Hybrid intelligence can reconcile biodiversity and agriculture

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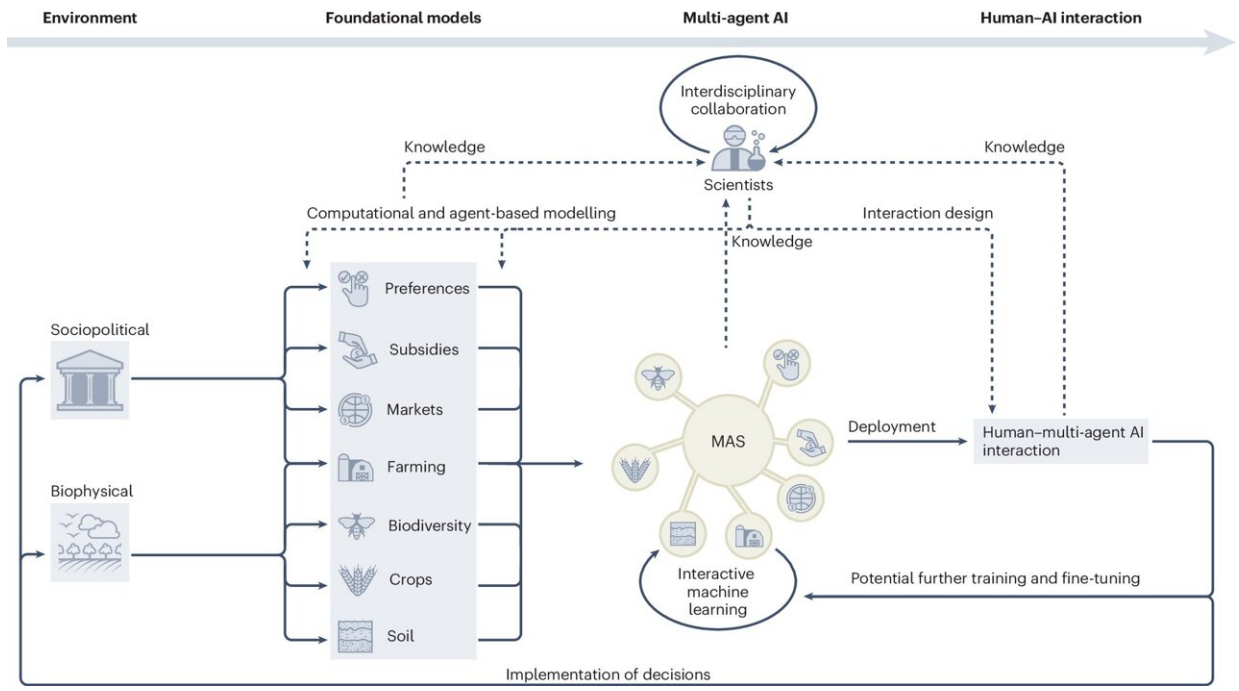

Schematic diagram of the socio-technical system and processes for hybrid intelligence. Knowledge generation in human–AI teams showing interaction with foundational models and multi-agent AI. Credit: *Nature Food* (2024). DOI: 10.1038/s43016-024-00963-6

A research team at the University of Hohenheim and Technical University of Munich has developed a new transdisciplinary approach to resolve the tradeoff between biodiversity and agricultural production.

Preserving biodiversity without reducing agricultural productivity: So far, these two goals have not be reconciled because the socio-ecological system of agriculture is highly complex, and the interactions between humans and the environment are difficult to capture using conventional methods.

Thanks to new technology, a research team at the University of Hohenheim in Stuttgart and the Technical University of Munich is showing a promising way to achieve both goals at the same time. The members of the team are focusing on further developing artificial intelligence in combination with collective human judgment: the use of hybrid intelligence. They have published their article in the current issue of *Nature Food*.

"Although we have more and more data sets at our disposal, we have not yet been able to use them to solve the problem. Available data from remote sensing, proximal sensing and statistical surveys are disconnected and highly fragmented," said Prof. Dr. Thomas Berger, agricultural economist at the University of Hohenheim and lead author of the publication.

"Another challenge is the different planning horizon: Agricultural practices are based on short- and medium-term economic objectives at the field and farm level, that is, on a scale of 1 hectare to 100 hectares. The long-term ecological effects, on the other hand, are evident at the landscape level of 100,000 hectares."

