Agroecological TRANSITIONS Programme

POLICY BRIEF

DECEMBER 2022

Digital tools for climate change adaptation and mitigation

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KEY MESSAGES

- Digital tool functions for agricultural technical advice and performance assessment related to climate change adaptation and mitigation are limited.
- Tools for technical advice provided functions related to climate change adaptation more often than mitigation. Yet most tools (92%) addressed three or fewer climate change adaptation indicators.
- Technical advice with access to weather information or early warning systems for hazardous weather was the most common function of the tools analyzed.
- Performance assessment tools were predominantly GHG emission calculators.
- Features for inclusive communication with tool users (e.g., iconography, video or audio messages) included messaging (31% of tools) and voice and video (28%).
- Exemplary tool features for climate change adaptation and mitigation should inform future digital tool development for agriculture and food systems.
- Tools that provide coaching functions and support farmer input enable farmers to weigh the trade-offs of their decisions and add context on how to achieve and sustain change.
- Achieving scale for climate-informed digital tools does not just mean increasing farmers' access to tools, but also supporting action recommendations in tools and identifying priority, large-scale impacts in terms of the level of climate risk mitigated and resilience built, or climate change mitigation achieved.

Digital tools to support climate change action

Digital tools to support farmer innovation are becoming more widespread. At the same time, farmers are increasingly feeling the effects of climate change and the demand for climate change adaptation and mitigation in agriculture is growing. Digital tools can play a role in scaling up practices, yet digital tools for agriculture often lack the technical content needed to support practices related to climate change. In addition, many smallholder farmers lack access to digital technology, electricity or mobile networks in low- and middle-income countries (LMICs), limiting digital tool's impacts. For example, only 28% of the population in Sub-Saharan Africa use mobile internet (GSMA, 2021). Smallholders generally have slower internet services than larger farms even when they do have access (Mehrabi et al., 2021).

To gain insight on the state of digital tools for scaling up climate-resilient and low-emissions agriculture, this brief sets out to answer two questions:

1. How well do available digital tools for agriculture support climate change mitigation or adaptation functions?
2. To what extent do digital tool features support inclusion for smallholder farmers by enabling farmers' input and communication about climate change practices in agriculture?

To answer these questions, we identified digital tools that provide technical advice and performance assessment and reviewed their features related to climate change adaptation and mitigation in agriculture and food systems. We identified 39 tools based on web searches, expert interviews and platforms such as the CGIAR Evidence Clearing House and Digital Agri Hub. We relied primarily on

information available online. Tools were classified as technical advisory resources if their primary function was to deliver recommendations regarding farming practices and as performance assessment if their primary function was to report on farm outcomes, status or operations. See Dittmer et al. (2022) for an in-depth description of the methodology.

How well do digital tools support climate change adaptation or mitigation functions?

Our review identified 39 digital tools that addressed climate change mitigation or adaptation related to technical advice or on-farm performance assessment (Table 1). Although we included all relevant tools identified in our search and interviews, this set of tools should be considered a sample, as some tools are not publicly available online.

Among the 39 digital tools reviewed in this study, 24 provided technical advice, 11 provided on-farm performance assessment and four provided both technical advice and performance assessment on climate change adaptation or mitigation. Twenty-three (59%) were initiatives of private companies. Over two-thirds of the tools were free or had free versions available.

Technical advisory digital tools

Tools for technical advice more commonly supported climate change adaptation than mitigation. The most common tool function related to climate change was access to weather and climate information or early warning systems for hazardous weather-related events (58%). Farmer information exchange (46%) was the second most common function for technical advisory tools, followed by water conservation or use efficiency (33%). Our review did not find any technical advisory tools related to emergency relief and only two tools provided access to crop insurance (Figure 1), which suggests a gap in climate change safety net functions in digital tools. Technical advisory tools did not necessarily inform users about priority actions for scaling impacts or the significance of the level of mitigation and adaptation impacts.

Only one technical advisory tool (FarmBetter) addressed climate change mitigation (Figure 1), indicating another major gap. Mitigation functions were more commonly found in performance assessment tools (See Performance assessment digital tools below).

