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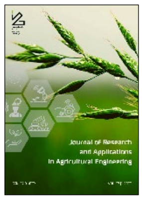

Reference Standard Process Model for Agriculture: Introduction and Steps for Further Development

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The use of digitalisation in agriculture can improve process efficiency on farms. Experience from a large-scale EU-funded project involving a software consortium shows that software companies have different knowledge and understanding of agricultural processes and the use of digitalisation technologies in agricultural processes. This finding, combined with expertise in the standard process model for IT governance (COBIT), triggered the idea of a reference standard process model for agriculture (RSPMA), which is presented in this paper. RSPMA is presented on a conceptual level, where concepts and the relations between them are presented and explained through conceptual sub-models, and some of the RSPMA processes are listed. A Delphi technique survey showed that RSPMA has the potential for implementation and further development. Based on this finding, the steps for further development are also defined and presented here.

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1. Introduction

In recent years, agriculture has become an area with an extensive need for the use of digitalisation technologies [1]. Several papers have confirmed that such technologies improve the efficiency of farm management and other agricultural processes [1-4]. The experience gained in an EU-funded project called AgroIT reveals that software companies possess different and unequal knowledge and understanding of agricultural processes, the use of precision agriculture in agricultural processes, activities within agricultural processes, and process metrics. This causes potential problems when software products and IoT systems need to be integrated. There are many software products and IoT systems on the market today, but each of them covers quite a narrow functional area, and for this reason integration is simply a necessity [2]. This finding, combined with expertise on COBIT – the standard process model for the governance and management of IT in companies – triggered the idea for a standard process model for agriculture. Such a model could become a reference for managing farms and performing agricultural processes, and consequently the proposed model is called the *Reference Standard Process Model for Agriculture – RSPMA*.

The objective of this paper is to present RSPMA in terms of concepts, the relations between them, and some processes. We believe that RSPMA would bring benefits for several target groups in agriculture: farm managers, professionals on farms, agricultural consultants, and product managers in software companies

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that develop software or IoT systems for precision agriculture. We also present the results of a survey in which the Delphi technique was used to evaluate RSPMA and assess its potential implementation in agriculture. Based on the results of the survey, we present plans for further development of RSPMA.

The paper is structured as follows. In the second section we introduce background and fundamentals for RSPMA, and related works. In the third section we present RSPMA on a conceptual level and discuss the benefits of the use of RSPMA for several target groups. In the last section we present the results of the survey through which we assessed RSPMA and its potential implementation in agriculture. We also present RSPMA's current state and plans for its further development.

2. Material and methods

The idea for RSPMA developed in the course of an EU-funded project related to the implementation of applications and digitalisation technologies in agriculture, called AgroIT. Several types of applications and other systems were implemented as part of the project. First was the farm ERP system for agriculture to facilitate farm management. This is a traditional ERP system for small and medium-sized enterprises, expanded with additional modules for agriculture: livestock, fruit growing, winery, etc. [1, 2, 5-8]. Second was a decision support system that uses advanced machine learning methods to support decision-making processes [20, 25]. Third came IoT systems with sensors used to facilitate automatic data collection about various measurements [4, 9-11].

During the analysis phase of the project, it became obvious that software partners had different and unequal knowledge and understanding of agricultural processes, the use of precision agriculture in agricultural processes, activities within agricultural processes, and process metrics. In the final phase of the project, the idea arose to define a reference standard process model for agriculture. The idea for RSPMA is mainly based on expertise on COBIT [17, 18, 19], the standard process model for the governance and management of IT in companies.

The construction of RSPMA was based on three approaches. First, the concepts of COBIT were directly transferred to RSPMA unchanged. Second, the concepts of COBIT were transformed to a form more directly transferred to RSPMA unchanged. Second, the concepts of COBIT were transformed to a form more suitable for agriculture. It is important to emphasise that the mission of RSPMA is broader than the the mission of COBIT: COBIT covers the field of IT in companies, while RSPMA covers various areas of agriculture. IT is a horizontal category in companies and other organisations, while the areas of agriculture are better viewed as vertical categories. Third, other concepts were also added to RSPMA.

