KKU	KHON KAEN UNIVERSITY
RUB	Royal University of Bhutan
TOGAF	The Open Group Architecture Framework
ULL	Université Lumière Lyon 2
UWS	University of the West of Scotland

Definition of Terminologies

To stablish the smart lab architecture in SUNSpACe project, we define the terminologies we are using. This document includes the definition of the terminologies used in the pilot use cases.

Table 1: List of Terminologies

Term / Abbreviation	Definition
Pilot	done as an experiment or test before being introduced more widely (adj.) or test (a scheme, project, etc.) before introducing it more widely (verb)
Use case	a specific situation in which a product or service could potentially be used
Use case description	A **use case** is a written **description** of how users will perform tasks. From a user's point of view, it outlines a system's behaviour as it responds to a request. Each **use case** is represented as a sequence of simple steps, beginning with a user's goal and ending when that goal is fulfilled.
Use case diagram	use case diagram's specific purpose is to gather system requirements and **actors**. Use case diagrams specify the events of a system and its flows. However, the use case diagram never describes how they are implemented.
Implementation	putting into effect; fulfilment; Go Live
Deployment	spreading out strategically or in an extended front or line, coming into a position ready for use
Implementation vs. deployment	Implementation is the process of moving an idea from concept to reality in business, engineering and other fields, *implementation* refers to the building process rather than the design process while *deployment* is an arrangement or classification of things.
Prototype	a prototype is an early sample, model, or release of a product built to **test** a concept or process or to act as a thing to be replicated or learned from
Demonstration	an incomplete version of the product to showcase idea, performance, method or features of the product (technology); an experiment to illustrate principles (scientific)
Intelligent (AI perspective)	able to *vary* its state or action *in response* to varying situations and past experience; self-reflection; robotic, automatic, self-regulating, smart (informal)
Smart	having or showing quick *intelligence* or ready mental capability (colloq.)
Information	data which has *meaning* for the receiver (leads directly or indirectly to act)

Knowledge	Domain-specific set of *information* giving the *context* from which meaning is a derivate
Platform (digital)	A digital platform is an *environment* in which a piece of software is executed. It may be the hardware or the operating system (OS), even a web browser and associated application programming interfaces, or *other underlying software*, as long as the program code is executed with it.
Enterprise Architecture	In TOGAF, "architecture" has two meanings depending upon the context: 1. A formal description of a system, or a detailed plan of the system at a component level to guide its implementation 2. The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time
Architecture framework	An architecture framework is a foundational structure, or set of structures, that can be used for developing a broad range of different architectures. It should describe a method for designing a target state of the enterprise in terms of a set of building blocks, and for showing how the building blocks fit together. It should contain a set of tools and provide a common vocabulary. It should also include a list of recommended standards and compliant products that can be used to implement the building blocks.

1 Introduction

The advantage of architecture can be summarised in that it helps to place the development of the smart farm lab in a strategic context. Almost all countries and regions already have a digitalisation strategy for agriculture, a policy for the economical use of natural and other resources (including, but not limited to, organic farming) or a system to support food chain security. As with all strategies, the strategic life cycle applies to digital agriculture: future status (vision, mission), the definition of goals and tasks, allocation of resources and risk analysis, decomposition of tasks, implementation, monitoring and evaluation, and finally, if necessary, intervention (Ehlers, Huber, and Finger, 2021).

The enterprise architecture model provides a framework for the strategic cycle, intending to move dynamically and continuously through a series of transition architectures from the baseline to the target. Ensuring reusability and interoperability is a key principle, together with standards, industry and quasi-standard solutions playing a key role in enforcing them. Moreover, the predictability of gradual transitions makes regular evaluation and reassessment of business functions, capabilities, and maturity essential (Wetering and Rogier, 2021).

The SUNSpACe project proposal can be considered as a project initiation document (PID). The goal is to create local practical training sites (Smart Labs) for the partners and an additional online platform providing theoretical knowledge. Both of them form the framework for blended learning. During the training, especially in the SmartLab exercises, data can be used well either during research or to identify good practices. In addition, the project aims to connect knowledge centres on a cross-country platform. In this way, the architecture vision includes three levels of architecture: the primary data collection, the knowledge centres, and the cross-country platform. After assessing and analysing the requirements, the baseline architecture applies to the SmartLab specification, procurement, and implementation. Achieving the target architecture is far from the project's scope, but transition architectures will be important to it.

The overall agrarian political and economic environment is outlined in D1.1. Then, based on the assessment and analysis of the needs, we identify the individual stakeholder groups (see D1.2 for details) and analyse the requirements that each stakeholder identifies as their specific interests and drivers.

The purpose of architectural design in the SUNSpACe project is to develop an appropriate adaptive learning system that trains farmers and implements the smart farm lab. This system is more than an information system. SUNSpace smart farm lab is based on an enterprise architecture within its different components.

In the following section, we introduce an overview of Enterprise Architecture concepts and the existing platform and framework in the literature.

1.1 Enterprise Architecture Concept and Overview

Architecture is a logical system of components. Architecture is a fundamental system consisting of embedded components, internal and environmental relations, design and development principles and high-level rules" (ISO / IEC 42010: 2007). Most of time, an aarchitecture concept is defined through a set of architectural representations. **A bubble chart** is the first architectural deliverable created by the architect. It is a conceptual representation which depicts requirements and constraints under the basic understanding of the prospective owner. The next set of architectural deliverables is called **architect's drawings.** The purpose is to enable the owner to relate to them and to agree or disagree: "That is exactly what I had in mind!" or "Make the following modifications (Zachman, 1987)**.** The **architect's plans** translate the owner's perceptions/requirements into a product. Each of these views displays a level of detail more than the previous one.

The history of Enterprise Architecture goes back to J. John Zachman. He was IBM's chief system analyst. In 1987, he published a ground-breaking article on a new approach to systems organisation and development, "The Framework for Information Systems Architecture" (Zachman, 1987). Zachman's framework is an enterprise ontology, and It's a fundamental structure for enterprise architecture, which provides a formal and structured way of viewing and defining an enterprise.

Zachman believed that as the computing infrastructure hardware and software evolved, there was a need for a more complex approach that better reflects the company's complexity. Searching for an analogy with computer architecture, he distinguished different levels of the approach in terms of aggregation and granularity (scope, business logic, system logic, physical implementation, components, and operation). Since this time, Zachman's approach has undergone several evolutions. The current version 3 defines rows by category. The Executive Perspective (Scope Contents) corresponds to the "bubble chart". The Business Management Perspective (Business Concepts) corresponds to architectural drawings. The Architect's Perspective (System Logic) corresponds to the architect's plans. The Engineer Perspective (Technology Physics) is where the contractor must redraw the architect's plans to represent the builder's perspective, with sufficient detail to understand the constraints of tools, technology, and materials. The Technician Perspective (Tool Components) corresponds to the detailed specifications given to programmers who code individual modules without being concerned with the overall context or structure of the system, and the Enterprise Perspective (Operations Instances). Furthermore, he argued that it makes sense to ask questions at all levels: what, how, where, who, and why. (Figure 1).