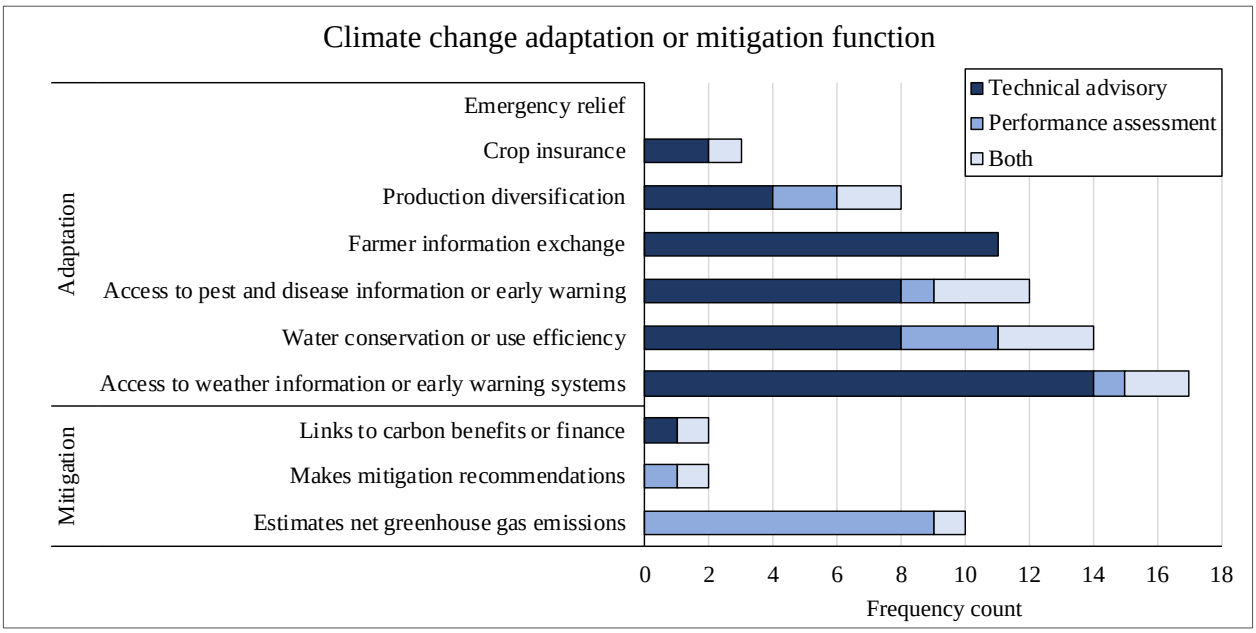

Figure 1: Number of digital tools that provide climate change mitigation or adaptation technical advice, on-farm performance assessment, or both (n=39).

Examples of exemplary features for tools that provided technical advice for climate change adaptation included delivering advisories through short messaging service (SMS) in local languages (Sowing App); artificial intelligence providing agroclimatic forecasts via WhatsApp, Facebook and Telegram (Melisa chatbot); or automated 24/7 hotlines or call centers (DigiFarm, Ushari) for farmers to receive timely and tailored advice regarding specific topics. It was also common for digital technical advisories to accommodate farmers with limited literacy by incorporating features such as iconography (Plantvillage Nuru, Esoko, Farming Solution, FarmBetter, iShamba,

Climate FarmRise), or videos or audio messages (Digital Green, Esoko, AgriApp, Plantvillage Nuru, Farming Solution, AgriExt App, Access Agriculture).

Tools that allowed farmers to exchange information were also considered exemplary as they enabled peer-to-peer learning, exchange of context-specific information and knowledge sharing. Examples of such tools included videos produced and disseminated by the community allowed farmers to share knowledge with one another in local languages and have ownership of their knowledge (Digital Green and Access Agriculture), two-way communication between farmers and extension services via voice messages (Ushari), or a free hotline that leveraged previous farmer-caller data (customer journey, location, agronomic context as well as their profile including gender) to provide timely information for farmers (CubicA).