We noted that in healthcare, the concepts of COBIT have been used as background to define a standard process model. There is a study which reveals that COBIT is used as a background to create a standardised reference process model in healthcare [12].

A literature review showed that there is no related research on a standard process model for agriculture. There are, however, some limited process standardisation initiatives in agriculture, which largely focus on technical aspects [15, 16].

3. RSPMA

3.1. The conceptual model of RSPMA

The concepts of RSPMA and the relationships between them are presented through a conceptual model. The traditional rectangle–arrow technique was selected as a means of presenting the conceptual model. RSPMA is presented through conceptual sub-models for better clarity. In the diagrams below, arrow labels show the name of the relationship to understand the meaning of the relationship between two concepts. The direction of an arrow indicates the direction in which the relationship should be read and understood. Below we introduce the conceptual model through diagrams representing conceptual sub-models, where the concepts and relations between them are explained in text. Here the *names of concepts* and the *relationships between them* are written in italics.

The process description conceptual sub-model is the first sub-model, shown in Figure 1. *Process* is a core concept of RSPMA. Each *process is grouped into* a process module, where each process module belongs to (is assigned to) a particular area of agriculture. The grouping of processes is only one view serving to explain the need to use modules and modularity in RSPMA. Another view results from the fact that agriculture encompasses several areas: livestock breeding, fruit growing, wine making, etc. Some process modules are divided into process submodules, because some areas of agriculture contain several sub-areas; for example, livestock breeding contains cattle breeding, pig breeding, sheep breeding, etc. *Domain* is a concept that represents the mission of the process module assigned to a domain and the hierarchical level: *governance level, management level and implementation level*. Each process module is assigned to one of three domain.

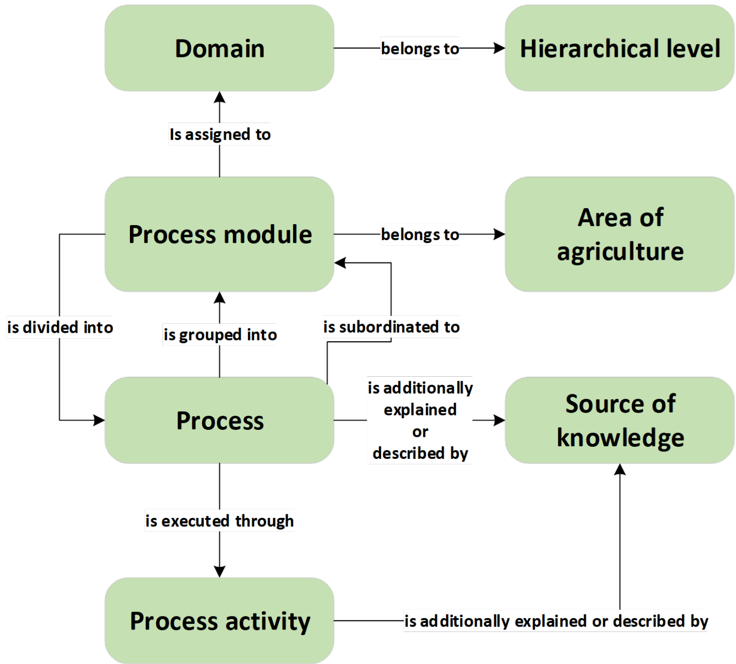

Fig. 1. Process description conceptual sub-mode

It is not the aim of RSPMA to prevail over any existing standard or source of knowledge for agriculture: textbook, scientific journal, digital library, standard, etc. RSPMA is defined and structured to have its own content as reference model, but also to be open, facilitating reference to any existing source of knowledge. In the conceptual model, this is shown as follows: process or process activity is additionally explained or described by a source of knowledge.

