Agroecological TRANSITIONS Programme

POLICY BRIEF

MARCH 2023

Digital tools for supporting climate-informed agroecological transition in beef production in Brazil

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KEY MESSAGES

- Despite many available digital tools in the digital ecosystem, many neglect smallholders' ranching. Also, they focus solely on performance indicators, lacking climate-informed agroecological features.
- Mitigation features are included only by performance assessment tools, although only by half of them.
- Adaptation features in digital tools include mitigation recommendations, access to pest and disease information or early warning, and product diversification.
- Of the digital tools providing performance assessment (6 total), all include agroecological principles, three included adaptation, and all mitigation indicators on average per tool.
- Social inclusion and co-design features are related to data protection for farmers, direct farmer contributions (on the improvement of the digital tools), and safety measures, especially amongst women.
- Tools with socially inclusive communication features are limited. Most of the tools reviewed here have more than one way of engaging farm users (IVR, SMS, etc.), and allow the integration of other tools.

Digital tools in agriculture are becoming increasingly important. Digital tools' growth, both in number and functions, can be attributed to the development of new technologies (e.g., offline functions and more accessible app interfaces) and the scope of the digital ecosystem. A growing number of digital tools are focused on supporting farmers' decision making by encouraging them to report production data.

Many agricultural digital tools do not focus on climate change or agroecology, are not reaching smallholder farmers, or their features are solely focused on farm management (Eichler Inwood and Dale, 2019). They generally lack the technical content needed to support practice change related to climate change mitigation and adaptation.

Agroecology can support climate change adaptation and mitigation outcomes most directly by promoting resilience, diversification, efficiency, synergies, circular economy, recycling, and co-creation (Andrieu and Kebede, 2020; Snapp et al., 2021). The agroecological principles can thus be a useful proxy to further assess climate change adaptation or mitigation outcomes that may not be an explicit function of a digital tool.

Smallholders – the majority of the world's farmers – are particularly disenfranchised in the equitable access to digital tools due to a lack of focus and investment for this group of farmers. The initiatives focused on this segment of users are related to virtual stores and strengthening the relationship between farmers and customers (Emmanuel et al., 2010).

To make agricultural digital tools inclusive for smallholders, several underlying factors need to be addressed, such as equity and equality of access to technology, electricity, and mobile networks (Garba, 2019). Gender, age, education, and wealth are additional factors that further influence the adoption of, or lack thereof, digital tools.

About 85% of Brazilian farms have access to a mobile phone, while sufficient rural connectivity is present on only 40.3% of the farms (Puntel et al., 2022). Mobile phone connectivity has yet to reach critical mass in many low-and-

middle-income countries (LMICs) (GSMA, 2021). In Brazil, only 28% of the small farms (< 50 hectares) use the internet (IBGE, 2017), and have a slower internet service compared to larger farms (Mehrabi et al., 2021).

The use of digital tools can benefit farmers by supporting decision making, acting as a mechanism to anticipate climate risks, or as a financial management application. At the same time, the data management and flow of information generated by the various tools can be used for scientific purposes, empowering research and amplifying its reach. A new generation of models that are better and more adapted to actors' needs in rural areas, especially when focused on sustainable practices, should include the main stakeholder in co-development: the farmer.

In this context, the EU-IFAD Agroecological TRANSITIONS Program's project on Inclusive Digital Tools (ATDT) aims to support the use of digital resources and citizen science to empower farmers to co-create, adapt, and innovate in practices for climate-resilient and low-emission agroecological outcomes at large scales in LMICs. A key component of this project is to map and understand the ecosystem of digital tools available to farmers and to engage with tool developers and users in the design of a roadmap for improving the co-creation of knowledge through best practice principles for inclusive digital tools. In Brazil, this project is focused on the beef cattle sector in the Amazon region, specifically in the Pará and Mato Grosso states, which have the largest cattle herds (~36 million heads), greenhouse gas (GHG) emissions (~130 million tCO_2e) and smallholder cattle ranchers (~100,000 farms) in the country (SEEG, 2022; IBGE, 2021).