Performance assessment digital tools

The most common performance assessment tools related to climate change were calculators for greenhouse gas (GHG) emissions. Calculators varied in the sources of emissions they covered. The most common sources of emissions covered among calculators were rice production, land use change and energy use. Only one tool calculated GHG emissions for food loss and waste (ACE). Calculators were almost evenly split between estimating emissions at the farm or landscape level, and the value chain. One performance assessment tool provided mitigation recommendations, assessed water conservation or use efficiency and pest or disease outbreaks, and will link users to carbon payments in future development (Extension Solution). Performance assessment tools did not necessarily inform users about priority actions for scaling impacts or the significance of the level of mitigation and adaptation impacts.

Exemplary features for GHG calculators included the ability for users to input their own emission factors (i.e., Tier 2 or 3); comprehensive Scope 1, 2 and 3 reporting for value chain products; complete accounting of significant GHG sources and sinks; minimized data needs for estimating GHG emissions; bundling of technical advice with performance assessment; data visualization in the tool or a downloadable report (Cool Farm Tool, CF-Rice, geoFootprint, Terra-I, EX-ACT, EX-ACT VC); and modeling different interventions to reduce adverse environmental footprints (geoFootprint). Only two tools (EX-ACT VC, AtSource) included analysis of multiple indicators related to environmental and social sustainability. More than half of the calculators determined a change in emissions based on comparison with a reference scenario.

Exemplary features for performance assessment tools that might be improved and used in digital tools more often in the future are

1. comprehensive assessment of food security and sustainability indicators,
2. agri-intelligence services or “watch dog” functions to alert decision makers about deforestation or other negative impacts,
3. functions for linking payments or finance to assessment of avoided emissions or sequestered carbon, and
4. recommendations for mitigation practices in performance assessment tools.

We found only four performance assessment tools with climate change adaptation functions (Mergdata, Carbon Benefits Project Toolkit, Extension Solution, AtSource). Three tools assessed water conservation or use efficiency (27%), two tools assessed product diversification (18%) and one tool had pest and disease information or early warning systems for pest and disease outbreaks (9%).

Technical advisory and performance assessment digital tools

Most tools that provided both technical advisory and performance assessment covered a wider range of climate change adaptation functions. One tool (SmartFarm) covered five of the seven adaptation functions (access to weather information or early warning systems, production diversification, crop insurance, water conservation or use efficiency, access to pest and disease information or early warning) and one mitigation function (linking to carbon benefits or finance). Other tools (Cool Farm Tool, DataGreen, Sustainable Coffee Verification) covered two to three adaptation functions and up to one mitigation function.

The Cool Farm Tool was exemplary for its farmer and sustainability focus, orientation towards action, and interactive functions. The tool began as an on-farm GHG calculator in Excel but was adapted for the web and now includes modules for measuring water footprint, soil carbon and biodiversity management using robust

quantification methods responsive to farm- and field-scale management decisions. The tool enables minimal data entry and supports farmers, the primary user, to enter their farm characteristics and get immediate results and feedback on the impact of different farm management decisions using "what-if" scenarios. This was one of only two tools that explicitly stated that users retain ownership of their assessment and personal data.

What information are farmers receiving?

Twenty-five of the 39 tools (65%) identified farmers as either the sole end-user or as one of the end-users. Most were technical advice tools (22). Only three provided farmer-facing performance assessment. The primary function of most (17) of the twenty-five tools was weather information or early warning systems for hazardous weather-related events. Gaining access to reliable and localized weather information has become increasingly important for smallholders in LMICs given the unpredictability of weather events due to climate change. A study in Colombia, for example, found SMS weather information services enabled smallholders to reduce crop losses by 11-14% (Camacho and Conover, 2019). In Ghana, a digital agronomy, and weather advisory service providing time-sensitive information helped farmers adapt to changing rainfall patterns (Barnett et al., 2019).

Aside from access to weather information or early warning systems, farmers were also using digital tools with functions related to agro-advisory services, farmer learning, and farm management. Such services included climate-related agronomic advice (e.g., diagnosing crop diseases, information on optimal use of fertilizers, water harvesting techniques, etc.), market price information, market linkages and insurance coverage through local languages and features including SMS, voice SMS, interactive voice response (IVR), call centers and community videos.