	Why	How	What	Who	Where	When
Contextual	Goal List	Process List	Material List	Organisational Unit & Role List	Geographical Locations List	Event List
Conceptual	Goal Relationship	Process Model	Entity Relationship Model	Organisational Unit & Role Relationship Model	Locations Model	Event Model
Logical	Rules Diagram	Process Diagram	Data Model Diagram	Role Relationship Diagram	Locations Diagram	Event Diagram
Physical	Rules Specification	Process Function Specification	Data Entity Specification	Role Specification	Location Specification	Event Specification
Detailed	Rules Details	Process Details	Data Details	Role Details	Location Details	Event Details

Figure 1: Zachman enterprise Framework (https://en.wikipedia.org/)

Since then, several approaches and methods have been developed. The Open Group, a non-profit association of hundreds of IT companies, has developed an Architecture-Based Systems approach to support the competitiveness and interoperability of their applications, analysing and using good practices related to Architecture Development Methodology (ADM), which are reviewed at regular intervals and adapted to the results of technological development (e.g. cloud services) (https://www.opengroup.org/).

1.2 The Open Group Architecture Framework (TOGAF – ADM)

For designing the E-Agriculture master plan, we must choose a good framework with guidelines, methods and tools. TOGAF is one of the most interesting frameworks that exist and have a point of view which is very rich for designing its systems for companies (Hermawan & Sumitra, 2019). TOGAF gives a straightforward method to build and implement the EA and the information system called the Architecture Development Method (ADM). TOGAF ADM is a method to develop and manage the life cycle of EA. It represents a clear vision and principles for developing an enterprise architecture. TOGAF-ADM is the aggregation of several components built for the iterations cycle, as depicted in Figure 2. These different components are explained below:

1) Architecture governance:
This component of TOGAF architecture is the practice and orientation by which Enterprise architecture and other architectures are managed and controlled at an enterprise-wide level. It deals with all the tasks related to architecture change management and implementation management.

2) Architecture context:
This component includes the "Preliminary framework and principals" that determines the framework and scope of the Enterprise Architecture (EA) to be developed and the definition of management elements, in which the architecture and organisational team are formed in

the Revenue Management Agency. The "vision of architecture" defines the scope of the foundation architecture effort, creates the vision architecture supporting requirements and constraints and obtains approvals to proceed (K L Putra, 2020).

3) Architecture delivery:

This component includes the three different domains of the architecture during implementation. "**Business architecture**" is a domain that defines the business strategy, governance, organisation, and critical business processes. It allows the development of a detailed business architecture for analysing the gap results. The "**Information system Architecture**" determines the data architecture and application architecture. The data architecture focuses more on how the data is used for the needs of business functions, processes and services. The "**Technology architecture**" enables the development of a technology infrastructure that is used to identify all components that will support the development, implementation and deployment processes (K L Putra, 2020). In some cases, it also includes "Data Architecture", which defines the architecture's logical and physical data set.

4) Transition planning:

This component of TOGAF architecture deals with opportunities and solutions and migration planning.

In TOGAF, "architecture" has two meanings depending upon the context: 1. A formal description of a system or a detailed plan of the system at a component level to guide its implementation and 2. The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time.

TOGAF covers the development of four architecture domains:

Architecture Type	Description
Business Architecture	The business strategy, governance, organization, and key business processes.
Data Architecture	The structure of an organization's logical and physical data assets and data management resources.
Application Architecture	A blueprint for the individual application systems to be deployed, their interactions, and their relationships to the core business processes of the organization.
Technology Architecture	The software and hardware capabilities that are required to support the deployment of business, data, and application services. This includes IT infrastructure, middleware, networks, communications, processing, and standards.

As introduced before, central to TOGAF is the Architecture Development Method (ADM). The ADM consists of a number of phases that cycle through a range of architecture domains that enable the architect to ensure a complex set of requirements to be adequately addressed as shown in Figure 2.

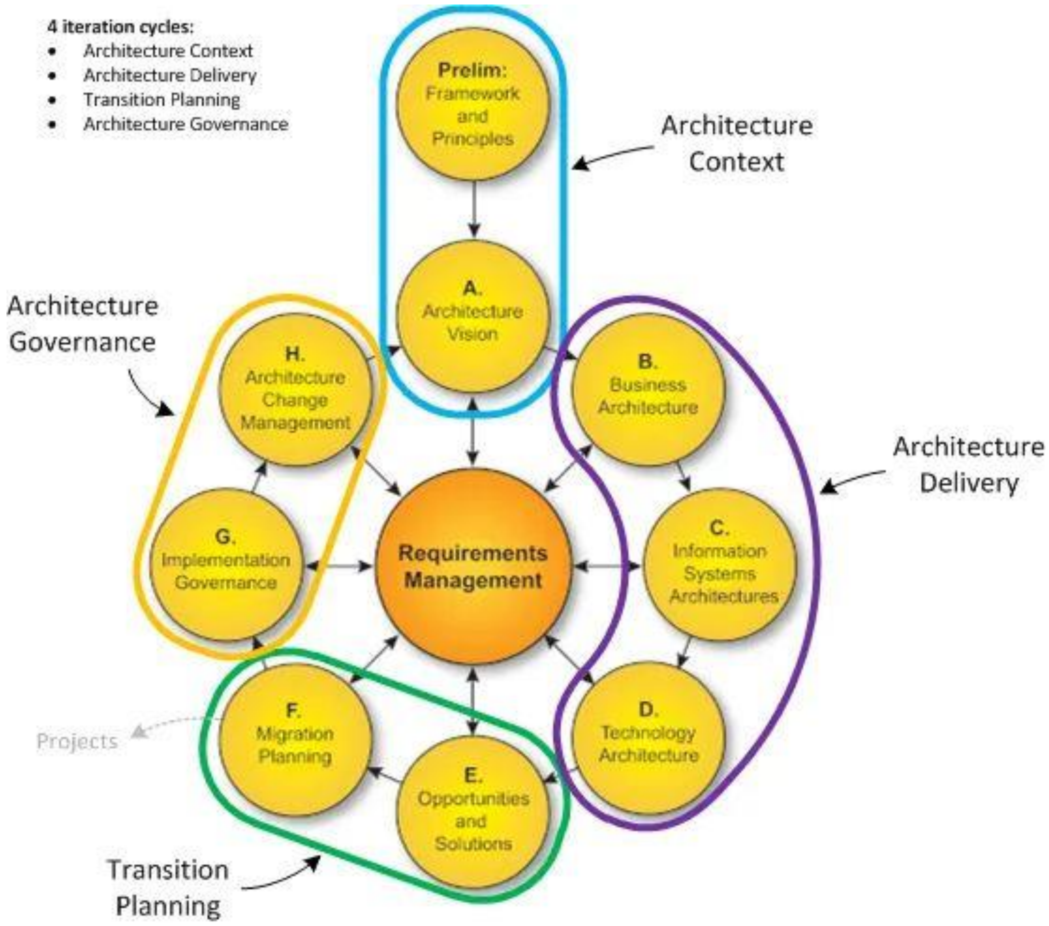

Figure 2: The Architecture Development Cycle (Open Group Architecture Framework)

The architecture capability (documented in TOGAF 9 Part VII: Architecture Capability Framework) operates the method. The method is supported by several guidelines and techniques (documented in TOGAF 9 Part III: ADM Guidelines and Techniques). This produces content to be stored in the repository (documented in TOGAF 9 Part IV: Architecture Content Framework), which is classified according to the Enterprise Continuum (documented in TOGAF 9 Part V: Enterprise Continuum and Tools). The repository is initially populated with the TOGAF Reference Models (documented in TOGAF 9 Part VI: TOGAF Reference Models).