To gain insight into the state of digital tools for climate-resilient and low-emission smallholders beef production in Brazil, this work seeks to address two fundamental questions:

1. How well do available digital tools support agroecology and climate change mitigation or adaptation outcomes?
2. How inclusive are current digital tools in supporting smallholders to co-create farming solutions?

To answer these questions, we identified 33 digital tools through expert interviews and platforms (e.g., MyAgriHub) and web searches with a focus on Pará and Mato Grosso state, Brazil. Keywords such as "cattle ranchers", "Pará", and "Mato Grosso" were used in the web search. We narrowed down this group to 15 digital tools applying secondary filters such as "performance assessment", "technical advisory", "reach of the tool", and "smallholder farmers" (Table 1). Digital tools were characterized based on information available online, 15 of the 33 initial tools had available online information. Selected tools were reviewed against 87 indicators developed by the ATDT team according to the methodology proposed by Dittmer et al., 2022. The response of a given indicator was recorded in a semi-quantitative way. Digital tools were compared based on the frequency of "yes" responses, assessing the completeness based on each group of indicators (e.g., climate change, agroecological principles, tech specs, social inclusion, and co-creation).

We define digital tools as an application, online resource (not a platform), or other software available on a digital device such as a cell phone, smartphone, computer, or tablet—including tools based on text, audio, and visual components. The World Bank (2013) defines social inclusion as "the process of improving the terms on which individuals and groups take part in society—improving the ability, opportunity, and dignity of those disadvantaged on the basis of their identity." In this context, marginalized or underrepresented groups must be included in the decision-making process for the development and improvement of the tools. In any case, the need for smallholders to fully engage with a digital tool must be understood.

Table 1: Selected digital tools with climate change adaptation or mitigation outcomes and their function. GIPS = sustainable livestock indicators guide.

Digital Tool	Simplified Function
@Fazenda	Management system for farms focused on controlling productive information
Agrolite	Remote farm management
Agrotag	Monitors GHG emissions reductions in agriculture and livestock
BovExo	A tool focused on planning, performance management, and opportunity analysis
Br Corte	System of nutritional requirements for beef cattle adapted to tropical conditions
Esteio Gestão	Herd and financial management of the farms
Extension Solutions (Solidaridad)	Increase the efficiency of technical assistance and rural extension
Farmin	App for field notes and beef cattle management
GHG Protocol	GHG calculator for estimating emissions associated to on-farm production
GIPS	Measurement and recommendations on sustainable livestock systems

IDH – Produção sustentável de bezerros	Improve the productive dynamics of livestock systems in economic, environmental, and social aspects
Intergado	Precision livestock system (connectivity with equipment)
LeiGado	Management system for dairy and beef cattle farms
Semper Corte	Farm management recommendations
SISATEG	Farm management tool focused on decision-making for farmers and technicians

How well do digital tools support agroecology, adaptation, and mitigation functions?

Gaining access to reliable and localized weather information has become invaluable to smallholders in LMICs given the increasing unpredictability of weather events due to climate change. In Brazil, the adoption of climate-smart production practices such as water and food storage, rotation and pasture recovery, and animal management proved to increase the average milk production for smallholders in the semi-arid region by 10% (Gori Maia et al., 2022). It is easy to understand why digital tools focused on weather forecasts have more acceptance and ease of use when a simpler map interface is applied (Romani et al., 2015).

The 15 digital tools reviewed in this study provide performance assessment or technical advisory for beef production. The majority of these selected tools focus on the farming system's financial or herd management. Few tools focus on climate-informed agroecological transitions, especially for smallholders, even when the digital tool has a technical advisory function. The main features of the 15 digital tools are provided below (Figure 1).

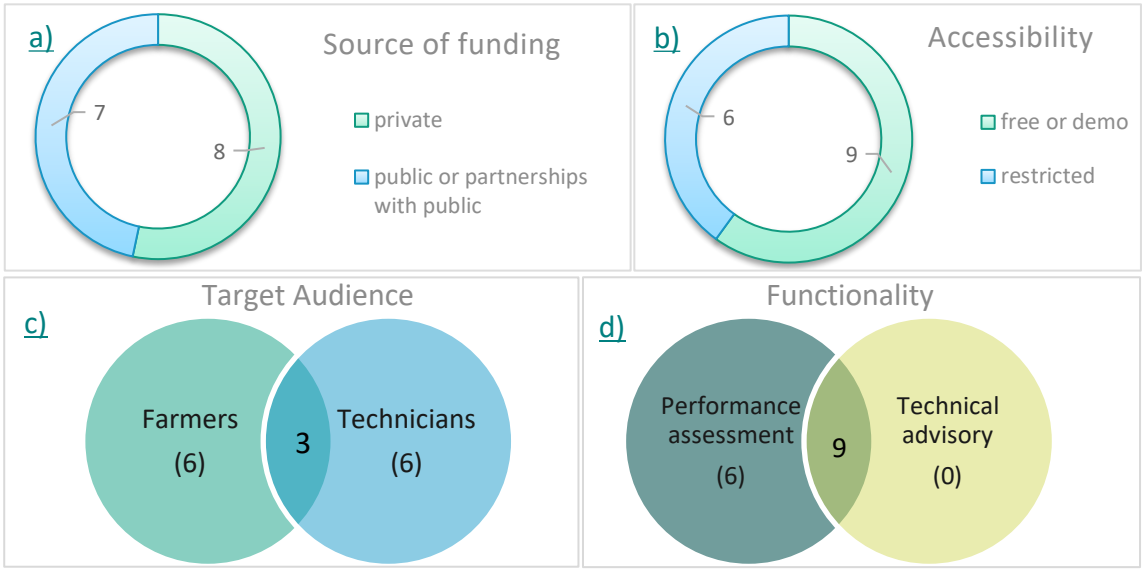

Figure 1: Distribution of tools by a) Source of funding, b) Accessibility, c) Target audience, and Separation of the tools according to its d) Functionality (n = 15).

Digital tools with technical assistance and performance assessment

Only three digital tools provide performance assessments on climate change, while most digital tools focus on technical recommendations for system productivity more broadly. The climate change functions available within the reviewed digital tools are presented in Figure 2.

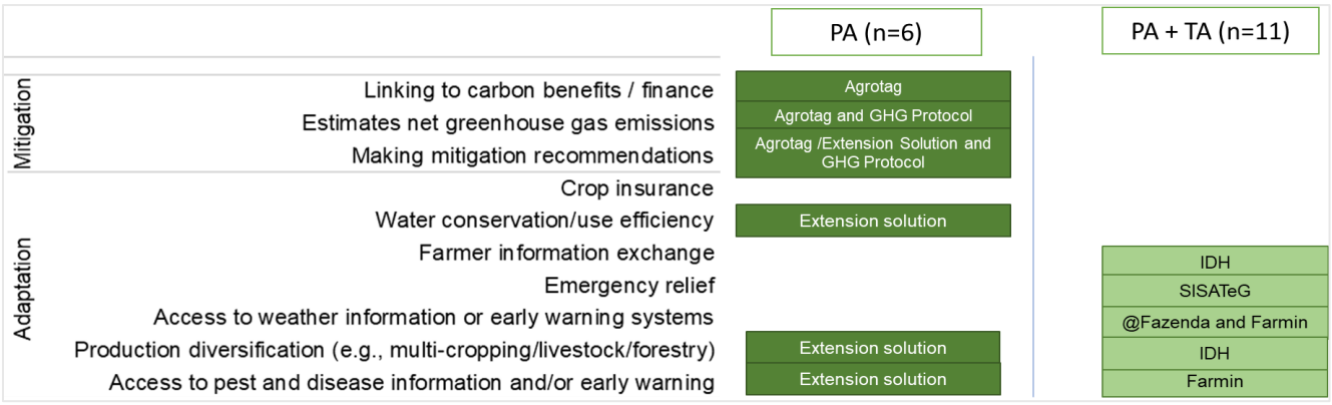

Figure 2: Frequency of digital tools providing on-farm performance assessment (PA) and technical advisory (TA) with PA for climate change mitigation or adaptation (n=15).

Adaptation was only covered within four digital tools that provide both technical assistance and performance assessment, and in one tool that provides performance assessment (Figure 2). The digital tools with the most adaptation features were Extension Solution (3), IDH (2) and Farmin (2). Only performance assessment digital tools included specific mitigation features. These digital tools included one calculator for estimating GHG emissions (GHG Protocol), and one GHG monitoring tool based on satellite images (Agrotag) (Box 1).

The link to carbon benefits and finance focuses on understanding the carbon flows in systems focused on beef cattle for smallholders. Evaluating these carbon flows can benefit the farmer by mitigating GHG emissions (seeking negative carbon balances, or greater removal than emission) and financial compensation for good agricultural practices. Agrotag is the only tool that includes this feature.

Mitigation recommendations were found in three digital tools and focus on providing technical suggestions to reduce farmers' GHG emissions. Those suggestions include the adoption of a no-tillage system, adequate pasture management (which directly impacts the carbon balance), adoption of complex production systems (e.g., silvopastoral systems), and best land management practices, among other technical advice.

Box 1. Estimating GHGs with GHG Protocol & Agrotag tools

The GHG Protocol calculator accounts for the contribution of trees on farms, land use change, livestock and pasture, and soil and nutrient management. Both the calculator and GHG monitor included food loss and waste emissions estimates. Their scope includes the farm-level estimates but does not include the entire value chain. Neither automatically establish an emission baseline with the scenario under the implemented practices, hence both scenarios need to be included in the tool to get results.

GHG Protocol gives users the possibility to use their own emission factors to estimate emissions from land-use change and herd structure (enteric fermentation). Agrotag also provides mitigation recommendations for land use change and links users to carbon benefits (diagnosis of the rural area, especially for decision-makers in the orientation of public policies).

Although both tools can estimate the GHG balance on farms, neither automatically assigns a baseline. Therefore, to compare changes in production systems, the farmer needs to create an alternative scenario to achieve the expected result.

Digital tools featuring agroecological principles

None of the reviewed digital tools covered all 12 agroecological principles[1] (Figure 3). Only six digital tools focused on performance assessment included agroecological principles, capturing six principles on average. Among those, the highest number of principles was found in IDH (10), Agrotag (9), Extension Solutions (9), and GIPS (9).

IDH also promotes agroecological principles and rural development through *in-loco* (and in-person) advisory for farmers. The technical advisory is centered on developing improved farming systems and the implementation of cattle ranchers' practices such as pasture management, the best use of fertilizers, paddock sizing, and agri-social questions.

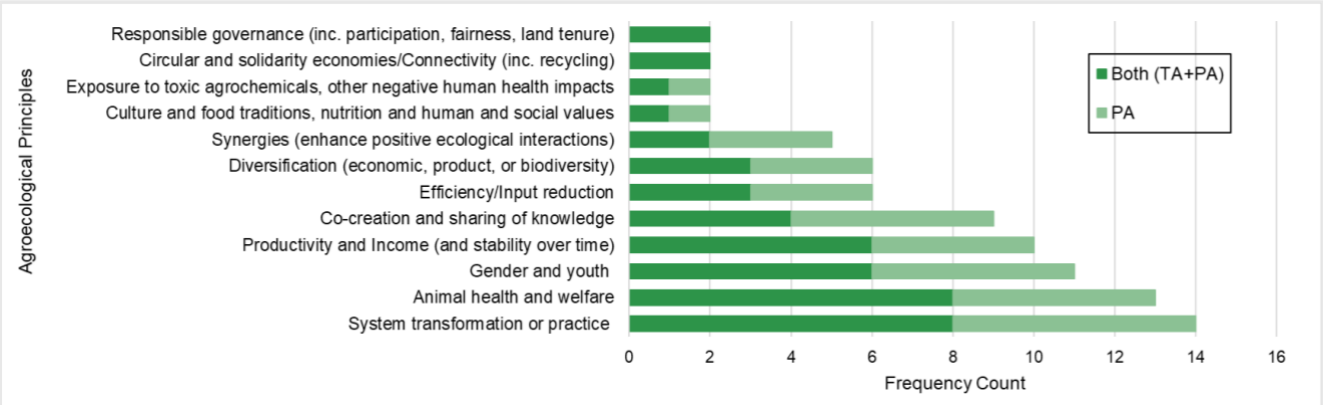

Figure 3: Frequency of digital tools providing on-farm PA or both TA and PA for agroecological principles (n=15).