The process risks, contribution, and efficiency conceptual sub-model is the second sub-model, shown in Figure 2. The contribution of a process to the overall outcome of a farm is reflected in general agricultural economic goals and process goals. Each process contributes to one or more general agricultural economic goals. A general agricultural economic goal is a set of economic goals relevant for agriculture and is defined at the level of RSPMA. More than one process can contribute to a particular general agricultural economic goal. Each process also contributes to one or more general goals defined by the area of agriculture. General goals defined by the area of agriculture is a set of goals defined at RSPMA level. Each process also has various additional goals defined to further describe and explain the process. Process efficiency is covered by the following concepts: key performance indicator, process metrics and benefit category. Each process additionally has various key performance indicators (KPIs) defined, and each KPI is additionally explained or described by a source of knowledge. The efficiency of achieving process goals is measured by process metrics.

Inefficient risk management can significantly lower the income of a farm, and for that reason risk management is an important issue [21, 22]. Consequently, RSPMA also includes concepts to cover risk management and risk assessment. *General risk* is a set of risks relevant for agriculture and is defined at RSPMA level. Each *process* has various general risks identified. Further, each *process has various specific process risks defined.*

3.2. Target groups for RSPMA

RSPMA is designed to be used by several target groups. The first target group consists of *product managers* in software companies developing software products and IoT systems for precision agriculture. Each process in RSPMA is described by the following components: process goals, process metrics, KPIs (Key Performance Indicators), process activities, links/relations to standards and other sources of knowledge. RSPMA can therefore be a reference model for product managers in defining the functionalities of their products [13, 14]. The second target group is *managers and owners* of larger farms. We are aware that through the further development of RSPMA the list of components will be extended, based on further steps of our research on RSPMA, which will be introduced later in the paper.