2 Overview of Farm Architecture System

Recent advances in ICT have greatly advanced the agriculture sector through the availability of services from computer-based agriculture systems to problems that were historically faced only through the scientific expertise of a few individuals. Present land degradation and loss, as well as concerns of food security and the requirement to adapt a sustainable farming approach, require the exploitation of modern technologies and approaches. In order to make good use of the latest technical advancements, new schemes, products, and frameworks should be built that would be able to manage heterogeneous data, perform data analysis and provide customised interfaces. In this section, we will investigate some of these approaches.

2.1 FAO Architecture

One of the most powerful frameworks is that the Food and Agriculture Organization (FAO) proposed, on which much research has been conducted to develop its capabilities (FAO, 1983). The fundamental concept of the methodology is based on two objectives: (i) provide suitable land classifications and (ii) evaluate the land procedures. The FAO framework has been built based on those two objectives. It has developed the concept of matching tables (known as transfer functions) that are designed to calculate the suitability of the land for specific purposes (Izadian & Afshin, 2019). In 1983 one of the first modifications of the initial FAO framework was developed and published, the Land Evaluation Computer System (LECS) methodology.

The LECS methodology is a pragmatic approach adopted for a regional study in Sumatra (Indonesia) with the available data. It is considered a simple model concerning more complex land systems that have been proposed later, but it largely illustrates the capabilities that a computerised evaluation offers. LECS uses physical and economic data to provide individual crop recommendations for each land unit on an economic basis (Baroudy, Abdelraouf, Mohamed, Moghanm, Shokr, Mohamed, Igor, Anton, Ding, Ahmed, Ali, Abdelaziz, Petr, Rosa, 2020). Two stages of analysis take place before the final output, the evaluation of each land unit (considering a soil degradation model) and the potential productivity at three management levels. Following, the FAO's framework, the Automated Land Evaluation System (ALES) was proposed in 1990, a computer program that allows land evaluators to build their knowledge-based system. The proposed model predicts the economic suitability of a land area considering different parameters without having a fixed list of land characteristics or land use requirements. ALES is not considered a user-friendly system but rather a system designed for experts that do not offer GIS functions or display the map of the geographical area being researched (Ershad & Ali, (2020).

The development of Geographic Information Systems (GIS) has revolutionised how people gather, manage, depict, and interpret data. A GIS can combine spatial locations with different kinds of information, as it organises them into layers and visualises those using maps and 3D scenes. Maps are used as geographic containers for incorporating data layers and analytics, such as image data, features, and base maps linked to spreadsheets and tables. As a result, GIS reveals deeper insights into data, patterns, and relationships and eventually provides a more intuitive depiction of data. GIS technology is applied in different scientific fields, including the agriculture sector, and materialises complicated systems that can communicate, perform analysis, share information, and solve complex problems (Vasu, Koranga, and Radha, 2020). Adoption of GIS technologies in the agriculture sector took place where a Multi Criteria Evaluation (MCE) framework was proposed aiming at the ease of the 191 decision-making processes through a finite number of alternatives for the problem of land suitability for agriculture. Eventually, a spatial decision support system is created through the integration of Multi-Criteria Decision Analysis Approaches (MCDAs) in a GIS environment, which produces land suitability maps using the ELimitation Et Choix Traduisant la REalit (ELECTRE Tri) method. Based on the concept of automatic methods' inefficiency for any kind of problem if they are not combined with analytical methods, Sys et al. modified the FAO methodology by assigning the correct severity level for the suitability of the land providing given data values for each land characteristic. The FAO-SYS methodology presents a variance of the method of matching tables which assigns the correct severity level of land suitability, given data values for each land characteristic (Lytos, Lagkas, Sarigiannidis, Zervakis, Livanos, and George, 2020). Five different descriptive classes are defined, indicating different levels of the land competency. There are three different sub-categories indicating the suitability of the land, suitable, moderately suitable and marginally suitable, whereas two sub-categories indicate unsuitability: unsuitable for economic reasons but otherwise marginally suitable, and unsuitable for physical reasons (Ranya, Mohamed Shariff, Amiri, Ahmad, Balasundram, Mohd Soom, 2013). Based on the FAO-SYS methodology, Tsoumakas and Vlahavas presented the Intelligent System for Land Evaluation (ISLE), a knowledge-based model with GIS functionality and map interaction capabilities. The system receives the digital map of an area alongside with its geographical database, displays the generated map, evaluates the land units selected by the user according to FAO-SYS methodology and finally visualises the results of the land units in colour (Ranya, Shariff, Amiri, Ahmad, Balasundram, and Amin,2013). A similar approach based on FAO SYS frameworks exploiting GIS capabilities was also followed in ALSE, where a realistic, practicable and functional system was introduced. The necessary modifications were realised in order for the system to determine the quality of land for different types of crops in tropical and subtropical regions (Malaysia). A similar approach for land evaluation is followed where the Intelligent Geographical Information System (LEIGIS), where a land suitability evaluation model is introduced through the combination of expert systems and GIS technologies is presented. The model is based on the FAO land classification for crops and both physical and economic parameters are considered. The novelty of this work lies in the models' ability to alter its rules based on different performance observed in local areas, while the map interaction capabilities offer a user-friendly environment that allows the evaluation of spatial datasets without requiring special computer skills. De la Rosa et al. (1992) introduced the software Mediterranean Land Evaluation Information System (MicroLEIS), focusing on the specific features of the Mediterranean land. MicroLEIS was developed through time, receiving significant updates, as it was originally developed in 1992 for Disk Operating System (DOS), and it has been integrated with many software tools such as databases, statistics, expert systems, neural networks, Web and GIS 235 applications, and it has been used for different case studies. The software has evolved towards an agroecological decision support system.

