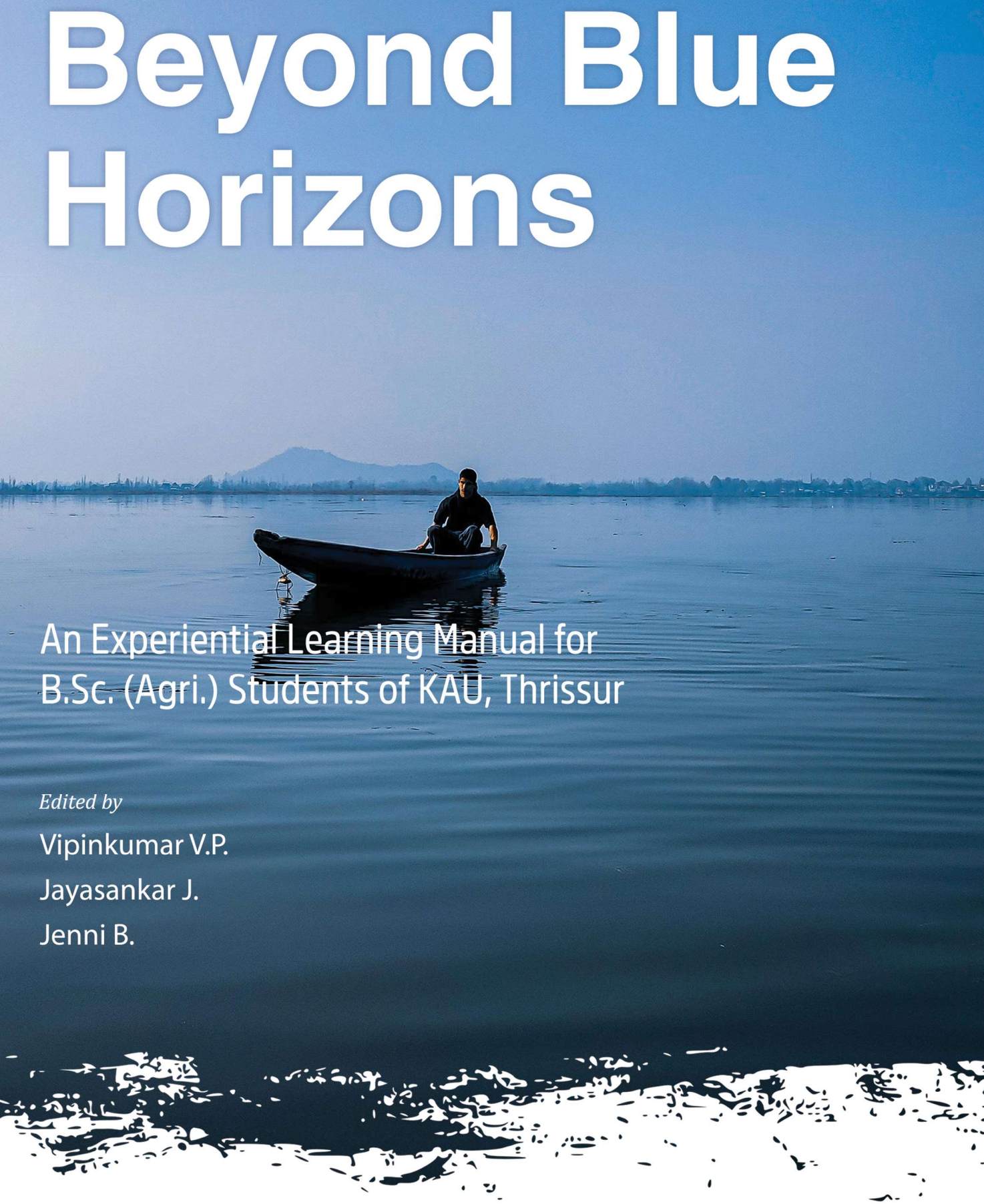
Beyond Blue Horizons



An Experiential Learning Manual for
B.Sc. (Agri.) Students of KAU, Thrissur

Edited by

Vipinkumar V.P.

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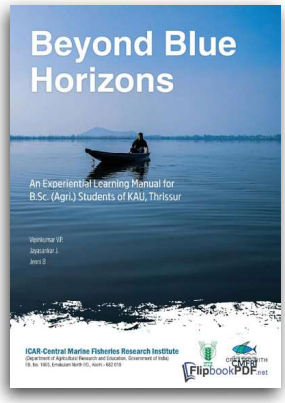

Beyond Blue Horizons
Training Manual for BSc (Agri) students of Kerala Agricultural University

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Citation:
Vipinkumar. V.P., Jayasankar J. and Jenni B. 2025. Beyond Blue Horizons: Training Manual for BSc (Agri) students of Kerala Agricultural University, ICAR-Central Marine Fisheries Research Institute, Kochi, 151p.