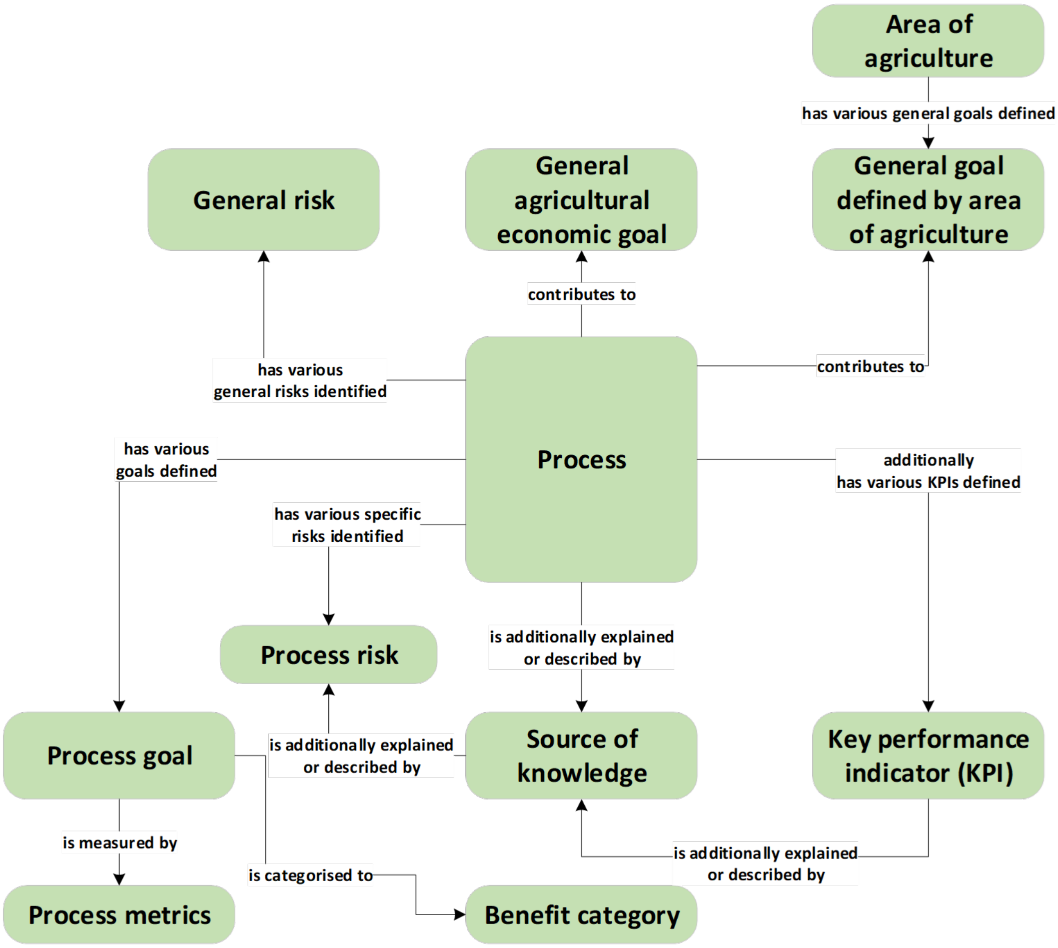

Fig. 2. Process risks, contribution, and efficiency conceptual sub-model

We believe that any standard process model should be tailored to larger institutions (organisations in general). Smaller institutions should then use it to the extent that they believe is suitable for them. This is considered in the design of RSPMA. The above-mentioned process components can help *managers and owners* to set goals, conduct monitoring and manage risks. The third target group is *consultants for agriculture*, who will be able to use RSPMA as a knowledge base and a reference for their work.

3.3. RSPMA domains, process modules and processes

There are three domains defined in RSPMA, each also having a code assigned: Govern and Monitor (GM), Plan and Manage (PM) and Implement and Execute (IE). Each domain has at least one process module assigned, but in some cases a process module can encompass a hierarchy of process sub-modules. Process modules and modularity are a necessity for RSPMA because agriculture is a large complex area which encompasses several sub-areas. Therefore, such a model can only be built step-by-step, where in each step a single process module representing a particular area of agriculture is added. For now, only process modules for the Livestock agricultural area (with code LS) have been defined for the PM and IE domains.

Each domain has a process module called a Common module with the code CM. The purpose of this process module is to cover processes that are common to all areas of agriculture and must be performed on any farm, regardless of the areas of agriculture in which the farm operates. The GM domain represents the governance level and has only the Common module. On the other hand, PM and IE domains have Common module and process modules for different areas of agriculture. The naming convention for processes is as follows. First, each process has its own unique code, which is a concatenation of the domain code, parent's process module codes, and process module code (e.g. IE.LS.CB – Cattle Breeding). Second, processes are named using imperative phrases that reflect the mission of a process, for example: *ensure risk governance, manage suppliers*, etc.

Figure 3 shows the relationships between domains, the hierarchy of process modules, and some processes. The GM domain's *common module* has 9 processes defined; some of them are: GM.02 – Ensure profitability, GM.03 – Ensure risk governance, GM.04 – Ensure machinery and equipment governance, GM.05 – Ensure IT and innovation governance, GM.06 – Ensure compliance with legislation, GM.07 – Enable external and internal control. The *common module* of the PM domain has 28 processes defined, among others: PM.CM.02 – Manage budget and costs, PM.CM.03 – Manage financials, PM.CM.04 – Manage risks, PM.CM.07 – Manage products sales, PM.CM.12 – Manage energy consumption, PM.CM.14 – Manage agricultural machinery, PM.CM.17 – Manage information system, PM.CM.22 – Manage changes based on legislation demands. The figure also shows some processes for the *implement and execute* domain.

As we can see, some *plan and manage* processes have an equivalent process (a subordinate process, in a way) in the *implement and execute* domain. In general, each *plan and manage process* has one or more equivalent (subordinate) processes.

We followed the top-down division into *governance*, *management* and *implementation*, where each of them is represented by a domain. There are top-down and bottom-up relations between processes on adjacent levels. Top-down and bottom-up relations between processes represent a vertical type of relation. When viewing relations between processes in a *top-down* direction, a process on a higher level *directs* one or more processes on a lower level. On the other hand, when viewing relations between processes in a *bottom-up* direction, a process on a lower level *contributes to* one or more processes on a higher level.

Figure 4 shows an example of relations between selected processes from all three domains. Because an information system is a tool needed for every process, it is not surprising that the relations are quite extensive. As we can see there are also *supports/enables* relations between processes, that is, relations that are not based on hierarchy.