From an ecological point of view, it is therefore necessary to look at the landscape level and better understand the interactions of many farms in terms of space and time. "There is little cross-farm coordination for agri-environmental measures," stated Prof. Dr. Senthold Asseng from the Chair of Digital Agriculture at the Technical University of Munich.

Previous funding programs in agricultural and environmental policy were not designed to enable biodiversity-friendly synergies among farmers, between farmers and other stakeholders, and in science.

The problem is also very challenging from a social science perspective, according to Prof. Dr. Claudia Bieling from the Hohenheim Department of Societal Transition and Agriculture. "This is the classic situation of a social dilemma. Why should individual stakeholders forgo productivity on their own initiative when the common public good of biodiversity conservation benefits many other stakeholders free of charge?"

There are also similar situations that block progress in other economic sectors, e.g., in recycling and waste management as well as in energy and transport.

In order to capture the complexity of the problem and develop new intelligent solutions, joint expertise from the natural and social sciences, engineering, and computer science is required, as well as close cooperation between science and practice.

Technological progress enables new interaction between humans and machines

A 13-person team with precisely this expertise joined forces to develop a transdisciplinary approach—exploiting the new possibilities offered by artificial intelligence in merging and processing large volumes of data. The authors of the publication refer to this combination as "hybrid intelligence."

"By combining the intuitive abilities of humans with the computing power of modern computers and the analytical capabilities of artificial intelligence, for the first time we can develop human-machine systems

that successfully address complexity in agriculture," said Prof. Berger.

One component of such systems are computer models with what the team refers to as "multi-agent technology" for the various ecological, social, and economic processes. By enriching these models with artificial intelligence, the research team aims to create a detailed, interactive image of reality in which various biodiversity measures and effects can be simulated and stakeholders can be supported in joint decision-making.

Group payments as a practical example of hybrid intelligence

The authors explain practical implementations in several applied examples, e.g., compensation payments to groups of farmers instead of individual farms.

"The EU provides various subsidies for species protection measures, for example by giving farmers money to set up flower strips," stated Prof. Asseng. "Up to now, farmers have planted the flower strips on their own and without coordinating with their neighbors. Overall, the flower strips are fragmented and have limited effectiveness."

Group payment programs for farmers who coordinate their flower strips at the landscape level with the use of hybrid intelligence are more promising.

In a first step, hybrid intelligence could analyze complex data on soil conditions, local biodiversity, and similar factors and thus identify the locations where cross-farm environmental measures would be particularly effective and crop losses as lowest as possible.

In a second step, AI systems could provide communication platforms that facilitate exchanging information and planning joint projects without excessive bureaucracy. "Another goal would be a fair balance among all parties involved, for example, through new auction mechanisms for subsidies," said Prof. Berger.

The virtual image of their economic and ecological environment would give actors from agriculture, consulting, and politics the opportunity to try out the measures before deciding whether to implement them. "This would make it easier to assess the impact on biodiversity and crop yields and minimize the costs for everyone involved," added Prof. Bieling.

Above all, AI could serve as an automated moderator that follows the discussions within the group and improves decision-making by contributing information or alternative perspectives. "We can currently see the capabilities of generative AI in language processing and generating new content with ChatGPT. This can be particularly useful to ensure that all relevant information is considered in group discussions and creative solutions are found," explained Prof. Dr. Henner Gimpel from the Department of Digital Management at the University of Hohenheim.

Trust and transparency remain crucial for success

If the approach is to be successful, it must be transparent and participatory. "The technology must be designed in such a way that people can trust it. The ethical use of the technology is also crucial," said Prof. Gimpel. Only if these conditions are met can hybrid intelligence systems develop their full potential and find broad acceptance.

According to Prof. Berger, hybrid intelligence holds the key to solving some of the most pressing issues in agriculture. "The prospects are very promising, but there is still a need for fundamental research in order to

successfully develop this technology further and then implement it. To achieve this, we need the cooperation of all stakeholders from science, practice, and society."

More information: T. Berger et al, Hybrid intelligence for reconciling biodiversity and productivity in agriculture, *Nature Food* (2024). DOI: 10.1038/s43016-024-00963-6.
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