2.2 IoT Based Architecture

Figure 3 represents a Smart Farming Architecture presented by Basoti et al. Based on the initial observation, smart farming requires an integration framework from planting the seed process until the crop period. At the beginning of the planting process, variables such as temperature, humidity, soil water composure, fertiliser composition, air quality, wind and other climate factors affect the seed plant. All these elements can be captured through the planted sensor, while the picture and video can be detected through the installed camera in the field. The plant's leaves and stems will be monitored, and all data will be transmitted to a server for further analysis. The data will be processed to identify the plant disease in the early stage so that the farmer may act immediately. The location tag also plays an important role in notifying the exact location of the detected plant disease, so the farmer will not have difficulty checking the infected plant. All the collected data will be sent through a data network. This monitoring process from seed plantation till crop will be continued and make synergy among each part to achieve optimum harvest. The data analysis will serve as an observatory and decision support for a farmer to take immediate action against a specific plant infected by disease or destroyed by climate factors as soon as possible to maintain the finest harvest.

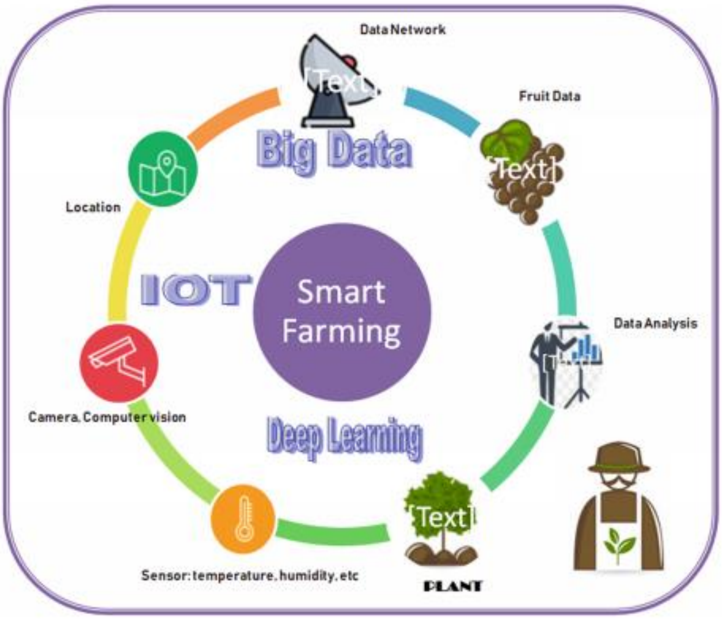

Figure 3 Smart Farming IOT Based Architecture

2.3 A Proposed Framework for AKIS

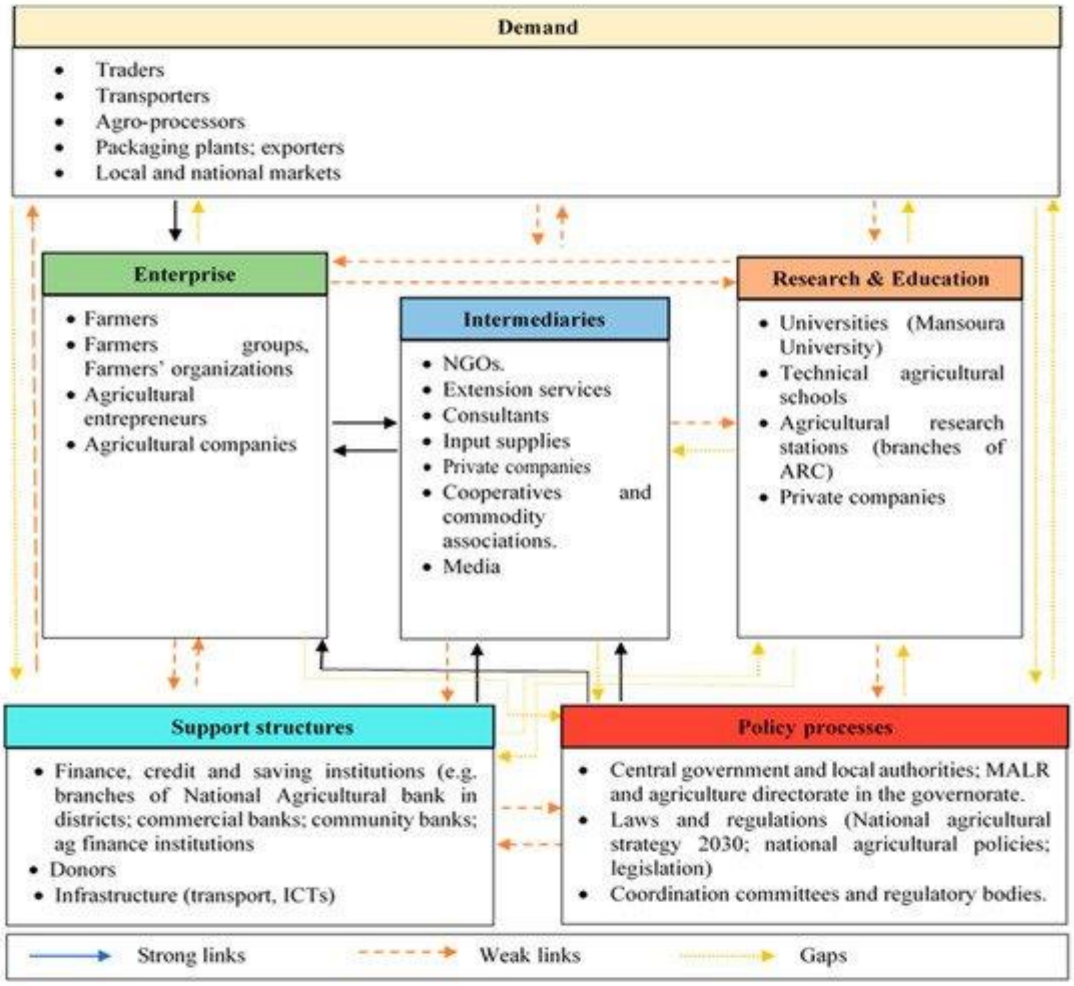

Figure 4: A Proposed Framework for AKIS

The regional innovation system (RIS) concept was developed based on specific geographical space, local conditions, and structural patterns. RIS has five basic structural dimensions: actors, institutions, infrastructure (knowledge, physical, and financial), interactions, and technologies (Ricardo & Ana, 2018). In the context of the present study, the AKIS in Dakhalia governorate (hereafter referred to as the DG-AKIS) is comprised of multiple actors, both in the public and private sectors. As shown in Figure 4:, the framework includes three main domains: Farmer enterprises, intermediaries/bridging institutions, and research and education institutions. These domains contain the key actors in the AKIS that interact in certain ways to facilitate agricultural innovation development and access. However, policy processes, support, and supply-demand structures influence their interactions. Farmers and farmer's cooperatives at the community level are the key actors of the farmer's enterprise domain. Intermediaries' domain includes actors, such as governmental extensions, NGOs, and private sectors. Mansoura University and ARC agricultural research stations are the key actors involved in developing, adapting, and disseminating agricultural innovations. In reviewing the strength of linkages between actors, only a few linkages were seen to be strong. Most of these linkages between actors were perceived to be weak, and non-existent linkages were observed in some cases.

2.4 AI in Smart Farming

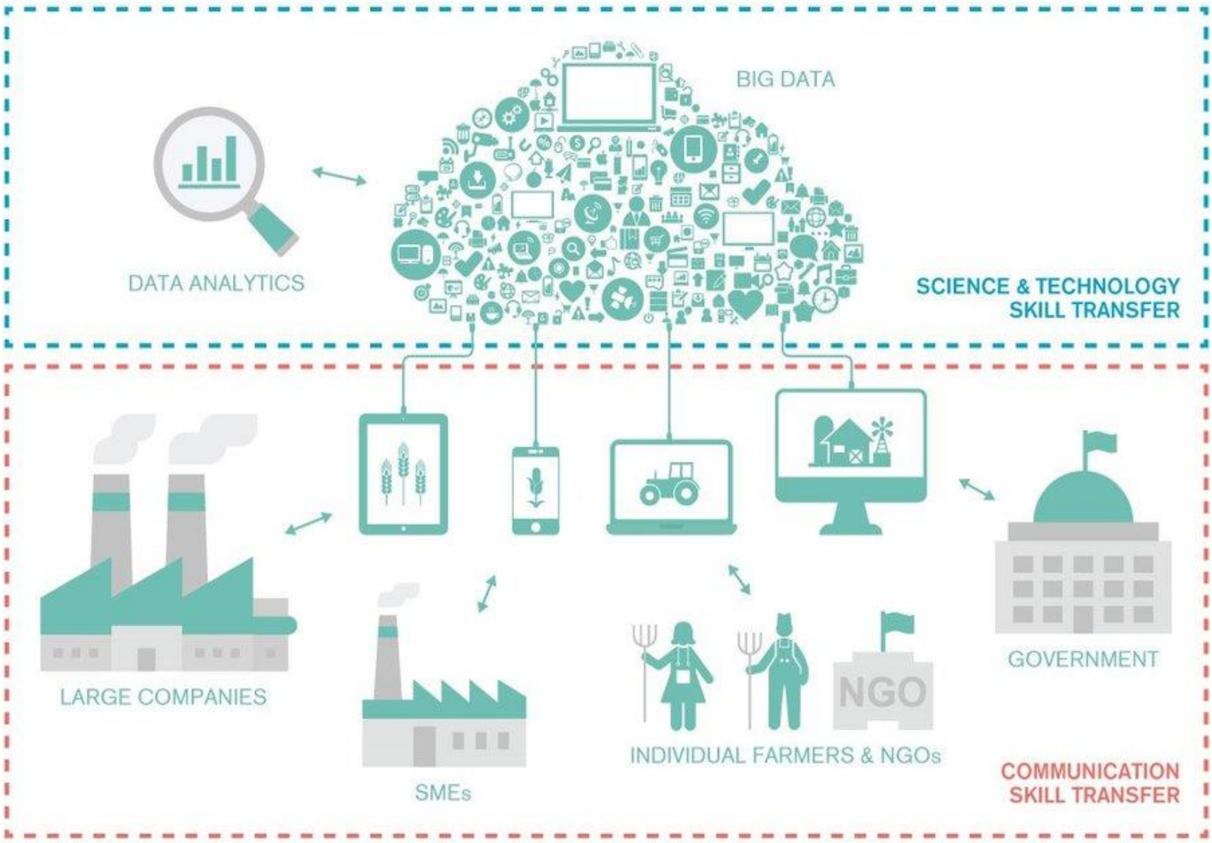

Figure 5: A Framework of AI in Smart Farming

Sensors, robots, satellites, GPS, and drones have become a part of everyday life and serve as invaluable data sources concerning crop growth, soil characteristics and weather conditions. Figure 5 represents a framework of AI in Smart Farming. Although each component listed in the figure is very interesting on its own, the datasets reach their full potential only after we aggregate them and apply advanced AI algorithms. There is a harsh debate in the scientific community about whether artificial intelligence will ever become as creative as humans will and whether it will ever become self-aware. In the 21st century, information technologies allow us to comprehend large amounts of data and extract hidden knowledge about agricultural production and processes inside plants. Sensors and technological advances have already been adopted by numerous farms globally to assist in more precise applications and better decisions in the framework of a new farming approach called precision agriculture.

2.5 Big Data in Smart Farming

A conceptual framework for using Big Data in Smart Farming is shown in Figure 6 (Wolfert et al., 2017). In this framework, the business processes (lower layer) focus on the generation and use of Big Data in the management of farming processes. For this reason, we subdivided this part into the data chain, the farm management, and the farm processes. The data chain interacts with farm processes and farm management processes through various decision-making processes in which information plays an important role. The stakeholder network (middle layer) comprises all stakeholders involved in these processes, not only users of Big Data but also companies that specialise in data management and regulatory and policy actors. Finally, the network management layer typifies the organisational and technological structures in the network that facilitate coordination and management of the processes that are performed by the actors in the stakeholder network layer. The technology component of network management (upper layer) focuses on the information infrastructure that supports the data chain. The organisational component focuses on the governance and business model of the data chain. Finally, several factors can be identified as key drivers for the development of Big Data in Smart Farming, and, as a result, challenges can be derived from this development.

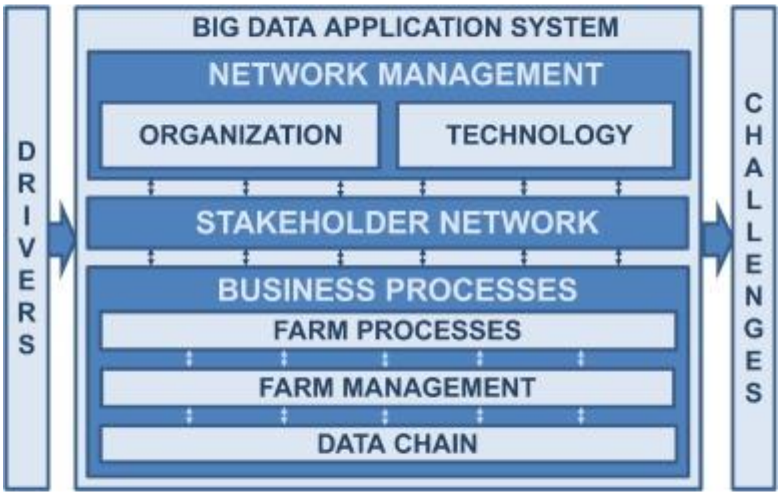

Figure 6 Big Data in Smart Farming, a conceptual framework (Wolfert et al., 2017)

3 SUNSpACe Architecture

The SUNSpACe architecture is a conceptual model which defines the structure, behaviour, and representation of the SUNSpACe project. It consists of components and sub-systems that basically work together to implement the overall SUNSpACe project. SUNSpACe architecture provides the analysis, design, planning, and implementation to build smart farms by providing quality training to the farmers. Figure 7 represents the SUNSpACe system architecture.

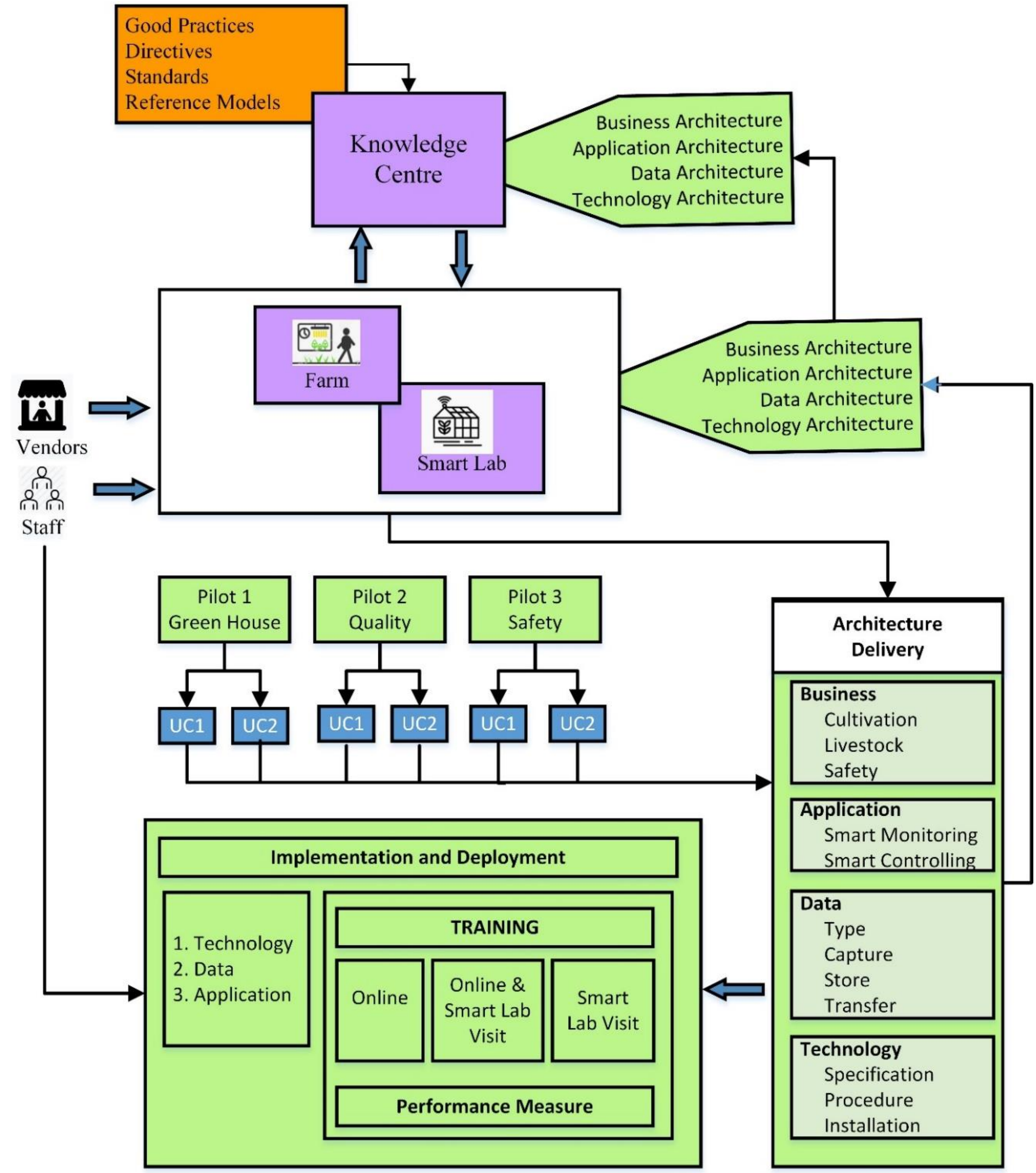

Figure 7 SUNSpACe Architecture

The components of the SUNSpACe architecture are explained below:

1. Knowledge Centre

A knowledge centre is an Internet-based community or system designed to help people remotely share information. Knowledge centres offer a variety of tools and accessories that enable the immediate or delayed sending and receiving of information. This can include online chat rooms, discussion boards, downloadable texts, and other materials, and sometimes even the ability to chat with multiple users via videoconferencing. A knowledge centre is usually set up within a community where its advantages are far-reaching and utilitarian, offering the ability to "information swap" among groups of people who otherwise could not communicate due to geographic or time constraints. Knowledge centres are typically highly specialised and niched, catering to a very specific audience. The basic features of a knowledge centre can be listed as: Good Practice; Standards; Directives; Technology innovations; Policies

The knowledge centre of the SUNSpACe project elaborates the following:

- What will the pilot project do?
- What will data be collected by the pilot project?
- How will the smart lab collect data at the project site?
- From where or whom will the smart labs collect data?
- What services will be provided by the pilot projects?
- To whom will the services be provided?
- What is the business model? (Revenue, cost, sustainability)
- Technology platform outline

2. Smart Lab

Specification: The smart labs at the Asian Partner institutions are based on the pilot type and use case. The purpose is to train farmers. These smart labs are comprised of advanced technology and well-trained professionals. The training includes blended online and smart lab visit training schedules; Practical lab assignments; and Certification.

In the following section, we will discuss the delivery component of the SUNSpACe architecture.

3.1 Architecture Development (Delivery)

After the development and acceptance of the target vision, the architecture will be developed. The enterprise architecture is divided into four parts (layers): business, data, and application and technology architectures. Within each layer, the starting point is the baseline architecture, and from there, we move towards the target architecture.

"D2.1.3 Implementation and Assessment Framework through Pilots - *Guideline (meta-model) for Pilots"* contains details. For example, it describes exactly in which location which SmartLab will be implemented, what comprehensive strategic goals and guidelines need to be enforced, what are the characteristics of the organisation and what is the purpose of the training. In the following, we highlight only a few aspects (architectural domains) that are important for enterprise architecture.

3.1.1 Business Architecture

It should be noted that the term 'business' is used in a much broader sense in the context of enterprise architecture than in the case of a standard commercial, service, or industrial company. Business architecture describes the organisation we have defined for the architectural purpose and enterprise or an extended enterprise. The description applies to the organisation, organisational relationships, functions and/or capabilities. Business architecture expresses who, when, where, what, and why they do it. It also includes the incentives, drivers, motivations, and barriers to achieving the goals.

For example, a vegetable producer (who) wants to produce organic vegetables (what) because there is a stable solvent demand for organic products (why). The condition for entering the market is obtaining the organic producer qualification, which influences the choice of the site (where), as it is a condition that it is at a sufficient distance from the neighbouring non-organic production sites (obstacle). Demand is steady and stable regardless of the season (when), so it shifts to greenhouse production. All production decisions and interventions are traditionally carried out (baseline). However, based on market demand and sales prospects, a more extensive modernisation investment is expected to pay off. So, the medium-term goal is to maximise automation where possible, building on precision agriculture tools and methods. With the introduction of new technologies, sales are also being reconsidered because new sales channels can be utilised (extended enterprise), which also changes the role and importance of the sales process (intermediary).

All of this cannot be accomplished in one single step, so in the first step (transition) the producer wants to introduce automatic data collection, which we may refer to *smart monitoring*, and only if it has been introduced, the producer will move one step further to the target *smart controlling*. Both smart monitoring and smart controlling designate the functions that characterise the organisation implementing vegetable production (irrigation, soil monitoring, etc.). Next, the architect will develop the data, application, and technology architecture along with identified features.

3.1.2 Data Architecture

A structured and comprehensive approach to data management enables the effective use of data to capitalise on its competitive advantages. Considerations include:

- A clear definition of which application components in the landscape will serve as the system of record or reference for enterprise master data
- Will there be an enterprise-wide standard that all application components, including software packages, need to adopt (in the main packages can be prescriptive about the data models and may not be flexible)?
- Clearly understand how data entities are utilised by business functions, processes, and services
- Clearly understand how and where enterprise data entities are created, stored, transported, and reported
- What is the level and complexity of data transformations required to support the information exchange needs between applications?
- What will be the requirement for software in supporting data integration with the enterprise's customers and suppliers (e.g., use of ETL tools during the data migration, data profiling tools to evaluate data quality, etc.)?

The "D2.1.3 Implementation and Assessment Framework through Pilots - Guideline (meta-model) for Pilots" already quoted gives a precise description of which use-case works with which *data*. From the perspective of architecture development, it is worth modelling the data with a suitable tool to make it part of the architecture repository. This is more justified because the same data types occur in multiple Smart Labs and are also good for integration and interoperability.

3.1.3 Application Architecture

The goal is to identify the main application systems needed to process the data and support the business.

- It is not a question of *designing* application systems but *determining* what types of application systems are relevant to the business.
- Applications are not described as a computer system but as logical groups of **capabilities** that manage data objects in data architecture and support the business functions of business architecture.
- Applications and their capabilities are defined *without* reference to specific technologies.
- Applications are stable and relatively unchanged over time, while the technology used to implement them will change over time based on currently available technologies and changing business needs.

The "D2.1.3 Implementation and Assessment Framework through Pilots - Guideline (meta-model) for Pilots" already quoted provides a precise description of which use case requires which applications. Regarding architecture development, it is worth comparing the application portfolio with the Open Group Integrated Information Infrastructure (III-RM) reference model, as III-RM focuses on the application-level components and services required to provide an integrated information infrastructure (https://pubs.opengroup.org/architecture /togaf8-doc/arch/chap22.html).

3.1.4 Technology Architecture

The already cited "D2.1.3 Implementation and Assessment Framework through Pilots - Guideline (meta-model) for Pilots" provides an accurate description of which use-case uses which technology platform. In terms of architecture development, it is worth comparing the application portfolio with the Open Group Technology Reference Model (TRM) reference model, as TRM focuses on the platform components needed to provide an integrated information infrastructure (http://www.opengroup.org/public/arch/p3/trm /trm_dtail.htm). Key aspects:

- **Technology architecture** involves transforming application components defined in the application architecture phase into a set of technology components (software and hardware components) available from the market or configurable into technology platforms within the organisation.
- Because the technology architecture defines the physical implementation of the solution, it is closely related to implementation and migration planning.
- Technology architecture starts from the baseline technology portfolio and forms a detailed roadmap for achieving the target architecture, identifying the most crucial work packages in the schedule.
- The technology architecture complements the architecture information set and therefore supports each migration scenario's cost assessment.
- Identifying the **models** required for each viewpoint using the tool or method selected questions to arise:
  - Are all aspects of stakeholders in place? If not, new models need to be created or existing ones expanded;

- Are the taxonomy of platform services and logical technology elements (including standards) appropriately provided?
- Are locations for technology installation relevant?
- Is the technology suitable to meet the new requirements (i.e. does it meet functional and non-functional requirements)? If not, refine taxonomy and product range

- **Impact**: scaling and costing, capacity planning, deployment, management
- **Performance**: Service detail will affect platform service requirements.
- **Sustainability**: If the detail of the service is too rough, changing the service is difficult and affects the maintenance of the service and the platform.
- **Location and latency**: Services can interact with each other over remote connections, and communication between them has a built-in latency.
- The impact of communication between these services on the platform and location should be considered when drawing the service's boundaries and determining the service's level of detail.
- **Availability**: Service calls depend on a network and/or service failure. The availability of a high level of communication is an important consideration when breaking down service and determining the level of detail of the service.
- **Product selection.** Existing products are reused, increasing capacity or product selection decisions are a constraint during the project.

3.2 Implementation

Figure 8 represents the implementation and deployment of the SUNSpACe training module. In the following section, we will discuss the implementation and deployment model.

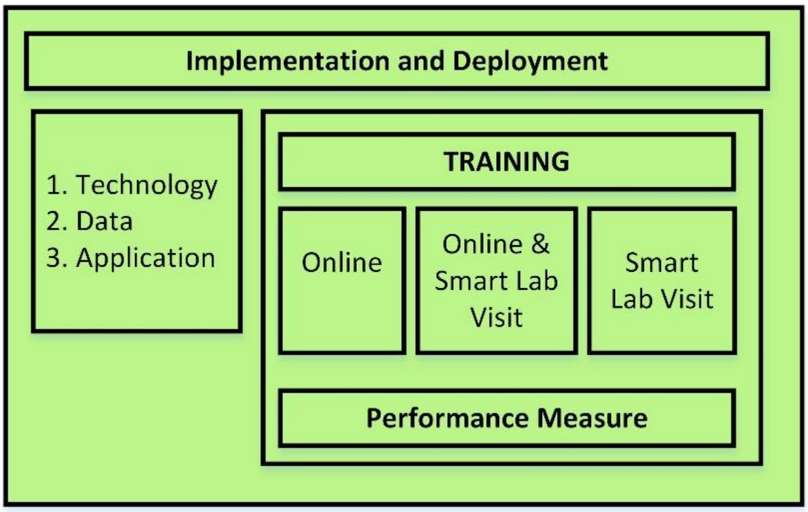

Figure 8 Implementation of SUNSpACe Training Model

Approach for Conducting Training	
Lecture aided with audio-visual media	In the smart lab at partner institutions
Hands-on-lab	In the smart lab at partner institutions
Online delivery	Through the servers managed by partner institutions
Technology Used	
Online Platform	To make available documents, audio and visual materials and pre/post evaluation of the trainees
Smart Lab	One lab each in one partner institution
Materials	
Online Materials	Available after accessing the respective servers of the partner institutions.
Printed Materials	Partner institutions provide it.
Localised Materials	Partner institutions provide it.
Training Types	
Online	Managed by the partner institution
Online and Smart Lab	Managed by the partner institution
Smart Lab Visit	Managed by the partner institution
Performance Measurement	

Pre-evaluation	Online exam
Post-evaluation	Online exam
Accreditation	
Institutional Accreditation	Provided by the institution within and after the project period
Consortium Accreditation	Provided by the consortium within the project period
Accreditation from a Government Body	Coordinated by each Asian partner institution
Others	Applicable if partner institution identifies any means to accredit the training.

4 SUNSpACe Architecture at Use Case Level

In the following subsection, we have developed a template to understand the SUNSpACe architecture at the use case level. Based on this template, each partner will present their pilot for a detailed explanation.

4.1 Architecture Vision

Pilot	
Use Case	
Objectives	
Local Collaborations	
International Collaborations	
Services provided	
Training at Smart Lab	

Beneficiary Stakeholders	
External Stakeholders	
Internal Stakeholders	

4.2 Business Architecture

Business Capabilities	
Strategic context	
Business drivers	
Business capabilities	

Input	
Output	
Constituents	

4.3 Data Architecture

Data Architecture bridges the business and technology architecture of the SUNSpACe project using the application architecture. It includes specifications used to describe the existing state, define data requirements and control data assets as put forth in a data strategy of the SUNSpACe Architecture.

The objective here is to define the major types and sources that interlink between the data and the application of the data necessary to support the project objective, which is helpful to the stakeholders.

Figure 9 shows the data architecture of the SUNSpACe Project.

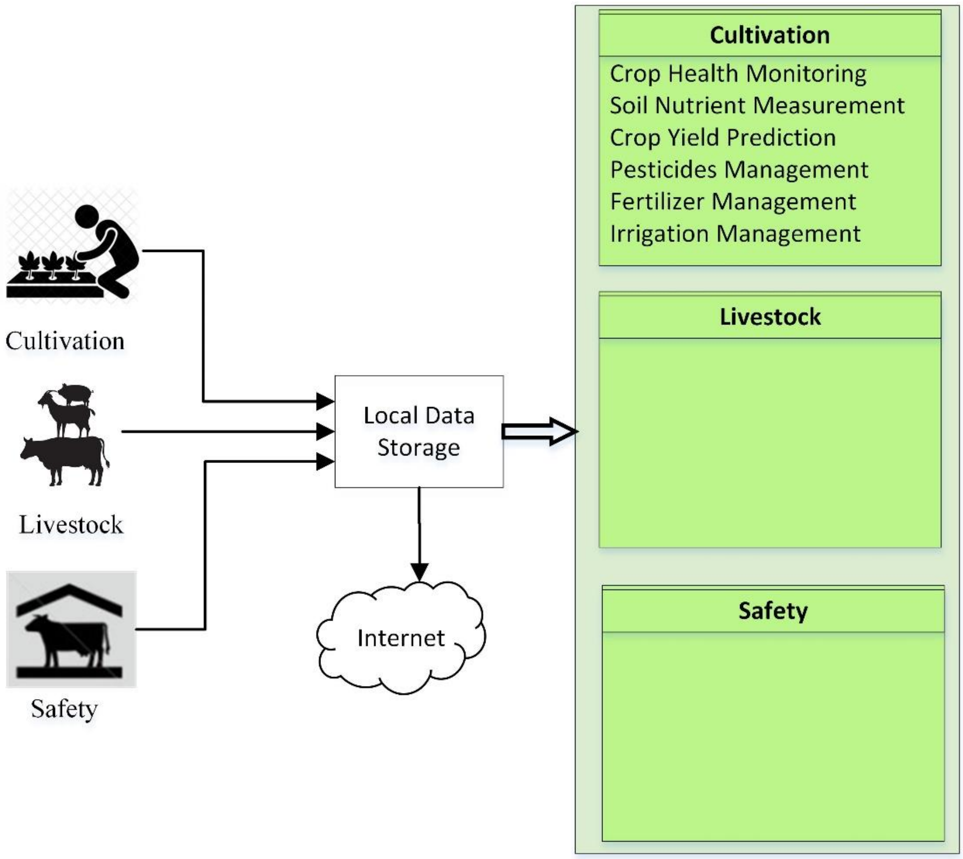

Figure 9 Data Architecture of SUNSpACe Project

Artefacts	
Type of Data Collected	
From where and how will the data be collected?	
Measures	
Storage (technical detail)	
Behaviour	
Local Collaborations	

International Collaborations	
Cross pilot	TBD
Activities	
Implementation at the Local level	
Implementation at International Level	TBD
Implementation in Cross Pilot	TBD

4.4 Application Architecture (Functions of the software)

Application architecture provides the visualisation of information of the technology architecture. The farmer can inspect the results of the review produced by the system's services and take action accordingly. The application software presents information in a user-friendly way. It may refer to different field optimisation deployments such as irrigation, pesticide drift control, cultivation process, crop disease prediction and protection.

Application Component	
Analysis of database	
Present output in a user-friendly model	
Structural Component	
Outcomes	

4.5 Technology Architecture

This section covers the technology foundation elements which power the capabilities of the project and realise the value streams.

Equipment	Description
Communication Protocols	
Field sensors to lab	
Lab to data Centre	
Lab to Cross Pilot	TBD
Description of Technology used for Data Processing	

Software	
Database	

5 Project Management

Project Management
Project Portfolio Project per use case Cross Pilot Management

5.1 Project Portfolio

The SUNSpACe project has following five work packages:

- WP1: Learning material & program design.
- WP2: Develop/implement smart farming technology lab.
- WP3: Quality plan linked to the training program and smart farmer qualification.
- WP4: Ensuring the dissemination and visibility of the project.
- WP5: SUNSpACe project management.

WP1 will be co-led by Corvinus University of Budapest (CUB) and Kantipur Engineering College (KEC) to guide the entire SUNSpACe consortium to conduct the smart farm review and identify and analyse the skills priorities. All SUNSpACe partners will contribute to the questionnaire development and data collection.

The University of the West of Scotland (UWS) and Royal University of Bhutan (RUB) will co-lead WP2, providing a technology transfer interface between European and Asian partners by setting up Smart Farm Labs.

Acme Engineering College (AEC) and University Lumiere Lyon 2 (ULL) will co-lead WP3 to facilitate the setting up the quality plan of the smart farm trainer and program with the control of the implementation a measuring impact of the farmer training and the sustainability of this SUNSpACe project.

Chiang Mai University (CMU) and the University of the West of Scotland (UWS) will co-lead WP4 to ensure the dissemination and visibility of this SUNSpACe project, i.e. planning of dissemination activities.

University Lumiere Lyon 2 (ULL) will lead WP5 to manage the overall SUNSpACe project. ULL will look to the project management and ensure the project is executed according to the timeline and budget. Also, ULL will facilitate the quality management of this SUNSpACe project.

5.2 Project per Use Case

Based on the template in section 4, each partner will present their pilot for a detailed explanation.

5.3 Cross-Pilot Management

The cross-pilot management is discussed in Deliverable D2.5.

5.4 Sustainability

A deliverable on the sustainability of the project has been presented separately as D 3.4.

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