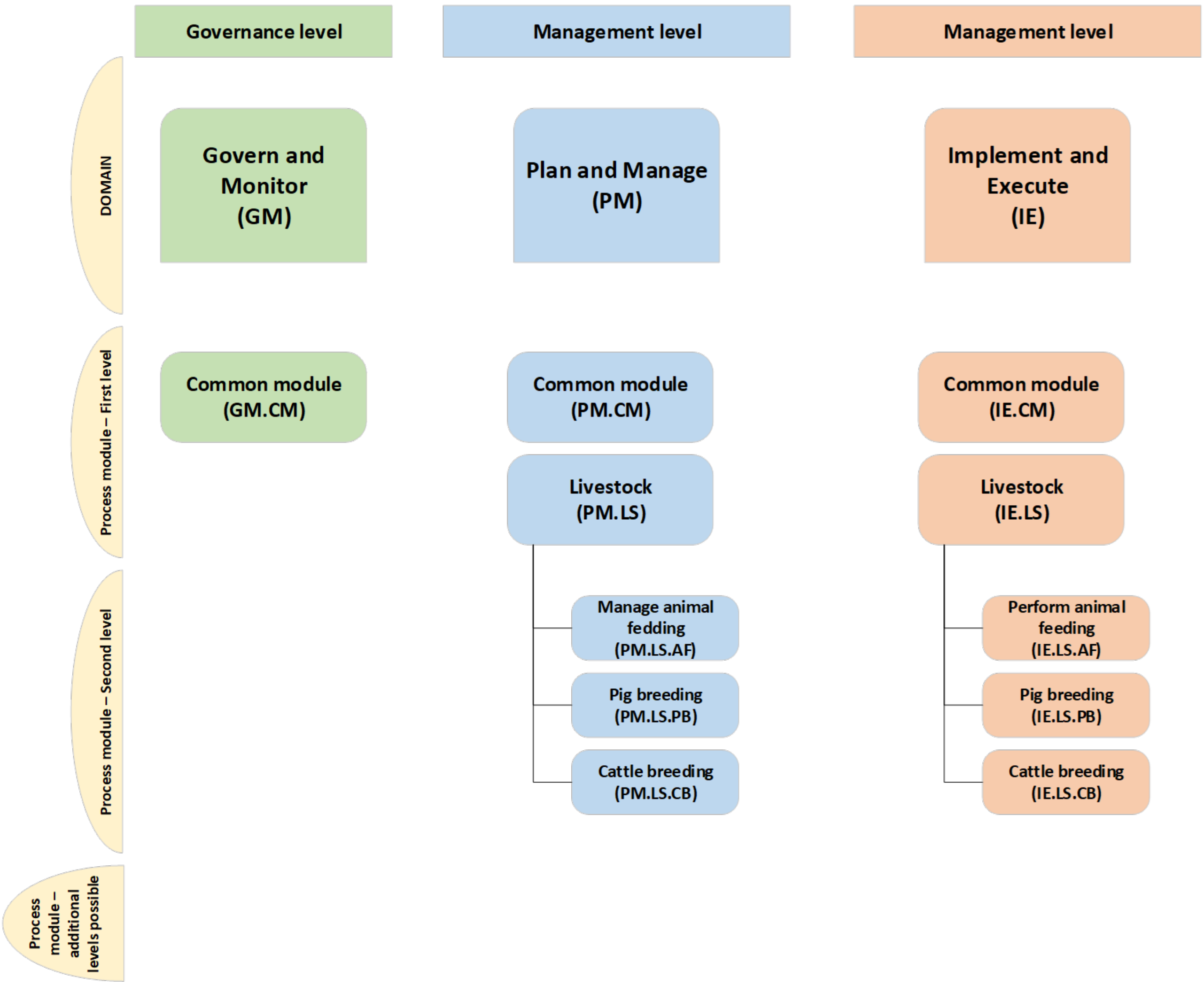

Fig. 3. Relationships between domains and the hierarchy of process modules

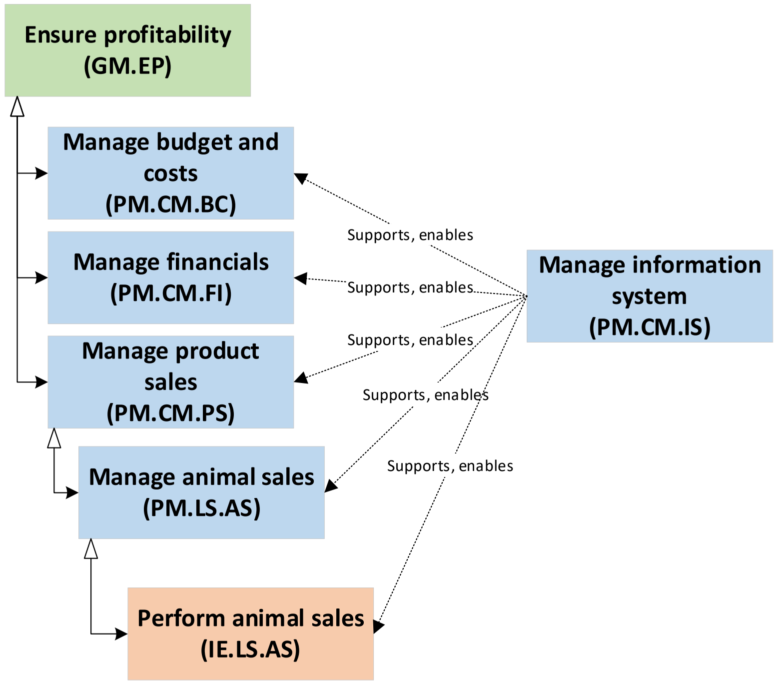

Fig. 4. Relations between selected processes

4. The evolution of RSPMA – Further development of RSPMA

After creating the first version of RSPMA we decided to evaluate it and assess its potential implementation in agriculture. As in the first version RSPMA is only defined on a conceptual level, we were quite limited in terms of the approach to be used. We selected the *Delphi technique*, which is used to elicit and refinegroup judgements on a particular problem or topic to reach a consensus among experts through a *Delphi consensus process* [23, 24]. In the first round of the *Delphi consensus process* we used open-ended questions to solicit the opinions of panellists. In the second round, through meetings, the panellists reached the consensus that *RSPMA has the potential for implementation and further development in agriculture*.

4.1. Analysis of the current state

Research on RSPMA has reached the point where we have the first version evaluated by experts using the *Delphi technique*. We know that there is space and potential for changes and improvements. For now, only a process module for livestock is covered by RSPMA, and as modules are added the need for an update of the process structure might emerge, and maybe also an update of the concepts of RSPMA. We are aware that RSPMA can only be properly developed further through a large-scale international project involving several teams of experts from different areas of agriculture. The development of COBIT, for example, has now been ongoing for about 20 years; it shows that such reference standard process models constantly evolve based on the coordinated work of different expert groups and that changes are based on observations and experience of the use in practice.

The presentation of processes as process workflows is always an issue in standard process models. COBIT, for example, does not include process workflows. Discussion with panel members about this issue indicated that process workflows might only confuse farm managers and that in many cases it would be very difficult to reach consensus on workflows. A group working on the framework for the governance of healthcare, for example, came to the same conclusion (based on discussions with various experts and managers) and the framework thus does not include process workflows [12]. We believe that existing RSPMA process description attributes (goals, activities, metrics, etc.) are sufficient.

A website would no doubt be an appropriate tool to promote RSPMA and its use. The website should be well structured, and have good search features and an effective user interface. It would also include links to other sources, since RSPMA is not considered to prevail over other standards and sources of knowledge in agriculture, but to provide structured access to them. We are also aware that it is essential for the governance and administration of RSPMA not to be co-financed by businesses, so that it remains independent and is not influenced by the interests of sponsoring companies.

4.2. Conclusion and further steps

Our research on RSPMA is now at a crossroads, where the next steps are being planned. Experience of communicating with experts has shown us that, despite their expertise, it requires some effort and time to explain the mission and the meaning of RSPMA if the structure is defined only on a conceptual level. For that reason, the first step will be the selection of 10 to 15 processes and provision of content for process description components: process goals, process metrics, KPIs (Key Performance Indicators), process activities, and links/relations to standards and other sources of knowledge. We expect potentially to identify additional process description components while providing content. The second step will be organising two or three workshops with farm managers and product managers from software companies which offer software products for agriculture. The aim of the workshops will be to obtain feedback through presentations and discussions. In the course of the workshops, we will also make a decision regarding the transition of RSPMA from a process orientation to an objective orientation. This is because the survey and other communication regarding RSPMA have shown that people believe each RSPMA process to be an entirely new process which did not exist in agriculture before. This is not the case, of course: RSPMA processes merely represent a standardised view of activities taking place on farms. On the other hand, an objective orientation does not suggest the introduction of entirely new processes, due to the difference in wording: the change from a process called *Manage Risks* to an objective called *Managed Risks*. We will, as mentioned, discuss this with workshop participants. Based on analysis of the outcome of the workshops, we will decide whether another *Delphi discussion process* is needed.

Another direction for further research is the introduction of a *government level*, as shown in Figure 5. The use of RSPMA in practice would in our opinion lead to *RSPMA compliant* software products for agriculture. *RSPMA compliance* of a software product means that the product contains and manages its data according to metrics and KPIs. This means that farms could electronically transfer carefully chosen data to the government. The collected data would in this case facilitate the formation of policies for agriculture and the determination of content for tenders. This triggers the idea for the *government level* and *Policy Planning* domain, which are added to the levels discussed so far and presented in Figure 3. It is an open question whether or not the government level should be a part of RSPMA. In any case, for farms, the levels discussed so far are essential.

We also plan to design and implement a prototype of a website for the use of RSPMA.

Finally, we will begin forming a consortium of partners to work on a project proposal for a large-scale EU-funded project. The project will have three high-level goals. First, process modules and processes for various areas of agriculture will be defined and provided with extensive content. Second, a website for the use of RSPMA will be developed. The third goal is the dissemination of information and promotion of the use of RSPMA.

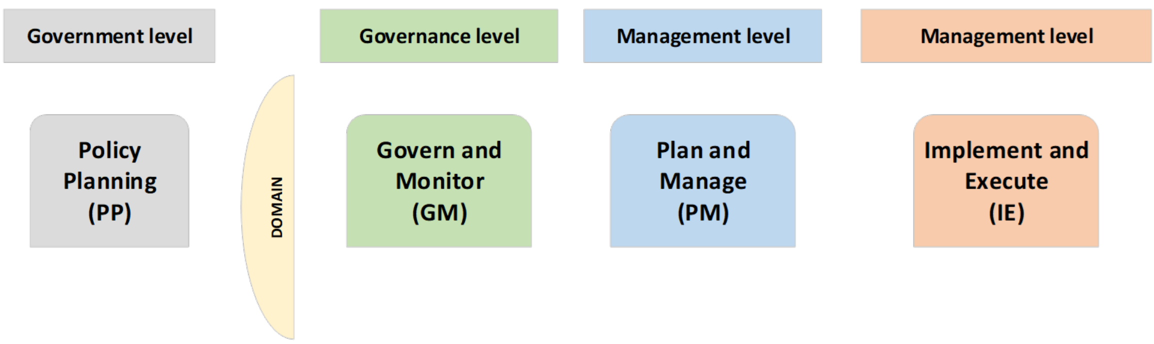

Fig. 5. The introduction of the Government level to RSPMA

References

[1] A. Kaloxylos et al. 2014. "A cloud-based Farm Management System: Architecture and implementation," Comput. Electron. Agric. 100, 168–179.

[2] Y. Ampatzidis, L. Tan, R. Haley, and M. D. Whiting. 2016. "Cloud-based harvest management information system for hand-harvested specialty crops," *Comput. Electron. Agric*. 122, 161–167.