Farmers are more likely to use tools that provide clear benefits and reflect a strong understanding of the context in which they are working (Rose et al., 2016). Digital tool functions that provide value to farmers included improved income; digital inputs layaway; e-extension services through video recordings, the web and smartphone applications. Tools that reflect a strong understanding of local context often involve farmers' peers or trusted contacts. For example, Digital Green Community Videos have been highly successful in part because of the inclusion of local farmers and extension officers in the instructional videos, which creates a sense of trust in, ownership of, and familiarity with the delivered content. Involving human intermediaries such as hotlines and coaching services linked to tools provide opportunities for farmers and experts to interact and design solutions best suited to farmers' needs.

Climate change tools and agroecological principles

Climate change tools generally did not support functions related to agroecology, as indicated by the Food and Agriculture Organization's ten elements of agroecology. Only one tool (Access Agriculture) captured a substantial number of agroecology functions (12). Ten tools did not cover any agroecological functions. The most common adaptation function for tools that included agroecology practices was information or assessment on water conservation or use efficiency, followed by production diversification and pest and disease information or early warning. About half of these tools have farmers as the primary end-user.

Productivity, income, and their stability over time were the most frequently represented function (60%), followed by efficiency or input reduction (43%), co-creation and sharing of knowledge or farmer relevant content (40%) and system transformation or practice (35%). Synergies (i.e., enhancing positive ecological interactions), circular and solidarity economies and responsible governance were the least represented agroecological function (13%, respectively).

Recommendations

There is an opportunity to improve climate change digital tools and to enhance the access and usability features of these digital tools for smallholder farmers in LMICs. Based on this review, we suggest to:

- Support exemplary features for climate change adaptation and mitigation in digital tool development for agriculture and food systems, considering the tools' objectives and contextual needs of farmers.
- Address gaps by improving the number of digital tools that provide technical advice for safety nets and climate change mitigation, and farmer-facing performance assessment tools.

- Bundle technical advice and performance assessment to encourage farmer action and adaptive management. For example, bundle functions that provide recommendations for farmer action with weather information, early warning systems or GHG estimates.
- Localize technical advice or performance assessment through farmer input.
- Develop "coaching" tools so farmers can weigh the trade-offs of their decisions and add context on how to achieve and sustain change.
- Design digital tools for scale. Achieving scale for climate-informed digital tools does not just mean increasing farmers' access to tools, but also supporting action recommendations in tools and identifying priority, large-scale impacts in terms of the level of climate risk mitigated and resilience built, or climate change mitigation achieved.

Digital tools for climate change are in an early stage of development. This analysis identified exemplary features of climate change tools that should be considered in future tool development. For digital tools to help scale up resilience to climate change—especially among smallholder farmers—and reduce emissions from agriculture, a wider understanding of potential exemplary features can enable farmers to get the technical information they need and demonstrate performance that can enable learning and access to additional benefits.

Table 1: Selected digital tools with climate change adaptation or mitigation outcomes and their function. GHG = greenhouse gas. SDGs = Sustainable Development Goals. AFOLU = agriculture, forestry and other land use. IVR = interactive voice response. SMS = short messaging service. AI = artificial intelligence.