[1] Adopted and refined from the FAO 10 Elements of Agroecology and HLPE (2019).

Tool features for social inclusion and co-creation

Expert interviews showed that dependency on physical devices and a constant internet connection are understood as barriers to digital tool uptake. The high access (85%) of farmers to mobile phones points out how this device may be the best way to engage smallholders in the Pará and Mato Grosso states.

The main technical characteristics of connectivity and device requirements of digital tools are presented in Figure 4. In most cases, a computer is not a requirement as the information could be accessed from tablets and smartphones. Information on internet connection requirements is incomplete, with almost a third of the digital tools not reporting on it. When available, the data showed that Farmin, Semper Corte, LeiGado, Intergado, and GHG Protocol digital tools do not rely on an internet connection at all, while Esteio Gestão, Agrolite, Extension Solution, GIPS, IDH, and SISATEG need internet for specific tasks but not continuously.

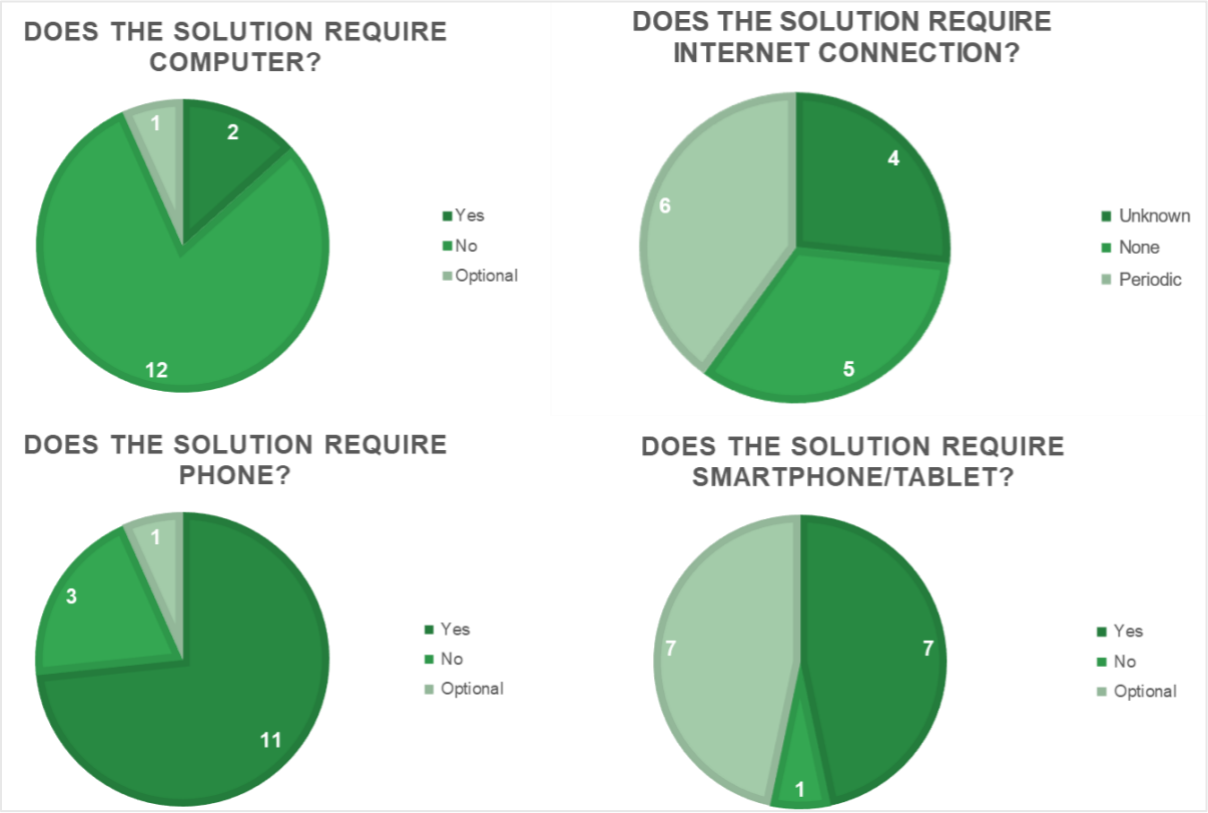

Figure 4: Subset of technological specifications of digital tools (n=15).

Tool features that improve farmer communication and engagement include iconography, short messaging service (SMS), interactive voice response (IVR), and video or non-IVR audio (Table 2). Features comprising two-way communication are more supportive of farmers' inclusion. Multiple channels of communication are integrated by most of the digital tools, which also allows integration with other tools, bringing additional layers of connectivity to the digital ecosystem.