FOREWORD

It is with great pleasure and deep satisfaction that I present this foreword to the Training Manual of the Science Camp titled "Beyond Blue Horizons: An Experiential Training Manual for B.Sc. Agriculture Students." Conducted from July 14 to 18, 2025, at the STI Hub Digital Training Hall, ATIC, ICAR-CMFRI, Kochi, this programme exemplifies our continued commitment to innovative, experiential, and interdisciplinary learning in agriculture and allied sectors.

Organized by ICAR-Central Marine Fisheries Research Institute through its Agricultural Technology Information Centre (ATIC), the training served as a dynamic platform for B.Sc. Agriculture students from the College of Agriculture, Vellanikkara, Thrissur. The thematic focus on integrating field-based experiences with advanced laboratory analyses reflects a progressive approach to education—one that fosters a seamless continuum between knowledge generation, validation, and application. Such initiatives are vital in equipping students with the skills and perspectives required to address emerging challenges in agriculture and fisheries.

I place on record my sincere appreciation to Dr. Vipinkumar V.P., Principal Scientist and ATIC Manager, ICAR-CMFRI, for his exemplary leadership, meticulous planning, and unwavering dedication in organizing this programme. His efforts, along with those of the entire team, have ensured the successful conduct of this Science Camp, setting a high standard for future capacity-building initiatives.

The programme was thoughtfully designed to bridge the gap between theoretical understanding and practical application. It offered participants a rich blend of innovative lectures on emerging topics, hands-on training sessions, field exposure visits, and institutional interactions. The opportunity to access advanced laboratories, aquarium facilities, and the museum at CMFRI significantly enriched the learning experience. Equally important were the interactive sessions with farmers, which fostered meaningful exchanges between academia and practitioners, grounding scientific knowledge in real-world contexts.

Such experiential learning opportunities are invaluable in enabling students to appreciate the dynamic flow of information from field observations to laboratory insights, ultimately supporting informed decision-making and innovation in production systems. I am confident that the knowledge and exposure gained through this Science Camp will contribute significantly to the academic growth and professional development of the participants.

I extend my warm congratulations to all the students and faculty members who actively engaged in this programme. Your enthusiasm, curiosity, and commitment to learning are truly commendable. May this experience inspire you to strive for excellence and contribute meaningfully to the advancement of agriculture and fisheries.

I am confident that this training manual will serve as a lasting resource, capturing the essence of the programme and reflecting the collective efforts that made this initiative both impactful and memorable.

Dr. Grinson George
Director, ICAR-CMFRI
Kochi

PREFACE

It is with immense pleasure and a deep sense of fulfilment that I present this compendium, "Beyond Blue Horizons: A Training Manual for B.Sc. Agriculture Students of Kerala Agricultural University." This volume encapsulates a unique and inspiring journey of experiential learning, meticulously designed and conducted at the STI Hub Digital Training Hall, ATIC, ICAR-CMFRI, Kochi, from July 14 to 18, 2025.

Envisioned as a transformative academic engagement, this Science Camp brought together bright and inquisitive B.Sc. Agriculture students from Kerala Agricultural University, Thrissur, and guided them through a rich continuum of learning—from field-level realities to the precision of laboratory analytics. At a time when agriculture is rapidly transitioning into a data-driven and innovation-led enterprise, the programme provided a vibrant platform for students to explore the convergence of traditional knowledge systems with modern scientific advancements, with a special emphasis on the fisheries sector.

The training was thoughtfully structured to deliver an immersive and practice-oriented learning experience. Through a dynamic blend of expert lectures, hands-on sessions, field exposure visits, institutional interactions, and meaningful dialogues with farmers, participants were encouraged not only to learn but to question, analyse, and innovate. The focus was on nurturing scientific curiosity, strengthening practical competencies, and inspiring a forward-looking approach to sustainable agriculture and fisheries development.

This manual, comprising ten thoughtfully curated chapters, reflects the thematic depth and diversity of the programme. It covers a wide spectrum of subjects including integrative analytics, digital interventions, field diagnostics, and emerging marine agri-technologies. What makes this volume particularly engaging is its strong practical orientation—each chapter offers insights, methodologies, and experiences that readers can readily connect with and apply. The concluding chapter, featuring the comprehensive report prepared by the students, stands as a testament to their active engagement and the effectiveness of the experiential learning model adopted during the camp.

I place on record my sincere gratitude to Dr. J. Jayasankar, Head of the FRAEE Division, and Dr. B. Jenni, ACTO, ATIC, for their scholarly contributions, editorial excellence, and steadfast support as co-editors of this compendium. Their efforts have been instrumental in shaping this manual into a valuable and enduring academic resource.

As the Course Director and Chief Editor, I consider this compendium not merely as a documentation of an event, but as a celebration of collaborative learning and an invitation to explore the vast and promising interface between agriculture and fisheries sciences. While this endeavour represents only a beginning—a glimpse into a much larger horizon—it is my earnest hope that this volume will inspire readers to delve deeper, think innovatively, and contribute meaningfully to this evolving domain.

I warmly invite students, researchers, academicians, and practitioners to engage with the chapters that follow—rich in practical insights, field-based observations, and scientific perspectives—and to draw inspiration for future learning and innovation.

Dr. Vipinkumar V. P.
Principal Scientist & ATIC Manager
ICAR-CMFRI, Kochi

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The Future of Primary Data Collection in Socio-Economic Agricultural Surveys: Leveraging Online and Artificial Intelligence platforms

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Anuja A. R., Vipinkumar V.P. and Saju George
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The drive to strengthen agricultural systems and improve the livelihoods of smallholder farmers hinges on robust, timely, and relevant socio-economic data. Surveys of farm households and rural communities provide critical insights into livelihoods, production practices, incomes, and social dynamics in agriculture. However, the conclusions drawn from such surveys very much depend on the process involved in collecting the information. Poor data collection methods lead to erroneous results of little value to policy makers.

Traditionally, primary data in social sciences has been gathered through pen-and-paper interviews, site visits, and laborious manual recording. These conventional approaches, while methodologically rigorous, are increasingly limited by their cost, logistics, data entry errors, difficulty in reaching remote respondents and lengthy survey timeliness.

Today, multiple pressures are converging that demand a transformation in how we collect agricultural socio-economic data. On one hand, global challenges like climate change and over exploitation of resources are intensifying, requiring timelier and data-driven decision making in agriculture. On the other, rapid advances in digital technology- from ubiquitous smartphones to artificial intelligence (AI)- are opening new possibilities to gather and analyse data faster and more accurately than ever before. In an era marked by digital transformation, the integration of online and AI-driven approaches offers unparalleled opportunities for scalability, inclusivity, and actionable insight.

The Role of Socio-Economic Surveys in Agriculture

Socio-economic surveys capture information vital to understanding farmer behavior, impact of interventions, and macroeconomic trends. These surveys underpin evidence-based policy and market interventions that benefit smallholders and the broader agrifood system. Some challenges of the traditional face-to-face primary data collection include: high operational costs and logistical barriers, especially in remote regions; Data quality risks due to human errors, delayed data processing and inconsistencies and limited reach in terms of sample size and demographic inclusivity.

Digital Innovations: Online Platforms

Modern online tools allow researchers to reach a broader and more diverse set of respondents. Tools such as mobile data collection apps and web-based questionnaires facilitate: Real time data entry and validation, Geo tagging and temporal monitoring, lowered costs and improved scales, and easier longitudinal tracking for panel studies.

One of the most prominent shifts in primary data collection is the move from Paper-and-Pen Interviews (PAPI) to digital platforms. Computer Assisted Personal Interviewing (CAPI) – using tablets, smartphones, or computers for field surveys- has largely replaced paper in many large studies. CAPI involves an enumerator putting responses directly into an electronic form rather than writing on paper, and it offers numerous advantages.

- Eliminates the need for carrying stacks of paper questionnaires. Instead, a single device can store all forms and transmit completed data back to a server instantly
- Save time by removing separate data entry step and provide much cleaner data on a real time basis
- Improve data quality through inbuilt validation checks (for example, the software can prevent implausible values or skip irrelevant questions)
- Capture ancillary information – GPS coordinates, time, photos of the farms or even record audio of the interview for later review

Insights from huge scale surveys conducted in different regions by Asian Development Bank study using CAPI indicate that compared to PAPI, the survey has fewer duration, reduced errors, cleaner data. The CAPI surveys had high upfront cost involving programming devices, software development and enumerator training. However, for large scale surveys, the CAPI turned out to be cheaper to PAPI by avoiding many recurring expenses of paper surveys. These features greatly enhance the quality and depth of socio-economic data collected in the field especially is a game changer for large scale surveys.

The National Statistics Office (NSO) now conducts its nation-wide socio-economic surveys on digital platforms using CAPI and web-based applications. Data collection and near real time monitoring are also accomplished through digital platforms (PIB, 2024). This transition by NSO highlights the necessary practices like training enumerators, real-time monitoring and quality control, and iterative improvement of survey instruments to fully leverage digital tools. This enables faster data release and improved accuracy in large scale critical surveys, a trend mirrored by statistical agencies in many other countries.
Digital surveys are not limited to face-to-face tablet interviews. A key trend is the rise of online and mobile survey modes as complements or alternatives to in-person data collection. Researchers, increasingly employ mixed-mode survey

designs, combining methods like web questionnaires, telephone interviews, and face-to-face visits to reach respondents in the most effective way. The COVID-19 pandemic greatly accelerated this shift as most of the researchers conducted phone or online survey to gather data remotely.

Mobile phone surveys are useful when travel options are restricted. They are automated, less expensive, and fast compared to in-person fieldwork. There are a few modalities: one is Computer Assisted Telephone Interviewing (CATI), where an interviewer calls respondents and fills an electronic form. Another approach requires no human interviewers- using text messages (SMS surveys) or Interactive Voice Response (IVR) robocalls to administer questions. Each mode has pros and cons: SMS requires literacy to read/ write texts, whereas IVR can reach anyone with a basic mobile phone. Often a combination works best as per the research requirement. It is desirable to keep the survey short and mixed modes and follow up improve the data quality and reliability.

A clear best practice in moving surveys online is to focus on respondent experience and inclusion. The survey designs must be inclusive and respondent friendly. Using inclusive design principles enhances acceptability of survey designs among respondents. Some examples are use of local language, ensure mobile-optimised layout, or provide an option for an enumerator assist via phone for those who cannot complete online. Particularly in rural agricultural communities, digital divide issues are real: older or less educated farmers may be less familiar or comfortable with digital surveys. Addressing this might require community sensitisation and trust building – e.g. explaining the purpose of the tablets or mobile surveys to respondents, or even allowing a paper option if needed – to ensure nobody is left out of the data collection.

Despite these challenges, the trajectory is clear: the future of primary data collection in agriculture will be predominantly digital and often multi-model, blending the convenience of online and mobile methods with the rigor of face-to-face techniques to achieve the best data quality and coverage. A case from sub-Saharan African nation using an open-source CAPI platform – Open Data Kit (ODK) for field data collection related to a major agricultural initiative- National Bean Program. This has helped to enhance the real time data syncing, built in validation and improved collaboration among stakeholders- scientists, extension officers and policy makers. In short, moving to digital primary data collection has streamlined workflows and empowered both researchers and farming communities with more timely information.

Emerging Technologies and Data Sources

Beyond digitalising traditional surveys, the future of data collection in agricultural socio-economic research will be shaped by new technologies and novel data sources that augment what surveys can do. Some important trends are: the integration of geospatial and sensor data with socio-economic surveys, the rise of AI tools for data analysis (and even data gathering), and the growth of participatory data collection by the farmers themselves.

Geospatial and Remote Sensing Data: Agricultural research increasingly combines survey data with geospatial information obtained via remote sensing (satellites, drones) or on-ground sensors (IoT devices). The International Maize and Wheat Improvement Centre (CIMMYT) in Southern Africa has adopted the use of unmanned aerial vehicles (UAVs) also known as drones to collect data as a critical part of a breeding programme. This facilitated instant data gathering and drones were able to collect data from 1000 plots in 10 minutes or less – a task that might take 8 hours to do so manually. The routine use of drone imagery has enabled CIMMYT breeders to manage large scale experiments and to focus on analysis and decision making. Moreover, when remote sensing data related to cropping pattern is linked with the socio-economic survey data, a new arena can be studied like how socio-economic factors of framers influence crop choices or to validate farmer reported outcomes with objective measurements. Geo spatial linkage is an emerging best practice- modern survey platforms often record the GPS location of each interview or field, making it easy to overlay survey responses on maps and integrate with satellite data layers (for rainfall, soil type, etc.,).

Another domain is the Internet of Things (IoT) and sensor networks, which gather environmental or farm data continuously. Socio economic researchers can correlate sensor readings with farmers' reported decisions or outcomes from surveys. In the future, we may see survey respondents provided with sensor devices that feed data directly into research databases – for instance, a farmer could have a farm rain gauge or a smartphone-based crop scanner, and those readings could be paired with their survey responses about crop yields or input use. These approaches blur the line between primary survey and automated data collection. By moving towards multi-source data collection, the speed and quality of data collection can be enhanced.

***Harnessing AI: From Data Collection to Insight Generation*:** While still emergent, Artificial Intelligence (AI) is being applied at various stages of the data collection and analysis pipeline to make socio-economic surveys smarter and more efficient. AI can help analyse existing data to identify patterns and then suggest a more efficient sampling design for a new survey. There is also work on using algorithms to adapt questionnaires on a real time basis by personalised questions based on respondent answers, improving relevance and engagement.

Machine learning also enables predictive modelling and identification of determinants of farmers behaviour and technology adoption.

AI can also enhance the data quality by using algorithms to scan anomalies in the incoming data. Along with the data collected, access to paradata such as interview duration, GPS, keystroke pattern, etc. enable machine learning models to predict the quality of the interview. Moreover, AI can help fill data gaps though imputation by understanding underlying general patterns. Another possibility is using voice recognition and Natural Language Processing (NLP) to assist enumerators which can enhance efficiency in terms of speed and accuracy. Analysis of Open-Ended Responses is another area where NLP can of assistance. Open ended questions result in free-text answers and Large Language Models (LLMs) can categorise these texts by theme and even flag key issues mentioned by respondents. In socio economic research, sentiment analysis of textual data has emerged as a useful tool to gauge farmer opinions and social attitudes. We can expect AI to become a standard aid for processing qualitative survey data.

AI may not just assist in design and analysis – it might become a mode of data collection itself employing tools such as chatbots and virtual assistants. AI enabled chatbots might survey farmers online about their cropping decision and simultaneously provide them some personalised advice related to crop-blurring data collection and extension service into one. AI can also handle unstructured interaction; a farmer could, for instance, send a photo of a crop issue and the AI could both diagnose it and record that data point for researchers.

In summary, AI offers tools to make data collection smarter, faster and more insightful. It can reduce the burden on respondents (through shorter adaptive surveys or conversational formats) and on researchers (through automated data processing). However, alongside these opportunities come new responsibilities: ensuring algorithms are transparent and fair, guarding against AI-induced biases, and maintaining the human touch where needed (surveys are ultimately about people's voices). However, developing some basic understanding in data science and AI will be increasingly valuable in socio economic research and surveys in agriculture and allied science in the very near future.

Farmer-Led and Crowd-Sourced Data

Participatory data collection involving farmers and communities directly in gathering and sharing data is another complementary trend. These methods involve farmers as active data collectors and knowledge partners instead of mere survey respondents. For instance, using crowd sourcing platforms farmers can send SMS updates about market prices or weather conditions in their

regions, which are then aggregated. Such farmer-contributed datasets can complement formal surveys by providing real-time, ground truth information on agricultural activities.

One notable effort in participatory data is the development of standardised survey tools that farmers or local enumerators can use easily, ensuring that data from different places are comparable. The RHoMIS (Rural Household Multiple Indicator Survey) is one such tool- a simplified digital questionnaire, implemented on tablets or phones, that covers a broad range of farming and livelihood indicators. It was designed so that various organisations and projects globally could use it to rapidly collect core socio-economic metrics and then share/compare results. This is in line with the open science movement in agriculture where standardisation and open data are key themes. When many groups involved in data collection use the same format, their data can be merged to yield insights at larger scale avoiding redundant survey efforts.

Another aspect of farmer-led data is citizen science in agriculture. This is where farmers participate in trials and record results themselves. Such approaches greatly reduce the cost and increase the scalability of on-farm research. Moreover, they also empower the farmers with a sense of contribution and agency in agricultural innovation. It's worth noting that inclusivity and training are crucial for participatory data collection to work well.

Methodological and Ethical Considerations and Challenges

It is vital to adopt best practices that ensure data quality, ethical integrity, and usefulness of the information gather while we embrace new methods of data collection.

Thorough planning and pilot testing are key in digital surveys. This means piloting the survey on the device, checking that all questions display correctly, all options work, and that data can be successfully submitted and retrieved. Investing time in testing prevents costly errors in the field. Training field enumerators and supervisors is vital for success in advanced survey tools. During data collection, having supervisor monitor incoming data is important to catch problems early. Using the paradata features of digital tools- such as timestamps, GPS logos, and error counts per survey- supervisors can maintain a high-quality data standard.

With advanced survey tools and digital data collection regime, the researchers must implement robust data management practices. This includes having a backup system so that no data is lost if devices are broken or lost. Best practice is to regularly sync data to a cloud server and also keep local backups. Data security is another concern – survey data often contain personal and sensitive information. Socioeconomic researchers and students should become familiar

with basic data ethics: always obtain informed consent from participants, anonymise data before public sharing, and follow regulations like GDPR guidelines (the General Data Protection Regulation). New technologies like blockchain are even being explored to enhance data integrity and trust, by creating tamper evident records of survey submissions-though such solutions are still nascent in this field. Ensuring inadvertent inclusivity and avoiding bias is equally important. For example, an online survey might miss those without internet; a smartphone app will miss those without smartphones. Also algorithmic tools used in surveys should be watched for bias to ensure 'algorithmic fairness'.

Global collaboration and knowledge sharing is another important way forward. In the landscape of data collection, collaboration across institutions and countries is hugely beneficial especially for addressing challenges and sharing innovations. Open-source communities around tools like ODK or KoBoToolbox mean that improvements made by one team become available to all. Online courses are available to train interested candidates in CAPI or similar advanced survey options using software like CSPro (Census and Survey Processing System) and Survey Solutions. Embracing open science – sharing one's survey instruments, protocols, and even datasets and using elsewhere shared data for practice analysis or to do comparative studies- can accelerate progress of everyone. The key will be to tailor global best practices to local needs using appropriate technology and always validating that the data reflects ground realities.

Core issues for the next generation of surveys include: Sampling bias from online-only surveys; Digital literacy and access gaps; Ensuring informed consent and access gaps; and Algorithmic transparency and mitigation of bias in AI analytics.

Data Governance, Privacy, and Empowerment

As advanced tools in primary data collections such as digital and AI methods proliferate, clear principles on data ownership, benefit sharing, and interoperability are essential. Ensuring that farmers benefit from the data they contribute, and can access relevant insights for their own decision-making, remains a sector-wide imperative.

Future Outlook and Recommendations

Primary data collection in agricultural socio-economic research is undergoing a revolutionary change. The data collection is gradually moving to digital modes employing tablets and cloud servers; mixed modes using face-to-face, phones, and online interactions; to adaptive surveys. These technologies are intended to address the longstanding challenges faced during survey- based socio-economic research. Advanced tools help to enhance speed, accuracy and objective validation of the results. It also helps to reduce the drudgery of data collection and process the vast amount of data resulting from these surveys. Moreover, these platforms can aid in making sure the farmer participation and inclusiveness in the entire process. Rather than being passive data providers, farmers- the major stakeholder – can be an active participant through data collection and decision making, through participatory apps, citizen science trials, or simply by having their needs better captured through user-centred survey design.

Of course, the road ahead is not without challenges. Issues of digital access and literacy need continuous attention- one must ensure that the benefits of new methods reach the marginal farmers as well, and that no voices are left unheard due to digital divide. Privacy and data protection will remain paramount as more personal data flow through digital channels. Getting informed consent is also important. There will also be a learning curve for institutions and individuals alike to build capacity in these new tools. Training programs, academic curricula and funding priorities will need to adapt to produce researchers and workforce skilled in both social science and data science aspects of agricultural research. Voice interactive surveys or real-time dashboards for data collection and monitoring will be more common. Around the globe, best practices are converging on using mixed-methods, technology-enabled approaches to gather data that is timely, granular, and reliable. Adopting these in a way that respects local culture and involves the community will be a key to success.

Some key points to move forward include

- Build modular, interoperable survey platforms for cross-country comparability
- Train local enumerators in digital tools and ethical data handling
- Develop participatory feedback loops so that data supports both research and farm-level decision making
- Continue advancing standards around data privacy, algorithmic transparency, and farmer empowerment

The advances in digital transformation promises faster and better-quality data to inform policies for sustainable agriculture development. But it also places the onus on researchers and students to stay updated, be flexible, and uphold ethical standards in this rapidly evolving field. By understanding and harnessing the emerging trends – from digital survey tools and AI analytics to participatory data models – we can greatly enhance our ability to diagnose issues, evaluate interventions, and ultimately improve the livelihoods of farming communities. The tools may change, but the core goal remains the same: gathering truthful, insightful data about people and agriculture, and using it to drive positive change. With the right mix of technology and human-centered practice, the coming years will undoubtedly yield more inclusive, accurate, and actionable socio-economic insights for the agricultural sector.

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