Digital Tool	Function(s) & Exemplary feature(s)
Access Agriculture	Farmer-to-farmer training videos with agroecological principles applied. Translation of videos to local languages upon request. Farmer information exchange on topics such as production diversification, water conservation and pest/disease management.
ACE	Pre- and post-harvest GHG calculator for estimating emissions associated to a food product. Combines a calculation framework with datasets containing crops GHG intensities and food loss factors along the value chain.
AgriApp	Crop advisory, soil testing, drone services, crop practice advice, market access. Expert hotline for crop production, yield protection and climate-smart farming.
AgriExt App	Information and advice on crop or livestock management, good agricultural practices, sanitary and phytosanitary measures. Online assistance for locally adapted agricultural advice or extension services on demand.
AtSource	Traceability, carbon and water footprint calculator. Environmental footprint calculator is founded on Life Cycle Assessment methodology. Monitors nine core sustainability topics related to 12 SDGs.
BharatAgri	Personalized crop calendar, weather based advisory, crop advisory. Soil health reports printed and sent to farmers. Timely notifications on the preventive steps to be taken at the farm based on the weather conditions.
Carbon Benefits Project ToolKit	AFOLU carbon stock and GHG emission assessment. Simple (minimal data requirements) or detailed assessment.
CF-Rice	Calculator for carbon footprints of rice products. Comprehensive breakdown of emissions by cultivation and harvest & post-harvest. Excel or web-based.
Clima y cafe - Cafenica Prognostico	Early warning system, decision support, farm data collection. Alerts and recommendations on crop management, pest and disease prevention/control. Focus on family inclusion and protagonism of young people and women.
Climate FarmRise	Agronomic information and advice relevant to smallholder farmers. Farmer-to-farmer chat. Agricultural news and event information to educate farmers on industry developments and opportunities.
Cool Farm Tool	Online GHG, biodiversity and water calculator for farmers. Provides growers the ability to plug in their farm characteristics and get immediate results and feedback on the impact of different farming management options. Crop-specific or whole-farm assessment. Downloadable assessment results as a PDF.
CubicA	Agricultural advisory via free hotline or IVR. Field-level human-centered design. Advisory in local languages and on any mobile device. Internet connection not required.
DataGreen	Traceability, farm data management, certification, monitoring & evaluation. Farmer advisory services via audio or SMS. Offline mode. Geo-referencing capability. Customizable for unique needs.

DigiFarm	Access to quality farm inputs, input loans, learning content (crop and livestock), market access. Insurance yield cover and extension services through remote agronomists (call center or on ground advisors). Learning content available via app or SMS.
Digital Green (Community Videos)	Farming videos made by the community to share knowledge with one another. Illiteracy sensitive. Option to provide feedback about videos.
Sustainable Coffee Verification	Sustainability practice assessment (social, environmental and economic) and technical assistance for the coffee value chain. Provides producers with free verification of their sustainability practices.
Esoko	Weather information, early warning systems, climate-smart agronomic advice and crop protocols, market price information, market linkages and insurance coverage. Customizable announcements and reminders. Content delivered via SMS, voice SMS, IVR or call center.
Ex-Ante Carbon-balance Tool (EX-ACT)	AFOLU GHG emissions assessment including agricultural inputs, energy, infrastructure, management of organic soils and coastal wetlands. Flexibility in input data. Well known amongst scientific communities.
Extension Solution	Field activity monitoring and management, individual farmer workplan, certification and verification. Integrated with WhatsApp for direct communication.
EX-Ante Carbon-balance Tool for value chains (EX-ACT VC)	Environmental and socio-economic performance assessment of value chains. Additional analysis opportunities on gender and youth employment engagement. Makes direct links to six SDGs indicators.
FarmBetter	Tailored farm management recommendations. Strong focus on building climate change resilience. Linked to the Carbon Benefits project and connected to WOCAT Sustainable Land Management Database.
Farming Solution	Decision support and technical assistance on diverse crops and livestock. Illiteracy sensitive (information delivered via iconography, video and audio for agricultural management practices).
geoFootprint	Geospatial analysis and interactive visualization of supply chain environmental footprints. Combines data from satellite imagery with environmental metrics. Granular visibility down to 10×10 km.
iCow	Information disseminating aimed at improving extension services. iCow library consists of over 30,000 SMS categories across all practices of smallholder production systems.
iShamba	Call center for farming tips on crop and livestock, market prices and weather updates. SMS alerts for famer trainings in the user's area.
Kenya Agricultural Observatory Platform (KAOP)	Weather forecasts, agronomic advisory, agricultural insights. Integrated advisories available via SMS or online.
Melisa chatbot	AI system providing information on agroclimatic forecasts. Available across multiple platforms (Facebook, WhatsApp, Telegram).
Mergdata	Farm data collection integrated with IVR agro-advisory (weather, farming tips and market prices. Offline mode. Voice surveys. Inbuilt features that ensure data accuracy and reduce human error. GPS enabled.
mFarmer	Farm management recommendations, farm data collection, certification. Available on Facebook's Free Basics or as a browser based mobile website. Multiple languages.
Mozare3	Reports, recommendations, market access, field visits and training programs for capacity building of small farmers. Connects small farmers to agricultural export companies via contracts.
MyAgro	Input access, agricultural training, harvest-improving agricultural techniques tailored to specific regions and crops, mobile layaway.
Plantvillage Nuru	Mobile AI assistant, with human agents available, capable of diagnosing cassava diseases.
Premium Hortus	Market access, e-commerce of organic and agroecological products. Connects consumers to smallholder produce markets.
SECTOR	GHG calculator for rice production. Flexibility in emissions- and scaling factors. Based on the IPCC Tier 2 approach
Shade Tree Advice	Decision-support for selecting tree species in agroforestry systems. Developed via participatory approach. Focus on on-farm advice regarding climate change adaptation and mitigation.
SmartFarm	Farm data management, crop advisory via SMS, certification. Customizable business intelligence dashboard and reporting.
Sowing App	Insights around soil health, fertilizer recommendations and seven-day weather forecasts using AI and crop modelling tools.
Terra-I	Near-real time monitoring system for natural vegetation conversion at pan-tropical scale. Uses satellite data and computational neural networks to detect anthropogenic changes in the vegetation cover every 16 days.
Ushauri	Agricultural advice via automated 24/7 hotline or audio content, online platform for extension agents. Two-way communication. Developed via participatory approach.

Further reading

- Barnett, I., B. Faith, B. Mitchell, and C. Sefa-Nyarko. 2019. External evaluation of mobile phone technology-based nutrition and agriculture advisory services in Africa: Mobile phones, agriculture, and nutrition in Ghana: Qualitative follow-up study report.
- Burns, S., Dittmer, K.M., Shelton, S.W., Gehan, C., Costa, C. Jr., Wollenberg, E. 2022. A review of digital tools for agroecology and climate change. Agroecological TRANSITIONS: Inclusive Digital Tools to Enable Climate-informed Agroecological Transitions (ATDT). Cali, Colombia: Alliance of Bioversity & CIAT.
- Camacho, A., and E. Conover. 2019. The impact of receiving SMS price and weather information on small scale farmers in Colombia. World Development 123: 104596. doi: 10.1016/j.worlddev.2019.06.020.
- Dittmer, K.M., S.W. Shelton, S Burns, E. Wollenberg. 2022. Global digital tool review for agroecological transitions. Harvard Dataverse, V1, doi: 10.7910/DVN/HNBKJG
- GSMA. 2021. The State of Mobile Internet Connectivity 2021.
- Mehrabi, Z., M.J. McDowell, V. Ricciardi, C. Levers, J.D. Martinez, et al. 2021. The global divide in data-driven farming. Nat Sustain 4(2): 154–160. doi: 10.1038/s41893-020-00631-0.
- Rose, D.C., W.J. Sutherland, C. Parker, M. Lobley, M. Winter, et al. 2016. Decision support tools for agriculture: Towards effective design and delivery. Agricultural Systems 149: 165–174. doi: 10.1016/j.agsy.2016.09.009.

The Agroecological Transitions for Building Resilient, Inclusive, Agricultural and Food Systems (TRANSITIONS) Program aims to enable agroecological transitions through the development and adoption of holistic metrics for food and agricultural systems performance, inclusive digital tools, and transparent private sector engagement. The 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.

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Please cite*: Dittmer, K.M., Wollenberg, E., Burns, S., Shelton, S.W. 2022. Digital tools for climate change adaptation and mitigation. Agroecological TRANSITIONS: Inclusive Digital Tools to Enable Climate-informed Agroecological Transitions (ATDT). Cali, Colombia: Alliance of Bioversity & CIAT.*

About Agroecological TRANSITIONS Policy Briefs

The *Agroecological transitions for building resilient and inclusive agricultural and food systems* (TRANSITIONS) project 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: