Agricultural hydroinformatics

agricultural water systems management as a new application for hydroinformatics

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An overview of the interplay between **Agriculture** and **Hydroinformatics**

1. **Social, institutional and technological arrangements around water resources planning and management**
2. **Reliability and timeliness of access to (water) data, information and knowledge, in addition to elaborated decision-making tools.**
3. Fundamental role of **Stakeholders' mobilization** in achieving (socio-technical) transformations and transitions towards sustainable agriculture.

These elements, among others, are at the interface between agriculture and hydroinformatics and certainly **represent a path forward to achieve smart/sustainable agriculture.**

Celicourt, P., Rousseau, A., Gumiere, S. J. (2020). Agricultural hydroinformatics: An emerging framework for implementing and adopting information technologies to foster water management sustainability in farming systems. *Environmental Modeling and Software. Under Review.*

The agricultural hydroinformatics framework

Hydroinformatics, as applied to agriculture, combines, coordinates and interplays with scientific fields of study, and even practices, beyond **hydrology**, **hydraulics**, **ecology**, **economics**, and **sociology**. These fields and practices include:

a) **Geology:** land subsidence as a result of groundwater extraction for agriculture, flooding risks, water conflicts, water scarcity and, thus, food security;

b) **Legal sciences:** water governance institutions, water rights, and water conflicts resolution;

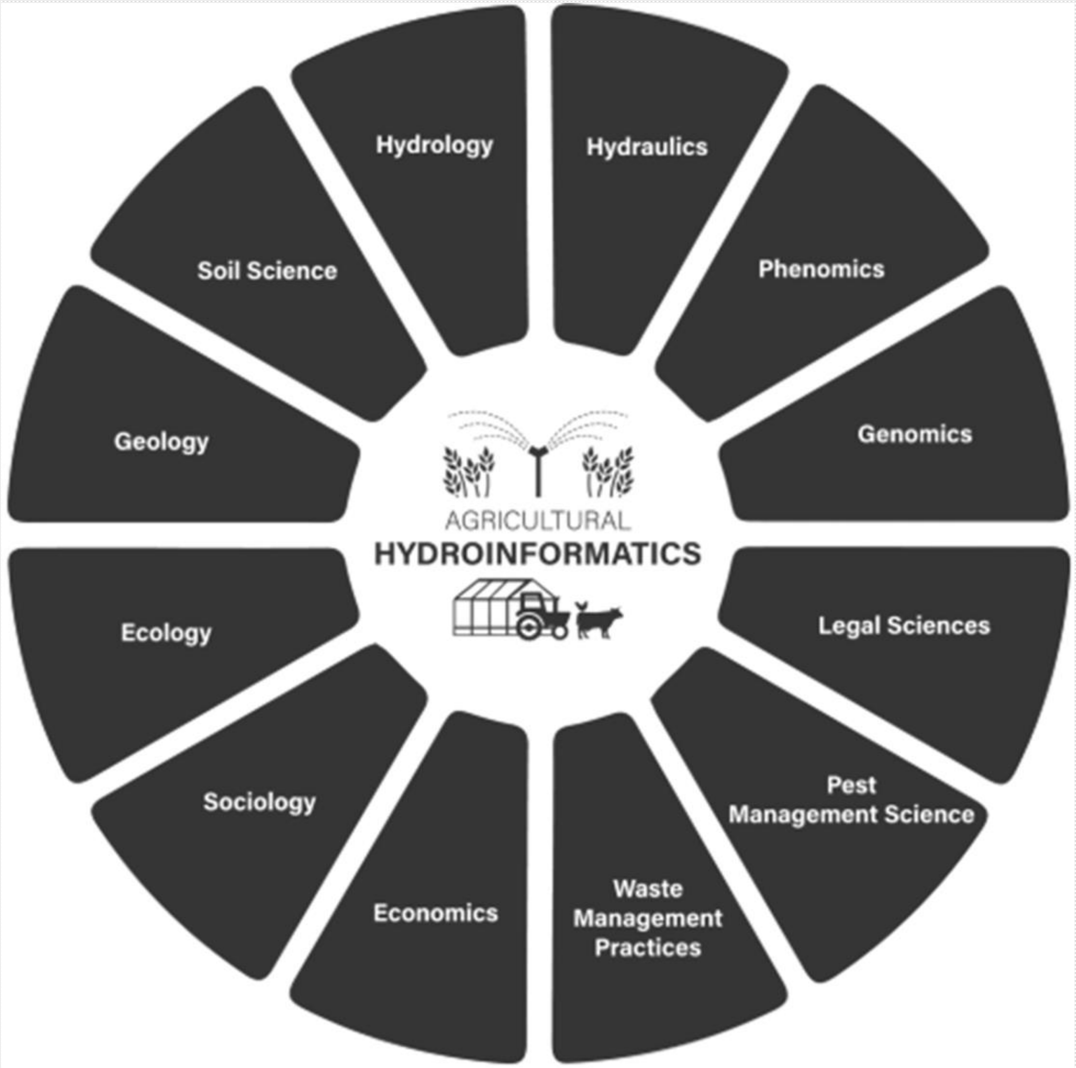
c) **Phenomics:** plant phenotypes (e.g., agricultural yield, growth, efficiency and resistance) due to water stress;

d) **Genomics:** water-related phenotypic traits in gene-based crop and livestock models of interactions between genotypes, growth environments (phenotypes) and farmers' management decisions and practices.

e) **Pest-management** regimes (**pest management science**) and **Waste management practices:** consequences on microbiological water quality with implications on water stress.

f) **Soil sciences:** improvement in extractable water from soil profiles, increase of soil water holding capacity, and decrease in leaching losses.

These fields and practices give rise to a **generic discipline-delineated conceptual framework** that epitomizes the **wholeness and inter-dependencies of agricultural systems studies and modelling** to support, not only integrated agricultural water resources management but also agricultural sustainability.

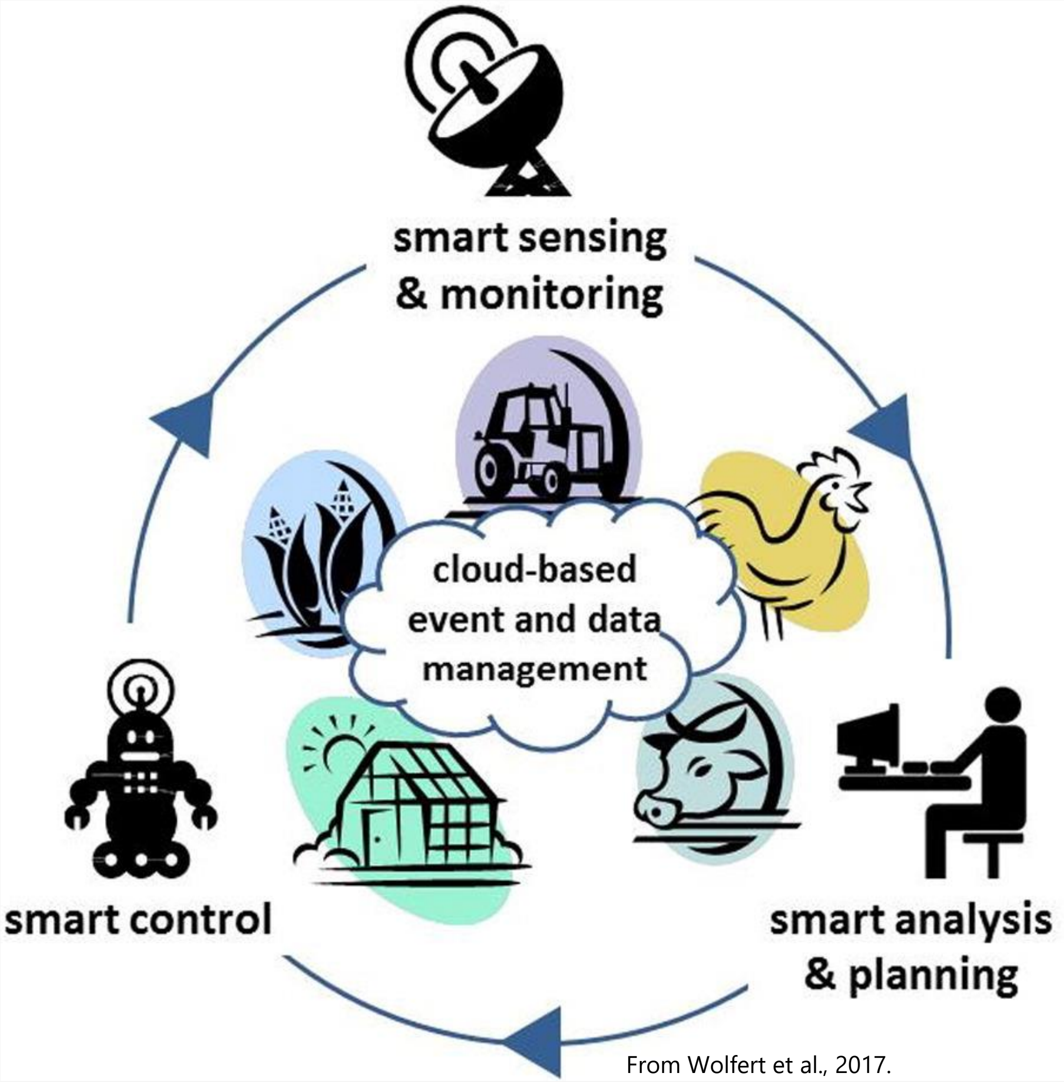


Towards a definition

1 Hydroinformatics in agriculture: understanding and management of agricultural water processes, together with its interactions with, transformation by, and impacts on surrounding environments such as plants, soil, animals, machinery, people, and vice versa.

2 Digital and physical constraints of hydroinformatics on the existing technology ecosystem in agriculture. Failure of many components of this ecosystem to deliver an acceptable level of technological capabilities (**reverse salient**; Jones et al., 2017).

Agricultural hydroinformatics is defined as "**the technology that should identify *reverse salient* in agriculture, support and promote corrective measures, and ultimately apply those measures (if necessary) capable of enhancing the performance delivery of the ecosystem of technologies as a whole.**"

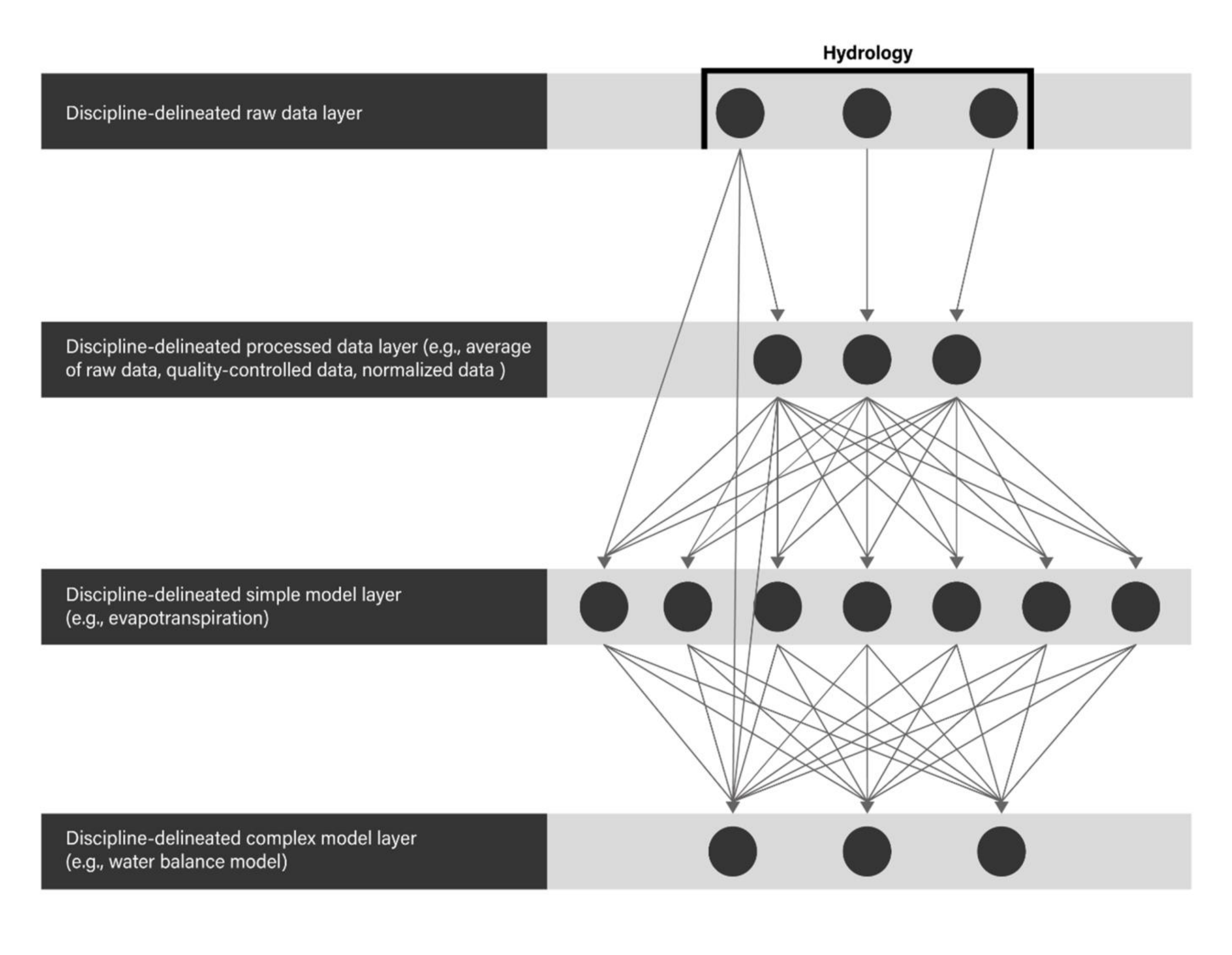


From Wolfert et al., 2017.

Jones, J.W. et al. (2017). Toward a new generation of agricultural system data, models, and knowledge products: State of agricultural systems science. *Agricultural systems*, 155, pp.269-288.
Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming–a review. *Agricultural Systems*, 153, 69-80.

Applicability of the framework

1. Development of discipline-delineated information models and data systems for agricultural water development projects descriptions and farming systems processes at various scales.
2. Development of an entirely integrated knowledge management workflow for agricultural-systems management consisting of raw data, metadata-annotated data, storage and dissemination, simulation models, and decision support systems.
3. Systematic and formal records of relationships among raw data, the processes that produce results and the results themselves in the form of a **deep-learning-like architecture**.
4. Implementation and integration of discipline-delineated simulation models and decision support systems on top of database that implements a discipline-delineated data model.



Opportunities and challenges for *agricultural hydroinformatics*

Adoption challenges: serious barriers towards practical applications, improvement, adaptation and maturation of innovations to empower farmers of all classes as genuine stakeholders.

The **lack of technology delivery mechanism** is a major impediment to adoption that hinders the perceived benefits and usability to justify upfront investments in new technologies. This shortcoming is often attributed *to the implementation problem* of Farm Management Information Systems that fail to capture the "tacit" knowledge and practical needs of farmers.

This problem is an example of ***technology relevance gap***, a discrepancy between scientific knowledge implemented in agricultural decision support systems (AgriDSS) and practical needs and experience-based knowledge of farmers.

THE GOOD NEWS: This **relevance gap** is driving a growing interest in the adoption of **socio-technical approaches** (Multi-Level Perspective, Agricultural Innovation Systems) to agricultural technologies development by integrating stakeholders in the development process (El Bilali, 2019).

This convergence in technologies development approaches between agriculture and hydroinformatics is another fourth element that further justifies the relevance of hydroinformatics to agriculture.

Abbott and Jonoski (2001) anticipated this exact kind of situation where hydroinformatics could play a vital role in producing and consuming knowledge that relates water-dependent soil-cultural practices and plant cultivation practices in new ways to promote justifiable productivity.

El Bilali, H. (2019). The multi-level perspective in research on sustainability transitions in agriculture and food systems: A systematic review. Agriculture, 9(4), 74.
Abbott, M. B., & Jonoski, A. (2001). The democratisation of decision-making processes in the water sector II. Journal of hydroinformatics, 3(1), 35-48.

Summary

Major transformations in agricultural practices through **technological, social and institutional innovations** to meet food demands within planetary boundaries. **Water resources planning, management and usage** at the field, farm, watershed, regional and national scales represent a pivotal effort to underpin these transformations. Another potential lies in the **transformation of the role of farmers, agricultural technologists and scientists** from **knowers to consumers of knowledge**.

Introduction of a **generic discipline-delineated conceptual framework** that stems from the **socio-technical dimension of applying hydroinformatics in agriculture**. Integration of data flows necessary to capture the wholeness and interdependencies necessary to conduct integrated water resources management in farming systems.

Applicability of the framework along with **opportunities and challenges** with a focus on technology adoption to exploit the full potential of the application of hydroinformatics in agriculture.

Caution: A growing **power/knowledge relationships** between business players in the landscape of **data-driven initiatives in agriculture**. Research and development efforts to tackle and reverse these relationships. This would be a turning point towards the co-creation of knowledge to the benefits of all categories of farmers. **This is one more challenge for agricultural hydroinformatics.**