Table 2: Digital tool features that aid in promoting social inclusion and co-creation, their use, and digital tools featuring them (n=15).

Tools	Feature	Use	Digital tools integrating the feature
1	IVR	Deliver recommendations in an accessible way with option to engage	Intergado*
6	Iconography	Provide opportunity for interaction without farmer literacy	Agrotag*, Semper Corte+, Agrolite+, Intergado*, GIPS*, IDH+
2	Video/non-IVR audio	Deliver recommendations to illiterate farmers, often from other farmers	Agrolite*, Extension Solution*
9	SMS	Cheap text communication farmers can read at any time	@Fazenda+, Farmin+, BrCorte+, Esteio Gestão*, Agrotag*, Agrolite+, Intergado*, Extension Solution*, IDH+
9	Multiple features	A combination of the above features	@Fazenda+, Farmin+, BrCorte+, Esteio Gestão*, Agrotag*, Agrolite+, Intergado*, Extension Solution*, Semper Corte+, DH+

* PA tools; + PA+TA tools.

Few tools were designed via a participatory approach (20%) or include citizen science (27%). Most tools allowed for direct farmer contributions (i.e., farmer-driven content) and ensured user security, especially amongst women and other underrepresented groups (80%, respectively). Only one tool did not specify whether farmers control or retain ownership of their personal data (Figure 5).

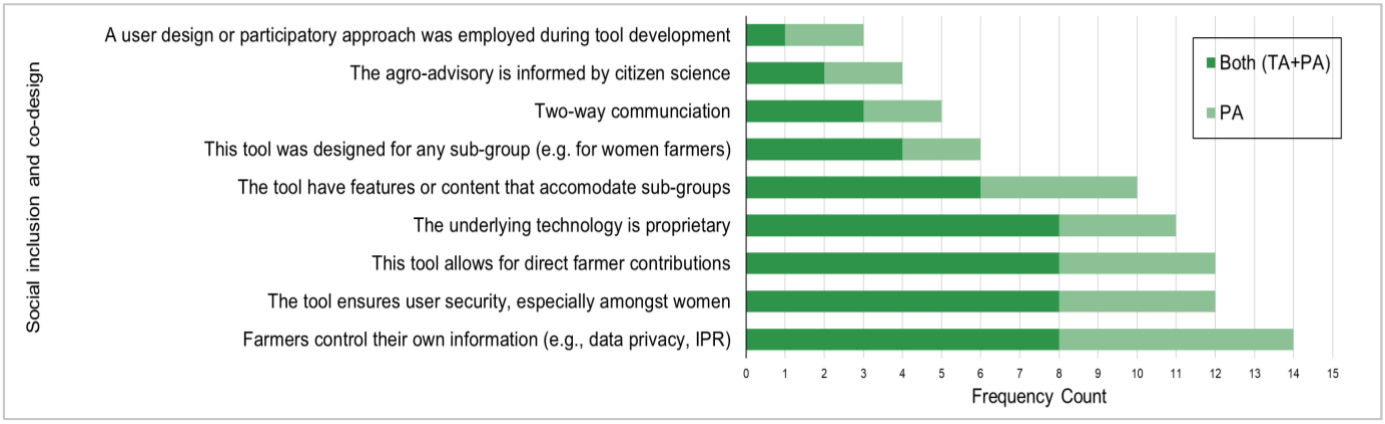

Figure 5: Frequency count of digital tools that on-farm PA, or both TA and PA that promote social inclusion and co-design (n=15).