[3] R. Rupnik, M. Kukar, P. Vračar, D. Košir, D. Pevec, and Z. Bosnić. 2018. "AgroDSS: A decision support system for agriculture and farming," *Comput. Electron. Agric*. 161, 260-271.

[4] S. Fountas et al. 2015. "Farm management information systems: Current situation and future perspectives," *Comput. Electron. Agric.* 115, 40–50.

[5] A. Kaloxylos et al. 2012. "Farm management systems and the Future Internet era," *Comput. Electron. Agric.* 89, 130–144.

[6] C. N. Verdouw, R. M. Robbemond, and J. Wolfert. 2015. "ERP in agriculture: Lessons learned from the Dutch horticulture," *Comput. Electron. Agric.* 114, 125–133.

[7] U. Lele and S. Goswami. 2017. "The fourth industrial revolution, agricultural and rural innovation, and implications for public policy and investments: a case of India," *Agric. Econ.* 48, 87–100.

[8] R. R. B. Khataza, A. Hailu, G. J. Doole, M. E. Kragt, and A. D. Alene. 2019. "Examining the relationship between farm size and productive efficiency: a Bayesian directional distance function approach," *Agric. Econ.* 50: 237–246.

[9] J. Santa, M. A. Zamora-Izquierdo, A. J. Jara, and A. F. Gómez-Skarmeta. 2012. "Telematic platform for integral management of agricultural/perishable goods in terrestrial logistics," *Comput. Electron. Agric.* 80, 31–40.

[10] C. Eastwood, M. Ayre, R. Nettle, and B. Dela Rue. 2019. "Making sense in the cloud: Farm advisory services in a smart farming future," *NJAS - Wageningen J. Life Sci.*

[11] B. Žvanut, M. Burnik, T. Š. Kolnik, and P. Pucer. 2020. "The applicability of COBIT processes representation structure for quality improvement in healthcare: a Delphi study," *Int. J. Qual. Heal. Care*, 2(9): 577–584.

[12] J. Tummers, A. Kassahun, and B. Tekinerdogan. 2019. "Obstacles and features of Farm Management Information Systems: A systematic literature review," *Computers and Electronics in Agriculture*. 157, 189–204.

[13] M. Vavpotic, D. and Bajec. 2009. "An approach for concurrent evaluation of technical and social aspects of software development methodologies," *Inf. Softw. Technol.,* 51(2): 528–545.

[14] C. G. Sørensen et al. 2010. "Conceptual model of a future farm management information system," *Comput. Electron. Agric.,* 72(1): 37–47.

[15] S. Fountas et al. 2015. "Farm management information systems: Current situation and future perspectives," *Comput. Electron. Agric*., 115, 40–50.

[16] ICASA, COBIT 2019. ISACA, 2019.

[17] ISACA, COBIT 4.1. 2007.

[18] D. Steuperaert. 2019. "COBIT 2019: A Significant Update," *EDP Audit. Control. Secur. Newsl*. 59(1): 14–18.

[19] O.B. Adeboye, B. Schultz, A.P. Adeboye, K.O. Adekalu, J.A. Osinbitan. 2021. "Application of the AquaCrop model in decision support for optimization of nitrogen fertilizer and water productivity of soybeans." *Information Processing in Agriculture,* 8: 419–436.

[20] I. Drobotă, T. Robu, B. Drobotă, and A. D. Robu. 2013. "Risk management in modern cereal farms," *Metal. Int.,* 18(8): 196–199.

[21] E. Gindu, A. Chiran, B. Drobota, and A.-F. Jitareanu. 2018. "Risk Management Methodology of Investment Projects With Environmental Impact," *J. Eng. Stud. Res.,* 21(1).

[22] M. M. Grime and G. Wright. 2016, "Delphi Method," *Wiley StatsRef: Statistics Reference Online*. 1–6.

[23] C. Hsu and T. Ohio. 2007. "The Delphi Technique: Making Sense Of Consensus," *Pract. Assess. Res. Eval.,* 12(10).

[24] M. O'Grady, D. Langton, F. Salinari, P. Daly, G. O'Hare. 2021. "Service design for climate-smart agriculture".