Main findings

Our findings allowed us to map and have a better understanding of the digital ecosystem regarding agroecological transitions in Brazil's livestock systems. Despite the availability of many digital tools designed for the sector, few focus on practices that are considered less harmful to the environment. The evolution of methodologies that can support a shift toward climate-informed agroecological transitions is essential and requires further attention.

Although many initiatives are focused on technical assistance to cattle ranchers (generating indicators for decision-making), digital tools still need to be improved before they can adequately complement in-person consultancy. This review highlights a gap in the number of climate change adaptation and mitigation features, or associated co-benefits, for digital tools related to smallholder beef production in Brazil. Digital tool features that promote social inclusion and co-design were generally well captured.

A common starting point for digital tools focused on farming systems remains crucial as digital tools do not yet focus on how to improve both productivity and farm management while mitigating and adapting to climate change. Opportunities to foster farmer and expert co-designing solutions tailored to farmers' priorities and capacities can be provided by introducing human intermediaries, such as hotlines and coaching services in the communication between the parties. Farmers' participation in the development of new versions of digital tools should be central to the iterative process.

Recommendations

Based on this review, we suggest taking the following considerations into account:

- **Farmers as key advisors** in the development of innovative solutions. Seek advice from the final users to understand the complexities and the major gaps of the existing tools (learn from the experience with other tools).
- **Permanent network for feedback and improvements** to connect farmers to developers for a continued loop of feedback based on user results and experiences. This can be achieved through human intermediaries as a channel between the parties.
- **Improve easy access** to technical advisory addressing adaptation and mitigation strategies. This includes incorporating communication features commonly used by the target users to share information and results in a practical and easily understandable way.
- **Use citizen science and a user-centered design approach** to ensure users obtain relevant content and co-design farming solutions.

- **Build bridges** between digital tool features and other solutions focused on reaching a more comprehensive digital ecosystem. This includes providing features to incentivize farmers to utilize digital tools, e.g., integrate agroecological or mitigation features to bank apps aiming to facilitate access to credit.
- **Strengthening donors' requirements** by requesting further integration of agroecological and climate change indicators that support digital tools development is key to ensuring the evolution of the agribusiness sector on climate change while allowing more farmers to contribute to these outcomes.

Further reading

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The Agroecological Transitions for Building Resilient, Inclusive, Agricultural and Food Systems (TRANSITIONS) Program aims to enable agroecological transitions. The TRANSITIONS Inclusive Digital Tools (ATDT) project aims to support the use of digital resources and citizen science to empower farmers to co-create, adapt, and innovate practices for climate-resilient and low-emission agroecological outcomes at large scales. In the Brazil site, the focus is on leveraging inclusive digital resources and citizen science to stimulate the beef cattle chain in Brazil to create, adapt and innovate production practices based on agroecological principles.

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***Please cite**: Heissler, G.H., Lazarri, H.E., de Souza, P.B., Costa, A.C., Silveira, R.F., Dittmer, K.M., Suber, M., Micollis, A., Terra, M., Angioni, C., Costa Jr, C. 2022. Digital tools for supporting climate-informed agroecological transition in beef production in Brazil. Cali, Colombia: Alliance of Bioversity & CIAT.*

About Agroecological TRANSITIONS Policy Briefs

The *Agroecological transitions for building resilient and inclusive agricultural and food systems* (TRANSITIONS) program is funded by the European Union through its DeSIRA initiative and managed by the International Fund for Agricultural Development (IFAD).

Funded by: Managed by: Implemented by: