Managing Organization (Hub) for Responsible Artificial Intelligence for Agriculture and Food Systems (AI4AFS) Innovation Research Network in Africa

RESPONSIBLE ARTIFICIAL INTELLIGENCE FOR AGRICULTURE AND FOOD SYSTEMS

TRAINING MANUAL

Funded by

IDRC · CRDI
International Development Research Centre
Centre de recherches pour le développement international

Canada

Sida

ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

Proudly AI4AFS Hub

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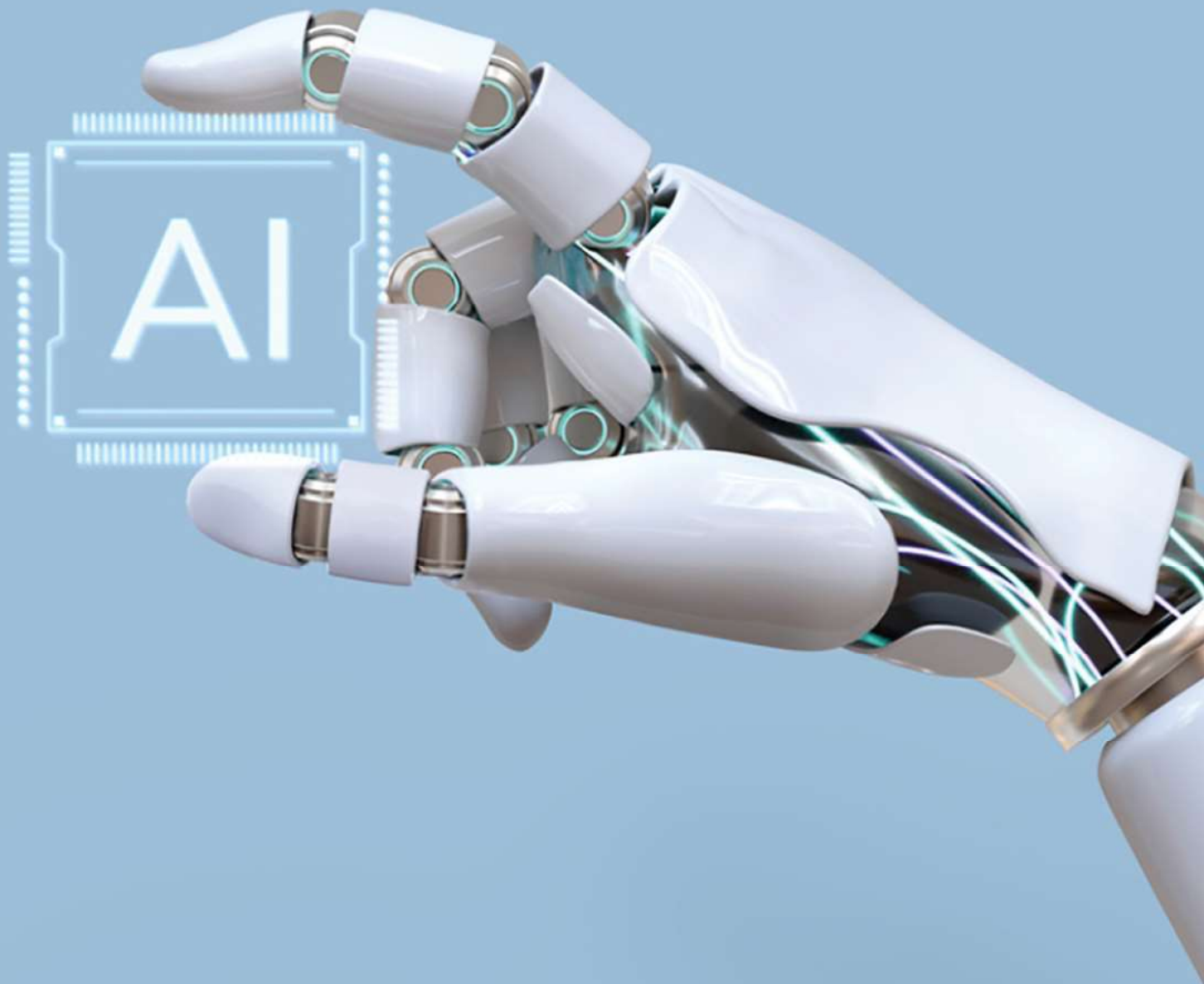
ISBN: 978-9966-124-46-3



ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

Proudly AI4AFS Hub

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ABOUT THE PROJECT

The Artificial Intelligence for Agriculture and Food System Hub is part of the AI4Dev Africa initiative. The AI4AFS innovation research network is ***to advance the responsible development, deployment and scaling of home-grown AI innovations to tackle pressing challenges in agriculture and food systems in Africa.*** Achieving this objective would make a significant contribution to agriculture, food and nutritional security as well as enhance the livelihoods of African people especially women and youth who form the majority of the small-scale farmers in Africa. By developing, deploying and scaling AI innovations that are homegrown, peculiar agricultural production and productivity challenges unique to Africa can be addressed. Overall, there will be adequate endogenous capacity, technology and innovations, infrastructure, and enabling policy environment to tackle pressing AFS challenges to achieve sustainable transformation in the sector and overall economies on the continent.

The **specific objectives** of the research network are to:

i) Deepen understanding of how to develop, deploy, and scale responsible AI innovations for sustainable AFS in Africa;
ii) Build the capacity of African innovators and researchers to develop, deploy and scale such AI applications in AFS; and
iii) Facilitate knowledge exchange and the contribution of African research to relevant international AI policy and practice conversations.

These objectives reflect the result of problem analyses that exposed the causes of weak technical innovations for AFS development in Africa, where, and how interventions can be deployed to achieve maximum impacts. The research network, managed by the Hub, will bring together and mobilize African innovators and researchers working on AI4AFS and representing linguistic, gender, and geographic diversity across Africa; diversity across relevant areas of application of AI for AFS; and diversity of relevant stakeholders (e.g., university researchers, start-ups, research-oriented think-tanks, consultancies, labs, etc.) to develop, deploy and scale responsible home-grown AI innovations for AFS in Africa.

ABOUT THE AI4AFS PARTNER ORGANIZATIONS

The African Technology Policy Studies (ATPS) is a trans-disciplinary network of researchers, policymakers, private sector actors, and civil society actors that promote science, technology, and innovation (STI) for African development, environmental sustainability, and global inclusion. With its Headquarters located in Nairobi, Kenya where it enjoys diplomatic privileges and immunities accorded other International and United Nations Organizations, the ATPS implements its activities through its National Chapter Offices distributed across 30 countries (27 in Africa and 3 in the Diaspora – Australia, UK, and USA). The ATPS has over 5,000 network members and 3,000 stakeholders in over 51 countries in 5 continents, with institutional partnerships worldwide. The ATPS is the lead organization in the AI for Agriculture and food systems project, administering and coordinating all activities of the Hub. As the lead organization, ATPS ensure a transparent selection of the research/innovation project proposal. Additionally, the organization leads in research synthesis, knowledge mobilization, and training of network grantees, specifically in the translation of knowledge outputs into policy products such as policy briefs for sustained impacts. The ATPS will also lead in all policy dialogue, knowledge brokerage, and network collaboration activities of the Hub. The organization's mission is to build Africa's capabilities in science, technology, and innovation for sustainable development and global inclusion. The ATPS Phase VIII Strategic Plan, 2017-2022 identifies four thematic priority areas of intervention, including Agriculture, food, and nutrition, Energy, Climate change, and environment, and Health innovations. The Strategic Plan also identifies five cross-cutting programmatic priority areas to deliver on the overall and specific objectives of the Artificial Intelligence for Agriculture and Foods System Hub. For more information, kindly visit the ATPS website at: https://atpsnet.org/

The International Centre of Insect Physiology and Ecology (icipe) is an inter-governmental organization operating in 41 African countries with over 500 staff and 300 partners globally. icipe's core focus is building the capacity of people and institutions to respond to Africa's development needs, particularly in training young scientists and informal training of extensionists, National Agriculture Research Systems staff, and farmers. The organization's DMMG Unit comprises seven scientists who utilize advanced mathematical, physical, AI, and DS methods and tools to track and predict pest trends, linkages, interactions, relationships, and mechanisms worldwide. The team's research activities are aimed at developing new computational techniques for decision support in the context of AFS, Integrated Pest Management implementation and practices, and climate change and variability impact assessments. icipe is committed to reducing the use of persistent organic pollutants for pest management as a Stockholm Convention Regional Centre, collaborating with the World Organization for Animal Health for Bee Health in Africa, serving as an FAO Reference Centre for Vectors and Vector-borne Animal Diseases, and partnering with WHO-AFRO for Vector Management. The organization has contributed to the AI for Agriculture and food systems innovation network by guiding grantees with its scientific expertise, selecting high-quality research projects, increasing skills, knowledge, and leadership, providing backstopping in research and science application of AI, and training and capacity building of the grantees. Website: http://www.icipe.org/

Kumasi Hive is a technology and innovation hub in Ghana that aims to build the capacity of young people in technology and business while creating sustainable innovations that solve local and global challenges. It supports entrepreneurs and innovators of all types and provides access to shared working spaces, Biolab and Makerspace with shared advanced manufacturing tools/resources that strengthen the goal of rapid prototyping of ideas. The Hive focuses on bridging the existing Digital and tech skills gap in the African digital entrepreneurship ecosystem and seeks to address it through integrated innovation. It provides training covering emerging technologies such as IoT, biotechnology, blockchain, mobile app/game/web development, AI, virtual/augmented reality, and 3D printing. Kumasi Hive also runs a training academy school for courses on augmented reality, hardware garage, IoT, code school, drone and UAVs, robotics, 3D printing/3D modelling, mobile app/game/web development, and AI. It also incubates selected promising hardware start-ups, helping them move from the idea stage through prototyping to the product-for-market stage with both technical and business development support. Kumasi Hive will offer these supports to the Hub. Kumasi Hive, as a private sector practitioner and entrepreneur is providing valuable inputs in internally determining the potential practical impacts of the AI research and innovation projects and how they can transit to commercially viable products and services for AFS. It will provide linkages with the private sector for the provision of much-needed research infrastructure, incubation facilities and expertise in AI. Website: https://kumasihive.com/

ABOUT THE DONORS

The International Development Research Centre (IDRC) is a Canadian federal corporation that supports research to find innovative solutions to some of the most pressing global challenges, including poverty, inequality, and climate change. In its effort to support Africa's development, the IDRC launched the Artificial Intelligence for Development (AI4D) initiative, a pan-African program aimed at harnessing the potential of AI for sustainable development. Through AI4D, the IDRC provides funding and technical support for research projects that use AI to address development challenges in Africa. The program focuses on building AI capacity in African countries and promoting gender and social inclusion in AI research and applications. The AI4D African Program brings together a network of African AI researchers, policymakers, and practitioners, enabling them to collaborate and share knowledge to advance the use of AI for development on the continent. The IDRC's support for the AI4D African Program demonstrates its commitment to promoting inclusive and sustainable development through innovation and research. Website: https://www.idrc.ca/

The Swedish International Development Cooperation Agency (Sida) is a government agency that provides support for sustainable development initiatives in low- and middle-income countries. One of the key areas of focus for Sida is promoting the use of technology and innovation to address development challenges. In line with this, Sida has provided significant support to the AI4D African Program, which aims to harness the power of artificial intelligence (AI) to drive socio-economic development across the African continent. The AI4D African Program is a collaboration between various African governments, the African Institute for Mathematical Sciences (AIMS), and the International Development Research Centre (IDRC). The program aims to build capacity in AI research and development across the continent, promote the use of AI to address social and economic challenges, and facilitate collaboration between researchers, policymakers, and other stakeholders. Sida has provided funding to support the program's activities, which include providing research grants to African researchers working on AI-related projects, organizing training workshops and hackathons to build capacity in AI, and supporting policy dialogues and stakeholder engagement activities to ensure that the use of AI is aligned with local needs and priorities. Through its support for the AI4D African Program, Sida is playing a key role in promoting the use of technology and innovation to address development challenges in Africa. By building local capacity in AI research and development, the program is helping to ensure that African countries can fully participate in the global AI revolution and leverage the potential of AI to drive socio-economic development and improve the lives of people across the continent. Website-: https://www.sida.se/

ABOUT THE TRAINING MANUAL

The training manuals developed following the AI4AFS Capacity Needs Assessment were designed to address the specific gaps identified in the report. The needs assessment revealed a variety of capacity gaps across AI4AFS grantees, with a focus on critical skills such as data management, AI development, product commercialization, carbon footprint tracking, intellectual property rights, and research design. The training manuals align with the overall objectives of the AI4AFS project by ensuring that grantees are equipped with the necessary knowledge and skills to develop, deploy, and scale responsible AI innovations. One of the key objectives of AI4AFS is to build the capacity of African innovators and researchers, enabling them to tackle pressing agricultural challenges using AI. The key objectives of the training manuals developed based on the AI4AFS Capacity Needs Assessment report are as follows:

i) **Build Capacity in AI Development and Deployment:** Equip AI4AFS grantees with the technical skills needed to develop, deploy, and scale AI algorithms that address agricultural and food system challenges in Africa.
ii) **Enhance Data Management Skills:** Provide training on responsible data collection and management, using tools like Open Data Kit (ODK) and REDCap, to ensure high-quality data for AI applications.
iii) **Support Product Development and Commercialization:** Guide grantees through the process of product development and commercialization, enabling them to bring AI innovations to market.
iv) **Enable Carbon Footprint Reporting:** Train grantees on how to integrate carbon footprint tracking using tools like Code Carbon, ensuring that their AI innovations are environmentally responsible.
v) **Strengthen Intellectual Property Rights Knowledge:** Increase grantees' capacity to understand and navigate intellectual property rights, helping them protect and commercialize their AI innovations.
vi) **Improve Research Design and Methods:** Offer guidance on effective research design and methods, ensuring grantees can conduct impactful research that aligns with AI4AFS goals.
vii) **Develop Policy Briefing and Advocacy Skills:** Empower grantees to develop policy briefs and engage in advocacy, promoting AI-friendly policies that support agricultural innovations across Africa

The training manuals cover both generic and customized training areas. Generic training includes essential topics such as grant management, policy brief development, and entrepreneurship, while the customized training is tailored to the specific needs of each grantee as identified in the assessment. For example, in response to the need for improved data management, the training manuals provide guidance on using tools like Open Data Kit (ODK) and REDCap for responsible data collection. Similarly, since 70% of the respondents lacked the capacity to deploy carbon footprint tracking technologies, specific modules on integrating Code Carbon were incorporated into the manual. By doing so, AI4AFS grantees can ensure that their AI models are not only innovative but also environmentally responsible.

Additionally, commercialization and intellectual property rights were highlighted as significant gaps. Only 20% of the grantees had experience with intellectual property rights, which are crucial for protecting innovations. The training manuals include detailed sections on navigating the intellectual property landscape and how to transition from research to commercialization—key steps in ensuring the sustainable impact of AI innovations. Furthermore, the training also addresses the need for policy brief development, an essential component for ensuring AI-

friendly policies. Since all grantees expressed a desire for training in this area, the manuals emphasize how to communicate complex AI research effectively to policymakers, enabling advocacy for AI in agriculture and food systems across Africa. The key outputs showing the effectiveness of these training manuals where the effectiveness of the research outputs of the grantees and the publication of 4-5 policy briefs from countries where the project was implemented

These training manuals are not only designed to fill specific capacity gaps but also to support the broader AI4AFS objective of fostering inclusive, responsible AI innovation for sustainable agricultural and food systems in Africa.

LIST OF CONTRIBUTORS

1. Prof. Dr. Moni Wekesa – Daystar University School of Law –*Intellectual Property Rights in Responsible AI for Agriculture and Food Systems in Africa Module.*

2. Prof. Michael Madukwe – University of Nigeria, Nsukka –*Developing Impactful Research Designs and Methods for Artificial Intelligence in Agriculture and Food Systems Research and Innovation Module.*

3. Prince Banini and Emmanuel Nti – Kumasi Hive, Ghana –*Product Development and Commercialization Module.*

4. Prof. Samuel Mwalili - Jomo Kenyatta University of Agriculture and Technology – *Introduction to Data Management and Data Science Module.*

5. Joel Tanui – Software Developer – Data Management, Modelling and Geo-information unit, International Centre of Insect Physiology and Ecology - *Digital Data Collection and Management with Open Data Kit (ODK) and REDCap Module.*

6. Engr. Chukwukadibia Ikevude – BrainK Limited, Lagos Nigeria. - *Tracking Carbon Footprint in AI Models for Responsible Artificial Intelligence in Agriculture and Food Systems Research and Innovation Module.*

7. Prof. Nicholas Ozor and Alfred Nyambane – African Technology Policy Studies Network (ATPS). - *Development of Policy Briefs for Effective Policy Influence and Advocacy Module.*

MODULE 1

Developing Impactful Research Designs and Methods for Artificial Intelligence in Agriculture and Food Systems Research and Innovation

1.0 Concept of Research Impact

Research impact is **the effect research has beyond academia.** Research impacts when the knowledge generated contributes to, benefits and influences society, culture, the environment and the economy.

Approach to Developing Impactful Research Design

1. Conceptualising the intended change (What are the existing gaps or changes the research plans to bring about, for whom, why, how, and when; Implications on social, economic, and environmental policies)

2. Identifying and engaging stakeholders (Identify the key stakeholders and develop strategies for strategic and sustained engagement)

3. Capacity development of clients (Develop strategies to build the capacity and capability of primary clients).

4. Influencing policy (Identify strategies to influence emerging policy issues through: workshops, seminars, conferences, training, policy briefs, and policy roundtables.

2.0 Concept of Research Design

The design of a study is the investigator's plan of action for answering the research questions. It involves all arrangements for data collection, analysis and how treatment and observation are measured and carried out. A proper design sets your study up for success. Successful research studies provide insights that are accurate and unbiased. The objective of selecting a research design is to minimize the possible error by maximizing the reliability and validity of the data.

Reliability refers to the consistency, stability and dependability of the data. Whenever an investigator measures a variable of interest, he/she wants to be sure that the measurement provides a dependable and consistent result. A reliable measurement is one that, if repeated the second time will give the same result as it did the first time. If the results are different, then the measurement is unreliable.

Validity refers to data that is not only reliable but also accurate. It is the extent to which a measurement does what it is supposed to do. If a measurement is valid, it is also reliable. But if it is reliable, it may or may not be valid.

Example:
Suppose an investigator asks a respondent, "How old are you?"
The respondent replies, "I am 32 years old."
The investigator then asks a second question to verify the consistency or reliability of the age measurement: "What is your date of birth?"
The respondent answers, "In March 1991."

If it is now March, 2023, the investigator calculated that indeed the respondent is 32 years old. In this example, two questions have been asked; each designed to determine how old the respondent is. The results are consistent, stable and dependable; they are therefore taken as reliable.

Suppose later on the investigator has to see the respondent's birth certificate which shows that the true date of birth is March 1989, the investigator then concludes that although those two first questions gave a reliable result, they did not give a valid result.

Exercise 1

Identify a variable in your study and give a similar example

Methods of determining or testing for reliability

In research, tests for reliability are conducted for variables that are measured as scales. Examples include scales that measure adoption, acceptance, attitude, and perceptions.

1. Test-retest (Each respondent has two scores from two administrations of the same questions).
2. Equivalent forms (Each respondent has two scores from two administrations of two difference, but equivalent questions).
3. Split-half. (Each respondent has two scores (from odd and even number question) from one administration of questions).

i. Test–Retest Method

Table 1: Arrangement of data for correlation analysis to test for reliability

Respondents	1st Test	2nd Test
1	3.2	3.1
2	2.1	2
3	2.3	3.2
4	1.8	2.8
5	2.0	3.9

The method administers the same instrument to the same persons twice at different times. The more 1st & 2nd scores are close (high correlation coefficient "r" above .74), the more the instrument of data collection and indeed the data collected are reliable.

ii. Equivalent forms

Two forms of the same scale or measure are administered to the same respondent at the same time. Scores of respondents from the 1st form of the scale and the 2nd form of the scale are correlated. The higher the correlation, the higher the reliability of the instrument and the data.

iii. Split half techniques

One instrument is administered to the respondent once and the scores on the questions bearing odd number items in the questions asked for that variable are added together to produce the total for half of the items and the scores for the questions bearing the even number items are added together to produce a total score for another half of the score of the items. Each respondent ends up having two scores; one from odd number items and the other from even number items. The two scores for all the respondents are correlated. The higher the value of the correlation coefficient, the higher the reliability of the data collection instrument and the data.

A variant of the split-half technique is to regress the total score of each respondent on the individual score for each item. Items not contributing to explaining the variation in the total score are modified or removed from the scale.

Exercise 2

Identify a scale in your study that must undergo a reliability test

Validity

There are two types of validity in relation to research processes and findings. They are internal and external validity.

Internal validity ensures that differences occur as a result of experimental treatment. The researcher must establish experimental control that will enable the conclusion that differences occur as a result of experimental treatment.

External validity refers to the generalizability or representativeness of findings of the study to a later time period or other geographical location based on the findings of the study.

Methods of determining or testing for Validity

One of the important prerequisites to good research is goodness of the research instrument. The research instrument is said to be good or valid, when it measures what it is supposed to measure correctly and consistently. The following types of validity exist:

a. face validity,
b. content validity,
c. construct validity and
d. criterion validity.

The two that relate to the nature of the current research will be briefly discussed

Face Validity

As the name implies, it is a measure based on how the instrument appears to be related to the specific objectives of the research. An instrument is said to possess face validity if its content simply looks relevant to the information required. Dichotomous variables are mostly used to determine face validity with options 'Yes' and 'No' which indicate favourable or unfavourable items.

Content Validity

Content validity involves the evaluation of the questionnaire with the zeal to ensure that all the items that are essential are included while unwanted ones are eliminated. The procedure requires researchers to give out the instrument to experts in order to facilitate validation. The location experts are among the factors limiting the conduct of validity tests on a survey instrument. For effective content validity, the following steps are recommended:

i. Review literature extensively to bring out the connected items.
ii. Use a three-point scale to assess the content in the survey instrument (related but not necessary, related but not essential, and related and essential).
iii. The questionnaire should be sent to professionals from the same area of discipline.
iv. The responses of experts are subjected to analysis.
v. Items that are insignificant are removed.

Threats to validity

The quality of a research design depends on the number of threats to validity that it controls. Some of the common threats to validity include:

1. **History:** Some events (unanticipated) occur during the life of a study that tends either to increase or decrease the expected outcomes of the study. For example, the death of a prominent member of the community during data collection.
2. **Selection:** When the people selected for the control group differ greatly from the people selected for the experimental group.
3. **Testing:** When a pre-test is given it tends to have an effect on the post-test. Sometimes in knowledge, attitude, and practice (KAP) surveys, the same group of people are repeatedly asked the same questions each year for several years. After a period of time, they begin to remember the correct answer to many of the questions asked.
4. **Instrumentation:** A change in the instrument of data collection between the pre and

post-tests or a fault or a change in the way information is collected can result in a threat to validity.

5. **Maturation:** Over time people mature and change. The maturation process can produce changes that are independent of the changes a programme intervention is designed to produce.
6. **Mortality:** In studies where the same group of people are followed over time, there is almost always some dropout or loss of cases, that affect the number of respondents and indeed the number of data available for analysis and degree of validity.

Research design is not the same as the design of conceptual framework or experimental design as understood by many. In the generic sense, it includes all things that need to be done in developing objectives and hypotheses, the collection and analysis of data and reporting.

The research design adopted for impactful research in artificial intelligence is informed by the nature of the investigation or purpose one intends to achieve. Once a design is selected, standard procedure relevant to that design is expected to be strictly adhered to. The design adopted for a particular investigation should be informed by reason and justifiable and should conform to the expected applications and assumptions of such design.

For instance, if an NGO embarked on an intervention "Using Artificial Intelligence to enhance the Production, Management and Marketing of Nsukka Yellow Pepper", an appropriate design for the research is one that will help us to determine changes in knowledge, skill and attitude as a result of this intervention. A research design that could be appropriate for this type of study is the 'Before and After' as shown in Table 2. The effectiveness of the intervention reflects in the changes in knowledge, skill and attitude of the individual or group involved. But this design may not be suitable if baseline data were not obtained, and in that condition 'With and Without' design can be used as shown in Table 3. These designs will be further described later.

Table 2: Elements of "before and after" research design

	Before Intervention	After Intervention	Change
Knowledge, skill and attitude			

Table 3: Elements of "with and without" research design

	Participants in the intervention	Non-participants	Difference
Knowledge, skill and attitude			

Exercise 3

With example show which of the design ("before and after" or "with and without") is applicable to your study

To clarify what is meant by research design in a particular study, the components of research design include:

1. **Sampling Approach:** The process of selecting units from the population.
2. **Observational Approach:** The techniques used for data collection.
3. **Statistical Design:** The tools and methods used for data analysis.
3. **Operational Design:** The procedures and techniques used to implement the sampling and observational plans.

The above explains why many designs are applied in a single study and why layers of designs that are not mutually exclusive are often recorded. It is not strange to find the engagement of several designs in particular research, depending on the nature and purpose of such a study.

The Technique of Choosing a Research Design

The objectives of your research topic will largely determine the type of research design you need.

Are you planning to do an evaluation of an agricultural programme? If yes, consider using an experimental or a quasi-experimental design.

Are you interested in describing a particular agricultural event or practice? If the event has already taken place, you can use a post-test–only design with multivariable analysis. If the event has not yet taken place, you might use a pre-test-post-test design or a time series or a non-equivalent control group.

Will you be conducting an experiment to determine the effect of a particular agricultural technology on farmers' output? If yes, obtain a randomly assigned control group or at least a comparison group that is similar to the experimental group.

Consider the ethical issues. If the design will result in a violation of people's rights and dignity, and denial of services that otherwise would be available, then the design should be modified or abandoned.

Be sure you have available resources to implement the design.

Determine which threats to validity are controlled and which are not.

Types/Groups of Research Designs (Different Research Designs)

There are three types/groups of research designs

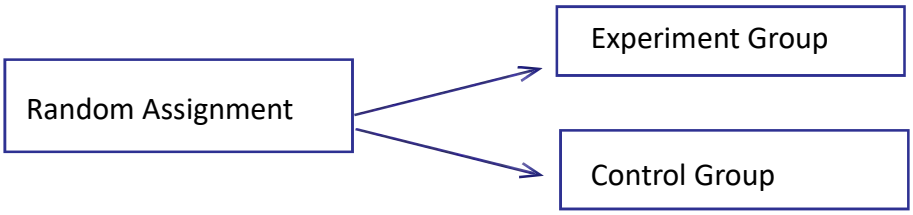
1. **True Experimental Designs**
   a. Pre-test-post-test Control Group Design
   b. Post-test-only Control Group Design

2. **Quasi-Experimental Designs**
   a. Time Series Design
   b. Non-equivalent Control Group Design
   c. Separate Sample Pre-test-Post-test Design

3. **Non-experimental Designs**
   a. Post-test-only Design
   b. Pre-test–Post-test Design
   c. Intact-group Comparison

These designs are some of the more frequently used designs in policy research. It will be helpful to use a common notation as explained below.

1. Random Assignment (RA) of respondents or cases into experimental and control groups



2. Time
The passage of time.
The extreme left of a design is the beginning of a project or study.
The extreme right the end

3. **X** An intervention programme; an experimental Intervention

4. **O** An observation/measurement.
The subscript is used to distinguish one observation from another.
For example, O_1, O_2, O_3, O_4.

5. ---------- A separation of two groups that have not been randomly assigned.

True Experimental Designs

These are true experimental designs because they provide control for **all sources of invalidity.**

Experiments are considered to be the prototypes of the scientific method of problem-solving. They are described as procedures for gaining knowledge by collecting new data under controlled conditions. They set up simple cause-effect situations where one or more variables are manipulated and their effects observed while other conditions are held constant.

If possible, social scientists prefer to use experimental designs to explain their findings, because it offers the best available design that allows the investigator to infer a 'cause-effect' relationship towards variables. This is because a well-designed experiment allows for a high level of control and impact.

Control means eliminating the influence of other variables except those which are of direct concern in the study. Control can be achieved in experimental studies through physical manipulation, selective manipulation and statistical manipulation.

(Random Assignment)	Pre-Treat Measurement of Dep. Variable	Treatment	Post-Treatment Measurement of Dep. Var.
Experimental Group	Yes	Yes	Yes
Control Group	Yes	No	Yes
Experimental Effect	[(Post-T Score for Exp Gp) minus (Pre-T Score for Exp GP)]		[(Post-Treatment Score for control Gp) minus (Pre-Treatment Score for control Gp)]

There are different designs classified under the broad typology of experimental designs. Important ones are discussed briefly with appropriate illustrations.

Pre-test-post-test Control Group Design

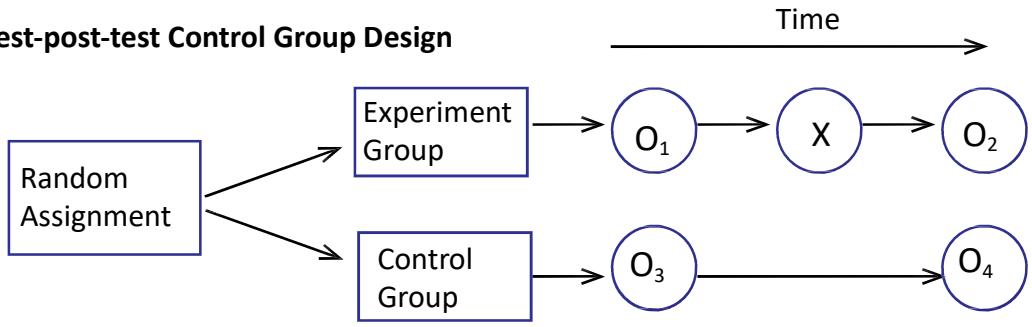


Table 3: Pre-test-post-test Control Group Design

The primary distinguishing feature is the random assignment of respondents/cases to the experimental and the control groups. This assures that the two groups will be equal in all characteristics before the intervention programme is introduced. Any difference observed later on between O_2 and O_4 can be attributed to the effect of the intervention programme (X).

It is one of the strongest designs, however, it is difficult to implement in studies targeting change in behaviour in agricultural production, and policy-related research, because it is difficult to assign cases randomly to experimental and control groups (Table 3).

There are, however, some situations where the random assignment of respondents/cases can be done such as when the number of personnel who require training exceeds the number of places available in a particular research setting. In such instances, experimental "respondent/ cases" can be randomly selected from the pool of persons requiring training. Those persons not selected become the control group.

Pre-test- Post-test Control group design (multi-group)

Here the dependent variable is measured for each group, but instead of one experimental group and one control, more experimental or control groups are added.

c

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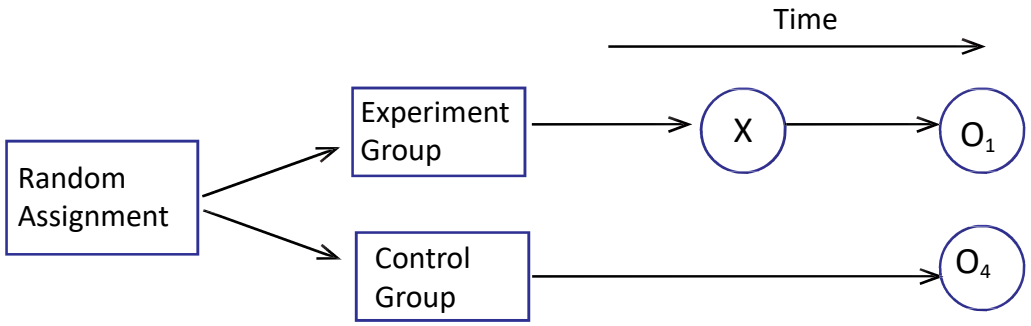
c

Table 4: Pre-test- Post-test Control group design (multi-group)

(Random Assignment)	Treatment	Response Rate
Experimental Group 1	$ 250	45%
Experimental Group 2	$ 500	51%
Experimental Group 3	$1,000	52%
Experimental Group 4	Plaque	37%
Control Group	No reward	30%

From the above results, it is observed that incentive indeed helps response rate but to a limit, as there is not much difference between the effect of $500 and $ 1000 incentives.

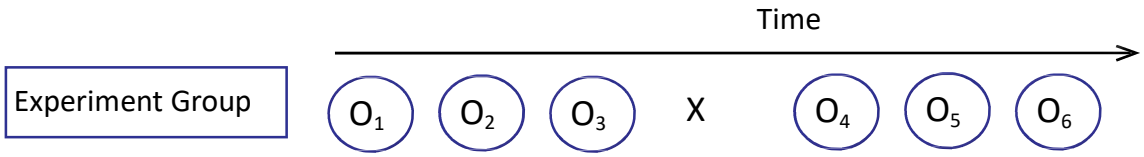
Post-test-only Control Group Design



This design has no pre-test. Since cases have been assigned randomly to the experimental and the control groups, these groups are assumed to be similar before the intervention programme. This design allows the investigator to measure the effect of a programme intervention on the experimental group by comparing that group with the control. This design does not allow an investigator to determine the extent of change within the experimental group because a baseline pre-test measurement was not taken.

Quasi-Experimental Designs

These designs are used in situations where experimental control is difficult or impossible to apply. These designs are some of the more frequently used designs related to behavioural changes in agriculture research. They tend to control for many threats to validity.



The time series design is similar to the non-experimental pre-test-post-test design except that it has the advantage of repeated measurement/observation before and after the intervention programme (X). If one finds that there is no difference between O_1 O_2 and O_3 but then a sudden increase occurs between O_3 and O_4 which is subsequently maintained in O_5 and O_6, one can conclude with some degree of confidence that the sudden increase was probably due to the effect of the intervention programme (X).

The time series design does not include a control group and does not account for the following threats to validity:

- History
- Instrumentation

However, it allows for a more detailed analysis of data and impact of intervention programme.
Time series design (multi-group)
Here, a research design includes several pre-treatment and post-treatment measurements. Multi-group time series design is used when a researcher is uncertain about exactly how quickly the effect of the independent variable should be observed or when the most reliable

pre-test measurement of the dependent variable should be taken. A good reason for this is to establish pre-treatment and post-treatment trends in the dependent (outcome) variable.

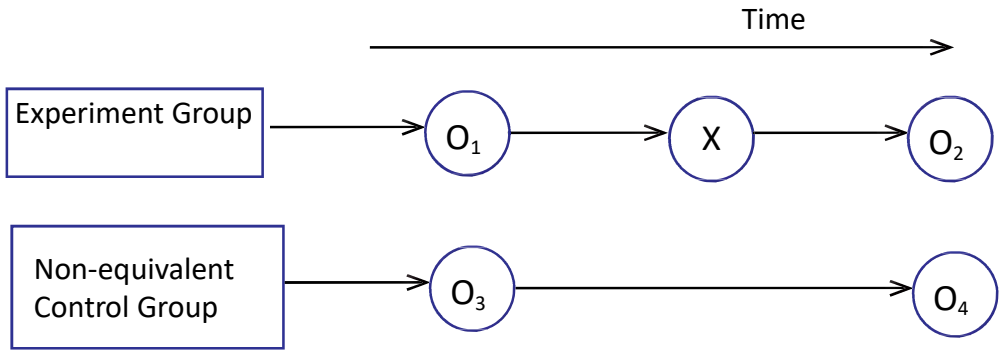
E.g. a three-Group, 4-measurement Design

This design is, thus, illustrated: It was hypothesized that the communication approach is an important factor in farm innovation adoption and that the method used to disseminate the technology affects adoption. The experiment design is shown in Table 5
Three randomized groups of maize farmers were selected. The first group was trained on improved maize cultivation using mass media and group methods. For another group, the individual method was added to the methods used for the group 1. The third had no treatment at all. For the three groups, mean yields were taken on early and late maize operations. Then, intervention (treatment) in form of an improved maize production programme was given (varied for groups 1 & 2), but none to group 3 (control group). Afterwards, the maize yields for the three groups were obtained for the following year both for early and late maize.

Table 5: Time series design (multi-group)

Pre-Test			Post-Test		
Random Assignment	1st	2nd	Treatment	1st	2nd
Experiment Group 1	Yes	Yes	Yes	Yes	Yes
Experiment Group 1	Yes	Yes	Yes but diff.	Yes	Yes
Control Group	Yes	Yes	No	Yes	Yes

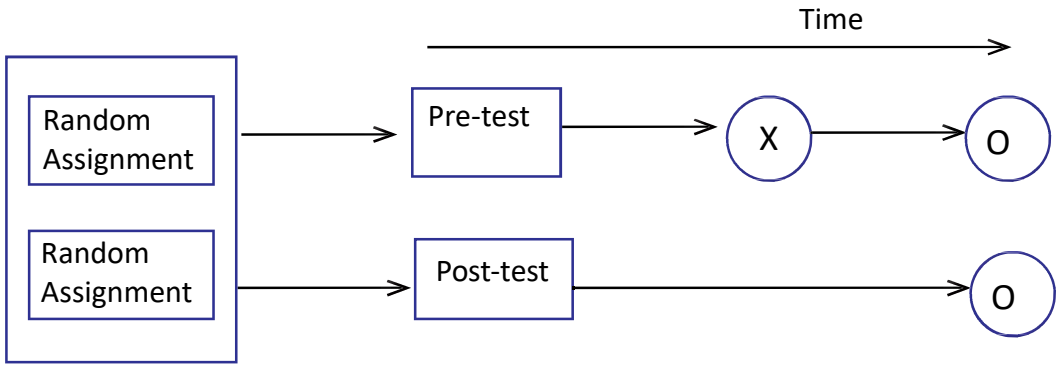
Non-equivalent control Group Design



This design compares an experimental group with a similar but not necessarily equivalent group. For example, suppose you want to study the effect of a training on Monitoring and Artificial Intelligence Tools for Smart Agriculture given to field agricultural workers. Groups of 20 field agricultural workers might be called into the training centre for a three-week retraining programme. These trainees could be given a pre-test (01), followed by the three-week training course and then the post-test (02). For purposes of comparison, a similar group of field agricultural workers who had not yet been given the refresher training course could be administered the same pre-test at the same time (03) and the same post-test (04). We could use the two pre-tests (01 and 03) to assess the extent to which the two groups of field agricultural workers were truly similar. Then we would compare the two post-test (02 and 04). We would expect that 02 would be greater than 04 because of the effect of the refresher

training (X). This design is good in the evaluations of training programmes or in comparing agricultural programme effects in a community where it was introduced against a similar but not necessarily an equivalent neighbouring community. In using this design attention must be given to the analysis of 01 against 03 and look for selection effects or other differences.

Separate Sample Pre-test-Post-test Design



The design involves doing a baseline pre-test (01) with a randomly selected sample from a study population. A programme intervention (X) is introduced, and then a post-test measurement (02) is made using a second randomly selected sample from the same study population. The design avoids testing effects, but it does not control for:

- History;
- Maturation;
- Mortality;
- and instrumentation.

Non-Experimental Designs

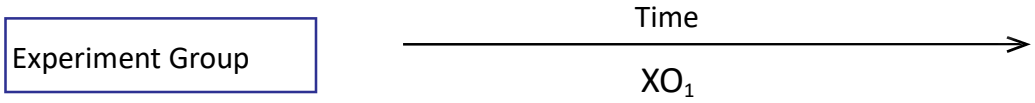
Non-experimental research is good at establishing that a relationship is present but has problems with the other two conditions (establishing proper time order and ruling out alternative explanations).

However, many research projects targeting behavioural change in agriculture would have to contend with the level of analysis non-experimental research designs offer since extraneous factors are usually present and absolute control are more or less an exception. Research involving humans cannot attain the level of manipulation possible in basic sciences.

In contrast to experimental research, which is a clearly defined research method, non-experimental quantitative research is more varied. However, those deployed in research related to changing agricultural practices and behaviours through the introduction of technology will be discussed.

These designs are most appropriate for collecting descriptive information or for doing small case studies of a particular situation. They are not recommended for evaluation studies that attempt to determine the effect of an agricultural intervention programme, but they may be useful in diagnostic studies to determine the reasons why a problem exists.

Post-test-only Design

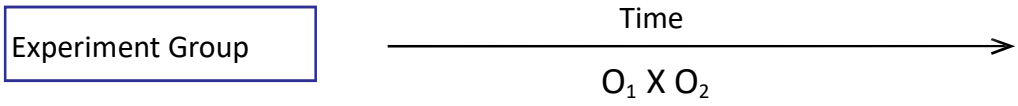


In this design, an intervention programme (X) has been introduced, and sometime after its introduction, a measurement observation (O1) is made. Since there is no control group, there is no possibility of comparing the O1, measurement with any other measurement. All that the O1 measurement can do is provide descriptive information. The threats to the validity of:

- History;
- Maturation;
- Selection; and
- Mortality are not controlled and, therefore, are factors to consider.

This design would be most appropriate if an investigator wanted to know, for example, the demographic characteristics of acceptor of a particular agricultural technique. The X would represent the treatment introduction of a particular agricultural technique. The O1 would consist of information collected from a group of acceptors. Much useful programme information can be obtained if multivariable data analysis techniques are used.

Pre-test – Post-test Design



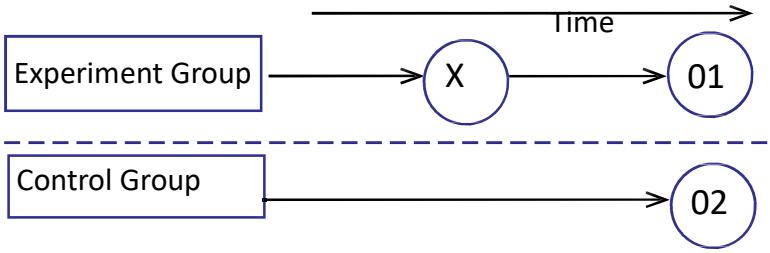
Pre-test-post-test design involves only one group that is given a pre-test, a test stimulus or treatment and a post-test. It is also called 'Before and After Design'. There is no control group and it is assumed that any change in the dependent variable is due to the test stimulus. There is no way of knowing for sure that a change in a dependent variable was due to the experimental variable and not to other factors.

A situation where pre-test-post-test is used is when a researcher sets at measuring the effectiveness of a certain agricultural technology among a group of farmers in a particular population. For instance, if an agricultural programme sets to empowering women through training on the use of AI technology to enhance the production of a particular crop or livestock, the participants are administered a test prior to training and again after. The difference accounts for what the training experience has contributed to the women's knowledge.

This design has no control group. It uses a pre-test to provide information on the experimental group before giving a post-test. The design allows the researcher to examine changes over time. It does not control for:

- History;
- Testing;
- Maturation; and
- Instrumentation.

Intact-Group Comparison



ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

This design has two groups – experimental and control groups. The experimental group receives an intervention programme (X) followed by a measurement observation (O1). This measurement observation is then compared against a second observation (O2) from a control group that did not receive the programme. A random process was not used to create the two groups, and there was no pre-test to check the equality or equivalence of the two groups. It fails to control for selection and mortality.

Mixed Methods Designs

There are three core mixed methods designs namely:

1. Convergent parallel mixed methods;
2. Explanatory sequential mixed methods; and
3. Exploratory sequential mixed methods. (Innovation Systems Method)

Exercise 4

Identify and name the designs applicable to your study

Convergent parallel mixed methods

This is a type of mixed methods research in which the researcher concurrently collects and combines quantitative and qualitative data to provide a full overview of the research problem. Typically, the researcher collects both types of data at nearly the same time, separately analyses the data and then combines the information into the overall results during interpretation or sometimes during data analyses.

Explanatory sequential mixed methods

This is a mixed methods design that appeals to those who have a strong quantitative background or come from sectors where qualitative approaches are relatively new. It is a two-part data-collecting project in which the researcher gathers quantitative data in the first phase, analyses the results, and then plans (or builds on) the qualitative phase in the second. The quantitative findings usually guide the types of people that will be purposefully chosen for the qualitative phase, as well as the types of questions that will be asked of them. The overarching goal of this approach is for the qualitative data to assist in explaining the initial quantitative results in greater depth.

Exploratory sequential mixed method

It begins with a qualitative phase and then moves on to a quantitative stage. A three-phase exploratory sequential mixed methods design is one in which the researcher starts with qualitative data and analysis, then creates a feature to be evaluated (e.g., a new instrument, experimental procedures, a website, or new variables) and tests it quantitatively in the third step. The second feature, like the explanatory sequential technique, builds on the initial database's results. The goal of this strategy is to experiment with a small group of people

initially, so that the quantitative phase may be adapted to the needs of the people being investigated. Establishing Internet application that is tailored to the needs of the people being examined. When researchers need to understand a community or population before providing instruments, the researchers would collect focus group data, analyse the results, create an innovation such as AI, and then deliver it to a population sample.

Innovation Systems Method

The concept of innovation refers to the quest for novel technologies developed, adapted, imitated, and used which are new to a specific environment.

On the other hand, the innovation system notion encompasses all of the actors involved in innovation and their interactions. It encompasses elements influencing demand for and application of innovation in productive ways, in addition to the generation of knowledge.

In the study of agricultural innovations, the innovation system framework is a valuable tool. The reality of agricultural innovation is that it includes a wide range of actors, each with its own sets of roles. Each role is critical, and actors and stakeholders must work together to accomplish innovation.

It shifts the focus away from agricultural technology to the entire system, of which research is just one component.

Steps in Applying the innovation system Method in Research Design

i. Review previous policies, acts and initiatives

Identify the previous policies, acts, and initiatives (activities, programmes and projects) related to the specific issue, such as crops, and livestock in a specified geographic location. State the science and technology issues coming from the review, such as evidence of learning and improvement of later policies over previous ones, the capability of staff, etc.

Assignment

Conduct the review of policies, acts and imitative in artificial intelligence and the agro-technology of concern in your study for your country

ii. Identify the major stakeholders within the agricultural innovation system

Defining and evaluating the significant players or stakeholders is one of the important aspects of adopting the innovation system. Each of the aforementioned could be an important actor in the system:

- Farms – small, medium, and large;
- Suppliers of inputs and services (such as seed, feed, agrochemicals, machinery/ equipment, transportation, financing, and insurance)
- Agro-processing firms (small, moderate, and big);
- Traders, market, and users; wholesalers, retailers, supermarkets, asset boards;
- Policymakers and lawmakers (groups that shape policy as well as generate resources);

- Agencies-ministries of agriculture, science & technology, education, trade and industry, commerce and regulatory bodies (IP, ISO);
- Research institutions (national, regional, international whether public, quasi-governmental, private);
- Training institutions- universities and other institutions of higher education;
- Extension service- organizations that disseminate information and services related to agricultural technology delivery;
- Farmers - Farmers' groups, cooperatives, as well as other non-governmental (public, corporate, or quasi-governmental) organizations that encourage collaboration;
- Business establishments and financial institutions that offer business services such as feasibility assessments and business blueprints, as well as assistance with marketing strategy formulation.

iii. Identify and map the linkages between the stakeholders within the system

It is essential to assess the interconnections that exist or should occur among actors in a system. The best way to improve the innovation cycle is to connect technology users to technology developers and agro-production to consumers. Partnerships are defined by the sharing of responsibilities, which leads to enhanced synergy in the creation and diffusion of technology. Defining all key stakeholders in the innovation system and mapping their interconnections in a particular sub-sector is a pivotal step in the diagnostic process since it allows one to see who is active in continuous innovation. Figure 1 depicts some of the primary actors in agricultural extension as well as the predicted linkages.

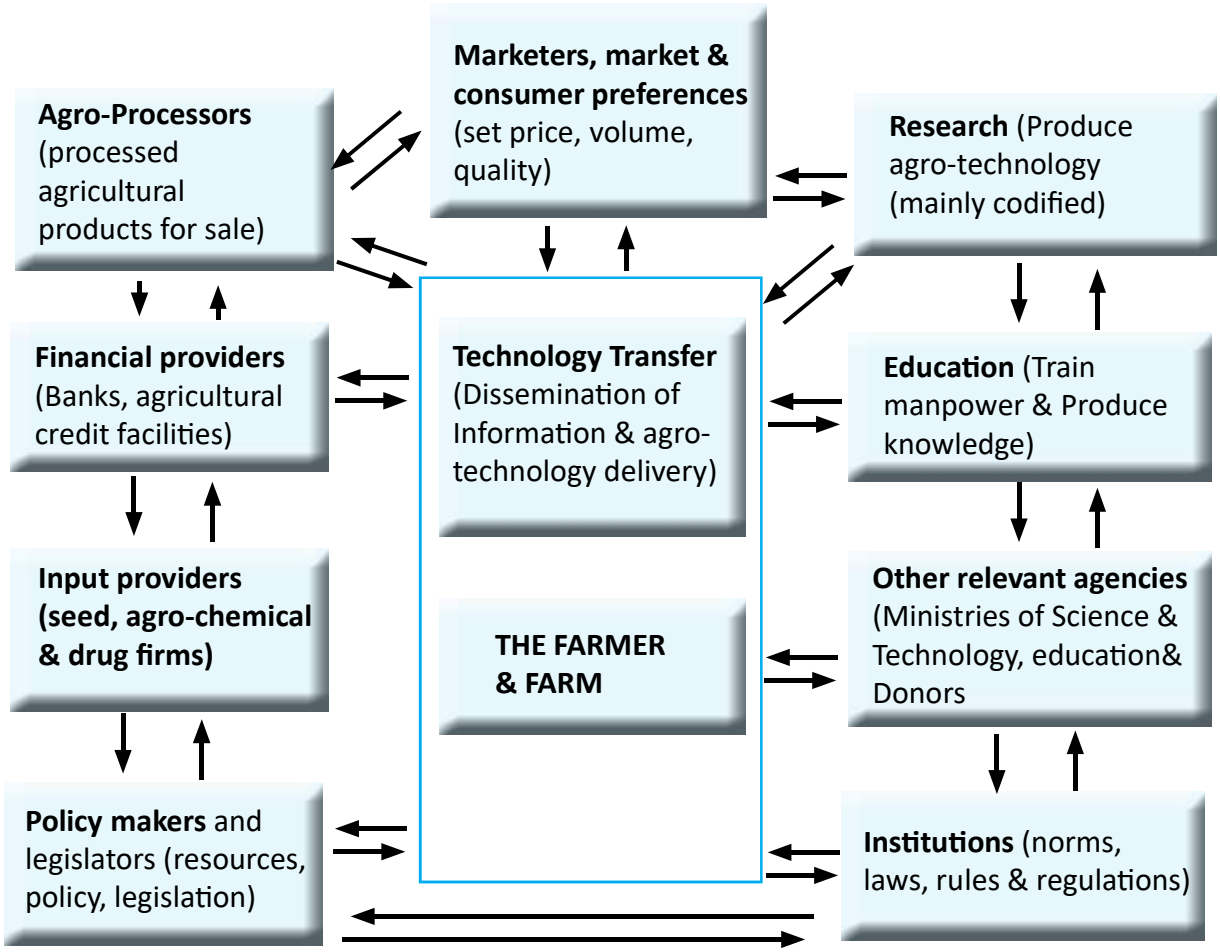


Figure 1 A framework for analysing the systems of innovation in agriculture

Figure 1 depicts the farmer and the farm as the core and focal point of agricultural innovation, and thus of agricultural policy. The producer and the farm are implanted, insulated and enveloped by the technology transfer agency. In an innovation system, the two actors are inextricably tied and interface with other actors, with all of the actors having direct relationships with one another. This means that each actor could perform activities beyond its primary domain. Actors can perform some functions in another actor's primary domain, based on the available capabilities. Farmers, for instance, are capable of developing agricultural technology and do so frequently. Researchers and higher institutions can produce agricultural technologies as well as transfer them to farmers.

Furthermore, the agricultural innovation system requires that, in order for a researcher to develop a specific agricultural technology, he or she must have empathy and connections with all players who have responsibility or interest (expressed or not) in the technology.

iv. Determine and the technological capabilities of agricultural extension innovation system actors

The knowledge necessary to comprehend technological innovations, adapt, accept, upgrade, and disseminate them is known as technological capability. They play a critical role in establishing and maintaining competitiveness among innovation system actors. Technological capability is built through learning. Individual actors or agencies, as well as the agency itself, gain knowledge. In general, technological capability is made up of seven elements. They are: investment, production, small and substantial modifications, linkage, marketing, and learning capacities. Learning capabilities traverse the other six technological competencies. When the actors in an innovation system learn through time, they build up technological knowledge and gradually take on new tasks and skill.
The final effect of the agricultural innovation system is on customers' or end users' technological skills. They are indicators of how successful the innovation system is, and they give essential data for policymaking and policy reform.

Research Reports

Introduction to Report Writing

A research report is a written document (or oral presentation based on a written document) that communicates the procedure and findings of research to others. It is a record of the research process. It includes a problem definition or the reasons for embarking on the project, a description of the project's steps (methodology/method), a presentation of data (results) and a discussion of how the data relate to the research question or topic.

A research report tells others what the researcher has done, how the research was done, and what was found. It is a method of disseminating knowledge or information. Producing a good report depends on the researcher's knowledge of his/her audience; language style.

The audience: The key question in report writing is: who are you writing for? Who is the primary audience (the general public, specialists or professional colleagues, policy makers etc.)? Regardless of the audience, it is important to present the information in a clear, accurate, and logical sequence, avoiding excessive use of technical jargon and inaccuracies. Specifically, when writing for scholars, such as in professional journals, there is no need to define well-

known standard procedures (e.g., focus group discussions and informant interviews) or to restate standard statistical formulas (e.g., chi-square, correlation analysis, t-test, analysis of variance). Key demands here will include a compact and well-written description of how the research is linked to theories and findings in the literature, the design of the research, how variables are measured, methods of data collection, and succinct presentation and discussion of results.

For professionals in practice, they may require a short summary of the methodology and results presented graphically (charts and graphs), and explicit lines of action in the conclusion (recommendations). For non-specialists or the general public, use
simple language devoid of technical terms. Avoid details of the methodology and highlight the implications of the findings with practical examples.

The style and tone: The style is the choice of words and the length and form of sentences or paragraphs used by the author. The tone is the author's relationship to the subject matter, how formal or informal and personalized the report is.

The following are guides to achieving an acceptable tone and style:

a. Do not personalize research reports (for example, "I found out that most extension agents had no mobile phones"; "Ineffective communication causes almost all our development problems");
b. Eschew all forms of sentimentality and generalizations in writing a report. These often lead to moralizing, use of flowery language and making recommendations that do not derive from data. Avoid the use of words such as "obviously" or "the study discovered" A more common but unacceptable style is to rely on passages in the Holy Books to conceptualize a research problem.
c. Write crisp and short sentences observing all forms of grammar, punctuation, case rules, etc. Use a language editor such as "Grammarly";
d. Discard every word that does not add value to the statement and go straight on to state what you want to say (for example, "results of the survey show that the majority (84%) of farmers were literate and…" This could read, "The majority (84%) of the farmers were literate and…"); and
e. Do not start sentences with figures. If you must, write in words and sparingly. When writing figures in the body, write double digits in figures and single digit in words.

Titles should be short and catchy, preferably between 2 and 18 words. Avoid using a colon (:) in the title.

Abstract or executive summary - the abstract is a summary of the report and may contain 50-250 words. Many journals and institutions place limits on the length. An abstract should give information on the topic, the research problem, methodology, conclusion and recommendations. On the other hand, an executive summary is a longer form (1-5 pages).

Introduction

The Introduction consists of Background Information, a Problem Statement, Objectives, Hypotheses and the Significance of the Study.

Background

Although the sub-headings may vary, the background statement covers in broad terms the past and present state (trend) of the subject under investigation ensuring that key concepts/ variables in the topic are defined and linked to theory. A traditional style is an inverted pyramid, which emphasizes starting from a broad/global perspective and narrowing down to the issue under study.

Problem Statement

The writer attempts to put the problem of study in context and in some cases may support it with earlier studies in order to establish a gap in knowledge. A problem is a perceived difficulty, the feeling of discomfort in the ways things are or a discrepancy in what someone believes should be and what is. **A problem** statement should contain the following:

- A perceived discrepancy between what is and what should be. The discrepancy can be in form of a condition or question.
- A question about why the discrepancy exists must be asked.
- At least two possible and plausible answers

Research questions This will naturally flow from the problem statement. The questions are converted to action statements which become the specific objectives. Prior to this, it is normal to state the purpose of the study, which is derivable from the key concepts in the title.

Hypotheses: This may be formulated around key variables or sub-samples.
Significance of the study: This relates to the rationale or justification for what is being studied, and the use and importance to various consumers of the information derived from the study.

Literature review: The literature review is a survey of existing information on the subject under study and includes opinions and empirical findings. It gives focus to the study and helps to establish the gap in knowledge which your study is intends to fill. This explains why some funding agencies and institutions insist that researchers begin with literature review. Organizing notes for the review is an easy task if the concepts/variables of the study are clearly identified and defined. It is easier to draw the outline based on these concepts as headings and sub-headings. Each section should be interlaced with findings of other related studies, some of which will be useful in the discussion of results. A literature review reads better where ideas flow and are linked to one another by the profuse use of conjunctions. Start the search from the recent sources and move backwards (2023, 2022, 2021, 2020, 2019, etc.)

Unless you want to show the perennial nature of the problem, do not use literature that is more than five years old, three years will be preferable.

Two sub-sections of the literature review include the theoretical framework and conceptual framework. The former is often found missing in many research reports. It is a review of all related theories that guide the work. Theories may not be testable in some cases, but they give insight into events in the real world and, therefore, help to clarify the direction the researcher intends to follow. For example, adoption has a number of theories and methods of measurement including economic and psychological theories. Which of the theories or a combination of them does the researcher intend to apply? These theories are used to build a structure for the study and form the basis on which the study will be tested. Conceptual framework refers to the inter-relationships between and among dependent, intervening and

independent variables in a study. It shows the direction of the study variables to be measured and the potential outputs as conceived by the researcher.

Methodology: The section describes:

1. **The design of the study:** It is useful to specifically state the design used for the study.
   (a) **Non-Experimental Designs** (Post-test-only Design, Pre-test – Post-test Design, Intact-Group Comparison);
   (b) **True Experimental Designs** (Pre-test-post-test Control Group Design, Post-test-only Control Group Design); and
   (c) **Quasi-Experimental Designs** (Time Series Design, Non-equivalent Control Group Design, Separate Sample Pre-test-Post-test Design).

2. **The study area.** Provide key information about the areas that are related to the study. A study of ICT use by farmers in a country should present the ICT characteristics of the country and the characteristics of farmers and farming in that country. A study of the use of AI in enhancing the production of a particular crop in a location should present the characteristics of the location in terms of facilities for the use of the AI and the persons to use the AI.

3. **Population of study; sample and sample selection (if any).**
   - Identify and name the sampling techniques used.

4. **Instrument for data collection; data collection technique and measurement of variables/ variable specification.**
   - Do not mix up objectives and variables
   - Properly identify all the variables in each objective.
   - Operationalize the variables by letting your reader know how each variable is defined and measured (variable specification).

5. **Data analysis and ethical issues where necessary.**
   - Report the statistical techniques used for each set of data.
   - Tie data analysis tool to data collection tool.
   - Do not include basic statistical formula (e.g., Percentage, Mean, Chi-square, ANOVA, etc.) in the report.

6. **Results and discussion:** The section is presented under headings derived from the specified objectives. Here data are summarized in tables and charts and presented in clear, straightforward language. It is neater to present only key results before each table and followed by the discussion.

7. **The following are involved:**
   - Present the data in such a way that the reader may not need to go back to the table;
   - Interpret the data, that is, say what the data means to the problem under investigation and;
   - Discuss the data by relating the findings to previous research and drawing inferences and conclusions. Are there any changes from previous findings? If not, why? If so, why? The discussion should focus on a concise and unbiased interpretation of the results, highlighting

unexpected findings, areas of agreement or disagreement with existing knowledge, possible alternative explanations for the results, and potential limitations.

Conclusion: This means wrapping up. It gives the opportunity to make a statement on the problem investigated based on the findings for the main objectives. Has a solution to the problem investigated been partially or completely found? What remains?

Recommendations

Here, identify how the findings or the identified solutions to the problem will be implemented. State who will do what (provide resources, implement, sensitize), how and when.

Reporting Qualitative Research

It is more difficult to report qualitative research than quantitative research because conventional procedures found in the latter are absent. It is often subjective as the volume of data is in the form of words, drawings, pictures, photographs, maps, quotes etc. Use natural history (reporting events as they unfold) and chronology (following the developmental cycle of a people or growth, e.g., shift from subsistence to commercial production of Nsukka Yellow pepper). It is commonly used in producing project appraisal and needs assessment reports.

Citation and Referencing

A citation is an identification of the source (author/document) from which an idea/quotation is taken. A citation is a reference to a document. It should include all the bibliographic details needed to trace the document. It consists of the surname of the author(s)/document, year of publication and or page number. For example:

1. Akpan and Udo, 2022;
2. Isife, 2021: 55; and
3. According to Akpan (2021a).

The first example shows the names of the authors and the year of publication. In the second example, the citation is used to start a sentence.

Personal communications are included in citations. Personal communications may be letters, memos, some electronic communication (e.g., e-mail or messages from non-archived discussion groups or electronic bulletin boards), personal interviews, telephone conversations, and the like. Because they do not provide recoverable data, personal communications are not included in the reference list. Cite personal communications in text only. Give the initials as well as the surname of the communicator, and provide as exact a date as possible for example, “According to T. K. Lutes (personal communication, April 18,2022) "

Key points to note

1. Where an author/s’ works published in the same year are cited in the same piece, differentiate them with letters, e.g., **(Akinbile & Afolayan, 2022a), (Akinbile & Afolayan, 2022b).**

2. Insert comma after surname of author before date (year). If multiple citation, break with semi-colon, e.g.,**(Agwu and Olajide, 2022; Igbokwe, 2021; Umar and Adamu, 2019)**. Note that the listing starts from the most recent.

Referencing

A reference is a complete information about the source cited in the report and listed at the end of the report. A **bibliography** is a list of documents (books, articles, papers) read for a specific essay or assignment, cited or not cited in the body of the report. In each case, It shows the full name of the author(s)/organisation, the title of the work or book/report, the volume and number in the case of journals and bulletins, the publisher and publishing city and the pages. It has to be emphasised that there are different formats for citation and referencing (such as the Library of Congress style, the American Sociological Association style and the American Psychological Association (APA, style).

The APA style is common in reporting studies in agricultural innovation and policy and is presented here. It should be noted that while APA style changes over time (see APA Website for latest information) Science publishers use variants that only approximate the current version. Depending on the style adopted or recommended by the publisher, institution/association or funding agency, the author must painstakingly maintain a high level of consistency. The sample format below is taken from the 7th edition of APA Website. You should make a habit to always consult the website to guide your citations and referencing.

Sample Format for Reference List Based on the APA Style

Please note the references used in this section are for illustration and do not exist.

1. Authors

Write all authors' names beginning with the surname(s), followed by their initials. If there is no author, place the title in the author position.

Examples

a. **One author:** Qing, S. (2020) Gender role attitudes and males-female income differences in China. Journal of Chinese Sociology 7 (12); 1-23 020) 7:12 https://doi.org/10.1186/s40711-020-00123-w
b. **Two authors:** Kehinde, A.D. & Ogundeji, A.A. (2022). The simultaneous impact of access to credit and co-operative services on cocoa productivity in South-western Nigeria. Agric & Food Security 11, 11 (2022). https://doi.org/10.1186/s40066-021-00351-4
c. **Three, Four or Five Authors:** Lamastra, L., Balderacchi, M., Di Guardo, A., Monchiero, M., &Trevisan, M. (2016). For the first cite, all the authrs should be cited inside the report as Lamastra, L., Balderacchi, M., Di Guardo, A., Monchiero, M., &Trevisan, M. (2016).

Further cites can be shortened to the first author's name followed by et al as Lamastra, L., et al. (2016). However, all the names of authors should be listed in the reference as Lamastra, L., Balderacchi, M., Di Guardo, A., Monchiero, M., &Trevisan, M. (2016). A novel fuzzy expert system to assess the sustainability of the viticulture at the wine-estate scale. Science of the Total Environment, 572, 724–733. https://doi.org/10.1016/j.scitotenv.2016.07.043

d. **Six or More Authors:** Only the first author's surname should be stated inside the report followed by et al, For detail guide visit https://www.mendeley.com/guides/apa-citation-guide/

MODULE 2

Digital Data Collection and Management with Open Data Kit (ODK) and REDCap

Introduction to data management and data science

Data management refers to the process of organizing, storing, and maintaining data so that it can be used effectively. This involves designing and implementing data storage systems, developing processes to ensure data quality and security and managing the retrieval and use of data. Effective data management is crucial for organizations that generate and use large amounts of data, as it enables them to make informed decisions based on accurate and reliable information. Data management can increase the visibility of your organization's data assets, making it easier for people to quickly and confidently find the right data for their analysis.
Data science, on the other hand, is the scientific study of data. It involves the use of statistical, computational, and mathematical methods to extract insights and knowledge from data. Data scientists use a combination of data analysis, machine learning, and predictive modeling to understand patterns and relationships in data, and to make predictions about future events and trends.

Data management and data science work together to create value from data. Data management provides the infrastructure for storing and accessing data, while data science provides the tools for analyzing and making sense of that data. The combination of these two fields enables organizations to turn raw data into valuable information that can be used to drive business decisions, support research, and improve operations.

One of the key challenges of data management is the growing volume and complexity of data. As more and more data is generated, it becomes increasingly difficult to store, manage, and analyze. This has led to the development of new tools and technologies, such as data warehousing and big data platforms, which allow organizations to store and process massive amounts of data in real-time.

Data science is also facing new challenges as the volume and complexity of data continues to grow. One of the main challenges is ensuring data quality and accuracy, which is essential for reliable data analysis and decision-making. Another challenge is the integration of data from multiple sources, which can be difficult and time-consuming, but is essential for creating a comprehensive view of the data.

Despite these challenges, the field of data management and data science continues to evolve and grow. New techniques and technologies are being developed all the time, and there is a growing demand for data professionals with the skills to turn data into actionable insights. Whether you are a business professional, researcher, or just someone with an interest in data, there has never been a better time to learn about data management and data science.
In conclusion, data management and data science are critical fields in today's data-driven world. Effective data management provides the infrastructure for storing and accessing data, while data

science provides the tools for analyzing and making sense of that data. Both fields are facing new challenges as the volume and complexity of data continue to grow, but the opportunities for creating value from data have never been greater. Whether you are just starting out in your career or are looking to expand your skills, data management and data science are exciting and rewarding fields to explore.

1.2 : Principles of Data Management

Data management is a crucial aspect of any organization, as it helps ensure the accuracy, quality, and security of data. The following are the principles of data management that organizations should follow:

1. Data Governance: This principle involves setting rules and policies for the management of data within an organization. It defines roles and responsibilities, establishes data standards and procedures, and ensures that data is used in a consistent and compliant manner.

2. Data Quality: This principle involves ensuring that data is accurate, complete, and relevant to the needs of the organization. This can be achieved through processes such as data validation, data cleansing, and data standardization.

3. Data Security: This principle involves protecting data from unauthorized access, theft, or damage. This can be achieved through techniques such as encryption, access control, and backup and recovery procedures.

4. Data Availability: This principle involves ensuring that data is accessible and usable when it is needed. This can be achieved through techniques such as replication, disaster recovery planning, and data archiving.

5. Data Privacy: This principle involves protecting sensitive and personal data from unauthorized access or misuse. This can be achieved through techniques such as data anonymization, access control, and data encryption.

6. Data Integration: This principle involves integrating data from different sources and formats into a common data model. This can be achieved through techniques such as data mapping, data warehousing, and data federation.

7. Data Analytics: This principle involves using data to make informed decisions and improve organizational performance. This can be achieved through techniques such as data visualization, data mining, and predictive analytics.

8. Data Retention: This principle involves ensuring that data is retained for the appropriate amount of time and disposed of in accordance with legal and regulatory requirements.

9. Data Backup and Recovery: This principle involves ensuring that data can be recovered in the event of a failure or disaster. This can be achieved through techniques such as backup and recovery planning, disaster recovery planning, and data archiving.

10. Data Auditing: This principle involves monitoring data to ensure that it is used in a compliant and ethical manner. This can be achieved through techniques such as data logging, data monitoring, and data analysis.

1.2.1 : Conclusion on principles of data management.

The principles of data management provide a framework for organizations to effectively manage their data. Adhering to these principles helps ensure that data is accurate, secure, and usable, and supports informed decision-making and improved organizational performance. Effective data management is a key component of a successful and sustainable organization.

1.3 : Principles of Data Science

Data Science is an interdisciplinary field that involves the use of mathematical and computational methods to extract insights and knowledge from data. The following are the principles of data science that guide the practice of data scientists:

1. **Evidence-based Decision Making:** This principle involves using data to make informed decisions, rather than relying on intuition or personal opinions. Data scientists collect and analyze data to test hypotheses and make predictions about real-world phenomena.

2. **Reproducibility:** This principle involves being able to reproduce the results of a data science project, so that others can verify and build upon the findings. This can be achieved through the use of version control systems, clear documentation, and open-source code.

3. **Iterative and Exploratory:** This principle involves using an iterative and exploratory approach to data analysis, rather than a one-size-fits-all approach. Data scientists often start with a broad understanding of the data and refine their analysis as they gain more insights.

4. **Collaboration and Communication:** This principle involves collaborating with other stakeholders, such as domain experts, business leaders, and data engineers, to understand their needs and communicate the results of data science projects. Data scientists must be able to present their findings in a clear and concise manner to a non- technical audience.

5. **Ethical and Responsible:** This principle involves being ethical and responsible in the collection, analysis, and use of data. Data scientists must consider the privacy, security, and fairness of the data they work with and ensure that their findings are not used to harm individuals or groups.

6. **Inclusiveness and Diversity:** This principle involves being inclusive and diverse in the data science community, so that a wide range of perspectives and experiences are represented. This helps ensure that data science projects are more likely to be effective and impactful, and that the results are representative of a diverse population.

7. **Continual Learning:** This principle involves being continuously learning and expanding one's knowledge and skills in data science. Data scientists must stay up-to-date with new technologies, algorithms, and methods to be effective in their practice.

8. **Problem-solving:** This principle involves using data science as a tool for solving real-world problems. Data scientists work to understand the problem, identify relevant data, and use their skills and knowledge to generate solutions and insights.

9. **Data-driven:** This principle involves being data-driven, rather than relying on intuition or assumptions. Data scientists collect, process, and analyze large amounts of data to generate insights and inform decision-making.

10 Robustness and Generalization: This principle involves ensuring that the results of data science projects are robust and generalizable, meaning that they can be applied to new and unseen data. Data scientists use cross-validation, bootstrapping, and other methods to test the robustness of their models.

1.3.1 : Summary on principles of data science.

The principles of data science provide a framework for data scientists to effectively practice their craft. Adhering to these principles helps ensure that data science projects are evidence-based, reliable, ethical, and impactful. Effective data science requires a combination of technical skills, problem-solving abilities, and communication and collaboration with other stakeholders.

1.4 : Data Tools

Internationally acceptable tools for Data Management and Data Science are:

Data Management Tools:

1. SQL databases such as MySQL, PostgreSQL, and Microsoft SQL Server
2. NoSQL databases such as MongoDB, Cassandra, and CouchDB
3. Data warehousing solutions like Amazon Redshift, Google BigQuery, and Snowflake
4. Data integration tools like Talend, Apache NiFi, and Microsoft Power Query
5. Data quality tools like Trillium Software and Informatica Data Quality

   ODK and REDCap 7.

Data Science Tools:

1. Programming languages like Python, R, and Julia
2. Data visualization tools like Tableau, QlikView, and D3.js
3. Machine learning frameworks like TensorFlow, PyTorch, and scikit-learn
4. Natural language processing libraries like spaCy, NLTK, and Gensim
5. Deep learning frameworks like Keras and PyTorch
6. Big data processing tools like Apache Spark and Hadoop
7. Collaboration and project management tools like Jupyter Notebook and GitHub

Note: The above list is not exhaustive and the tools used in Data Management and Data Science can vary depending on the specific requirements and needs of an organization or project.

1.5 : Advantages of ODK and REDCap over other Data Management tools

ODK (Open Data Kit) and REDCap (Research Electronic Data Capture) are two popular open-source data collection and management tools used in the field of research and public health.

Both tools offer several advantages over other data management tools:

1. **User-friendly:** Both ODK and REDCap have a user-friendly interface and are designed to be accessible to non-technical users. This makes it easier to collect and manage data, especially in low-resource settings where technical expertise may be limited.
2. **Customizable:** Both tools are highly customizable and allow users to design and configure

forms that meet their specific needs. This makes it possible to collect a wide range of data types and to adapt to changes in research or data collection requirements.

1. **Secure:** Both ODK and REDCap have robust security features that protect sensitive data and ensure that data privacy is maintained.
2. **Real-time data:** Both tools allow for real-time data collection and management, making it easier to monitor and manage data as it is being collected.
3. **Integration with other tools:** Both tools can be integrated with other data management and analysis tools, such as databases and statistical software, to support data management and analysis.
4. **Collaboration:** Both tools support collaboration and teamwork, allowing multiple users to work together on a project and share data and results.
6. **Cost-effective:** Both ODK and REDCap are open-source and free to use, making them cost-effective options for data management.

1.6 : Ethics of Data Management and Data Science as it relates to responsible Data Principles

The rapid growth of data management and data science has led to a corresponding increase in ethical considerations. As large amounts of personal and sensitive information are collected, processed, and analyzed, it is critical that organizations ensure that the data is being managed in a responsible and ethical manner. In this context, responsible data principles are a set of guidelines that help ensure that data is collected, processed, and used in a way that respects the privacy, security, and dignity of individuals.

1. **Transparency:** One of the key principles of responsible data management is transparency. Organizations must be open and transparent about what data they collect, how it is used, and who it is shared with. This helps to build trust with individuals, and ensures that the data is being used for legitimate purposes. Additionally, transparency helps to reduce the potential for misuse or abuse of data, as individuals are able to understand how their information is being used and can take steps to protect it if necessary.

2. **Privacy:** Privacy is another critical consideration in responsible data management. Organizations must take appropriate measures to protect the privacy of individuals, such as implementing security measures to prevent unauthorized access to the data, and only collecting and using data for legitimate purposes. This includes ensuring that any personal information is anonymized or pseudonymized if it is not necessary to identify individuals. Organizations should also have clear and concise privacy policies that outline how the data is being used and who has access to it.

3. **Consent:** Another important principle of responsible data management is consent. Organizations must obtain the informed consent of individuals before collecting and using their data. This includes explaining the purpose of the data collection, what types of data will be collected, and how it will be used. Individuals must be given the opportunity to opt-out of data collection if they do not wish to participate.

4 **Fairness:** Fairness is an important consideration in responsible data management and data science. This includes ensuring that data is not used to discriminate against individuals or groups based on factors such as race, gender, religion, or sexual orientation. Data scientists must also be aware of potential biases in the data that may result in unintended consequences, such as biased algorithms or models. Organizations should regularly review their data and processes to ensure that they are not perpetuating harmful biases.

5 **Responsibility:** The final principle of responsible data management is responsibility. Organizations must take responsibility for the data they manage, and ensure that it is used in a responsible and ethical manner. This includes implementing appropriate security measures, regularly reviewing data policies and practices, and being transparent about how the data is being used. Organizations should also have processes in place to address any concerns or complaints from individuals regarding the use of their data.

References.

1. Jim Gray,David T Liu, Maria Nieto-Santisteban, Alex Szalay, David J DeWitt, and Heber. Scientific data management in the coming d decade. Acm Sigmod Record, 34(4):34–41, 2005.

2. Tobias Schoenherr and Cheri Speier-Pero. Data science, predictive analytics, and big data in supply chain management: Current state and future potential. Journal of Business Logistics, 36(1):120–132, 2015

3 Jinchuan Chen, Yueguo Chen, Xiaoyong Du, Cuiping Li, Jiaheng Lu, Suyun Zhao, and Xuan Zhou. Big data challenge: a data management perspective. Frontiers of computer Science, 7:157–164, 2013.

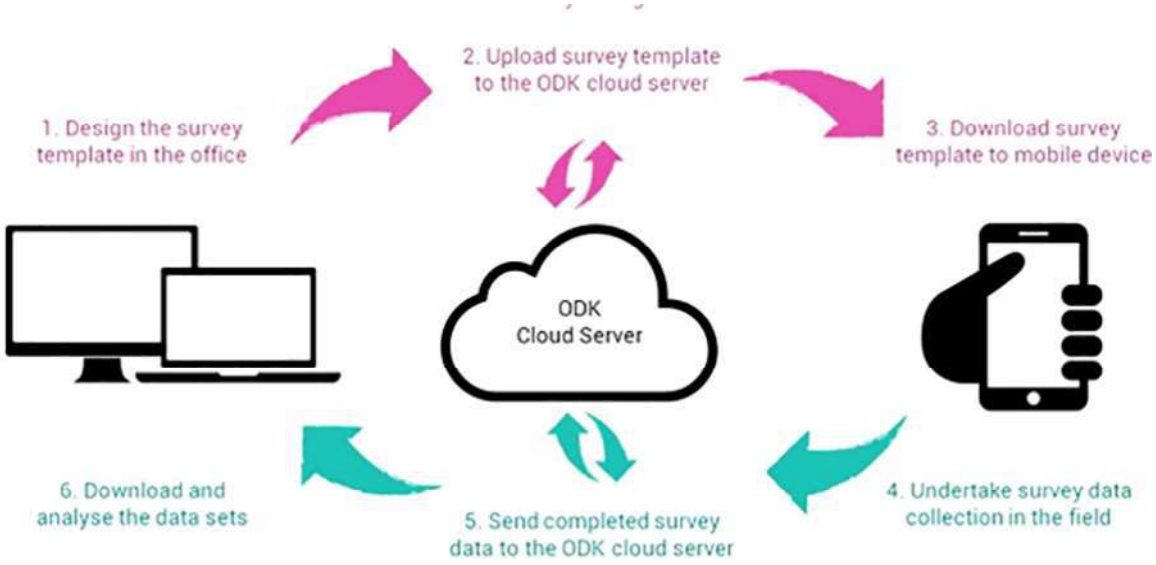
4. Wil Van Der Aalst. Process mining: data science in action, volume 2. Springer, 2016.

5. Fernando,L.F.Almeida. Benefits, challenges,and tools of big data management. Journal of Systems Integration (1804-2724), 8(4), 2017

Introduction to Open Data Kit (ODK)

Open Data Kit (ODK) is an open source data collection software that enables users collect photos, GPS locations, skip logic, calculations, external datasets, multiple languages, and more. Users use either mobile app or the web app where data collection forms and submissions are synced when a connection is found and can be accessed on ODK web application via user credentials and download their data or connect apps like Excel, Power BI, or R to create live-updating dashboards.

ODK workflow



ODK Website

This is the administration end that manages user accounts and permissions, stores form definitions and allows data collection mobile application to connect for form download and submission upload.

Below are the website features.

Creating and managing user accounts; website administrators can create and manage users who will access the website and mobile application forms.

There are two types of user accounts: Web Users and App Users
Web Users: have accounts on the management website. These accounts are global across all projects. They can login into the website and perform administrative functions like user management, form upload and management and submission data viewing and download.

App Users: can use mobile data collection app to connect to the website. Once connected through the app, they will be able to see the list of forms, download the ones they need and submit competed submissions to the website.

Role-based user permissions; the website allows assigning of roles to users, currently there are four roles: Administrator, Project Manager, Project Viewer and Data collectors.

Managing projects and forms; Web users with Project manager and Administrator roles can create projects and upload designed and programmed forms. Web user can be assigned to projects and given roles, app users can also be given access to programed forms, collect data and submit.

Form submission and management; in conjunction with website administration and data collection app on a mobile device, users can collect, and view data submitted through tabular and Map visualizer. Public access link feature also permits anyone with the link to collect and submit data online.

Clean and modern REST API for integration and extensibility; REST API makes website extensible with ability to integrate and build tools around the collected data.

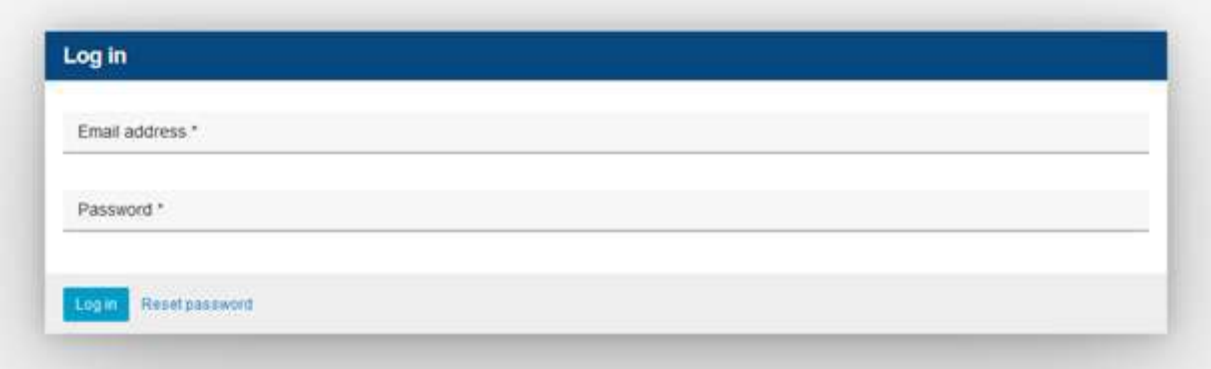
Clean and modern REST API for integration and extensibility; REST API makes website extensible with ability to integrate and build tools around the collected data.

Website Access

https://odk-server.icipe.org

Enter the above address on your **computer browser**, you should see the below screen. Then enter the below credentials.

Email: ai4afs@gmail.com Password: ai4afs@gmail.com123



Enter you **Email Address** and **Password**, password should be sent to you by the system administrator from ICIPE, then click on 

If you get the below notification, check if you have entered the right **Email Address** and **Password**, if it persists contact system administrator.

Projects and Form Access

Once you have successfully logged in, you will be navigated to a page which has the list of your assigned project(s) as below.

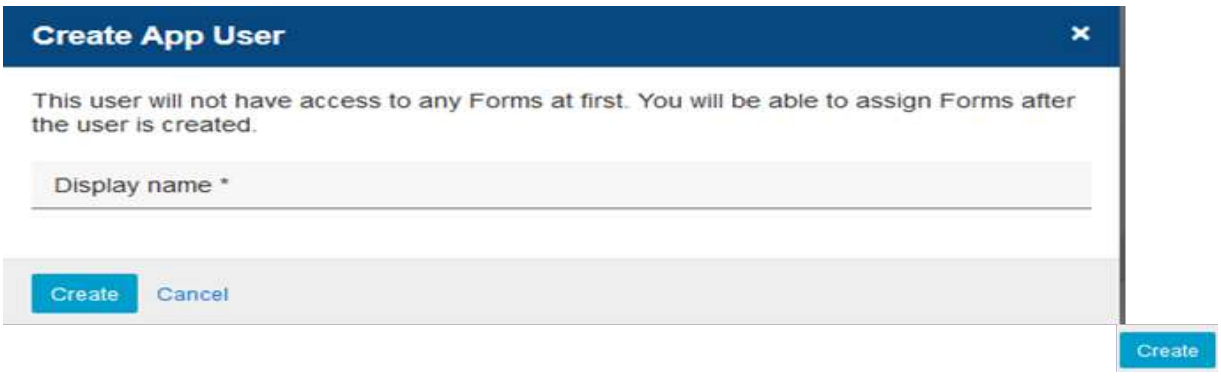
Click on the project name e.g. **ai4afsTraining**, this will navigate you to the list of project **Forms** as below.

You can click on  to preview the form structure and how it flows

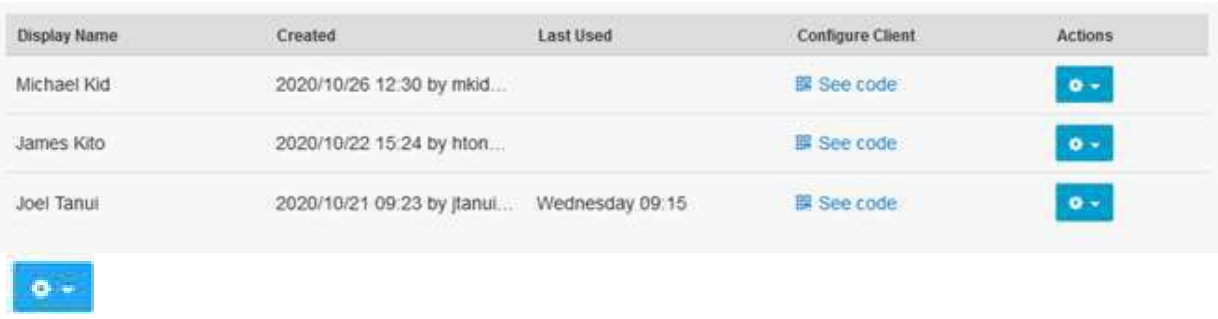
App Users

App Users are used to collect data from the mobile application on mobile devices. App users in a project can only download and use forms to collect data within a project.

Click the **App Users** tab as shown below



Enter the Display name of the App User(s) or the Group name of the App User. Click on and the name of the App user(s)/Group will appear as below.



Revoke App User: you can revoke or ban App User(s)/group from accessing project forms by clicking then 

Tab.  Below you will see the list of all App Users you created.

Check or Uncheck to allow App Users Access the forms on the mobile application. If you check ☑ the created App User(s)/Group will be able to access and download the form on the mobile application. If you uncheck ☐ the App User(s)/Group will not be able to access the form and collect data.
Click on Save to apply the changes.

Designing ODK Forms

There are 2 ways of designing ODK digital Forms

1. Using XLSForm
2. Using ODK Build

Using XLSForm

XLSForm is a form standard created to help simplify the authoring of forms in Excel. Authoring is done in a human readable format using a familiar tool that almost everyone knows - Excel. XLSForms provide a practical standard for sharing and collaborating on authoring forms. They are simple to get started with but allow for the authoring of complex forms by someone familiar with the syntax described below.

An Excel workbook typically contains two worksheets: 'Survey' and 'Choices.' A third, optional worksheet called 'Settings' can be added to include additional specifications for your form.

1 **The survey worksheet**

This worksheet gives your form its overall structure and contains most of the content of the form. It contains the full list of questions and information about how they should appear in the form. Each row usually represents one question; however, there are certain other features described below that you can add to the form to improve the user experience.

2 **The choices worksheet**

This worksheet is used to specify the answer choices for multiple choice questions. Each row represents an answer choice. Answer choices with the same list name are considered part of a related set of choices and will appear together for a question. This also allows a set of choices to be reused for multiple questions (for example, yes/no questions).

Setting up your worksheets

Both worksheets have a set of mandatory columns that must be present for the form to work. Additionally, each worksheet has a set of optional columns that allow further control over the behaviour of each entry in the form but are not essential to have. Every entry must have values for each of the mandatory columns, but the optional columns may be left blank.

- The **survey** worksheet has 3 mandatory columns: type, name, and label.
- The **type** column specifies the type of entry you are expecting for the question.
- The **name** column specifies the unique variable name for that entry.

  No two entries can have the same name. Names must start with a letter or an underscore.

Names can only contain letters, digits hyphens, underscores, and periods. Names are case-sensitive.

- The label column contains the actual text you see for the question in the form. Alternatively, label translation columns can be used.

type	name	label
today	today	
select_one gender	gender	Respondent's gender?
integer	age	Respondent's age?

survey | choices | settings

Question types

XLSForm supports a number of question types. These are just some of the options you can enter in the type column in the survey worksheet in your XLSForm:

Question type	Answer input
integer	Integer (i.e., whole number) input.
decimal	Decimal input.
range	Range input (including rating)
text	Free text response.
select_one [options]	Multiple choice question; only one answer can be selected.
select_multiple [options]	Multiple choice question; multiple answers can be selected.
select_one_from_file [file]	Multiple choice from file; only one answer can be selected.
select_multiple_from_file [file]	Multiple choice from file; multiple answers can be selected.
rank [options]	Rank question; order a list.
note	Display a note on the screen, takes no input. Shorthand for type=text with readonly=true.
geopoint	Collect a single GPS coordinate.
geotrace	Record a line of two or more GPS coordinates.
geoshape	Record a polygon of multiple GPS coordinates; the last point is the same as the first point.
date	Date input.
time	Time input.

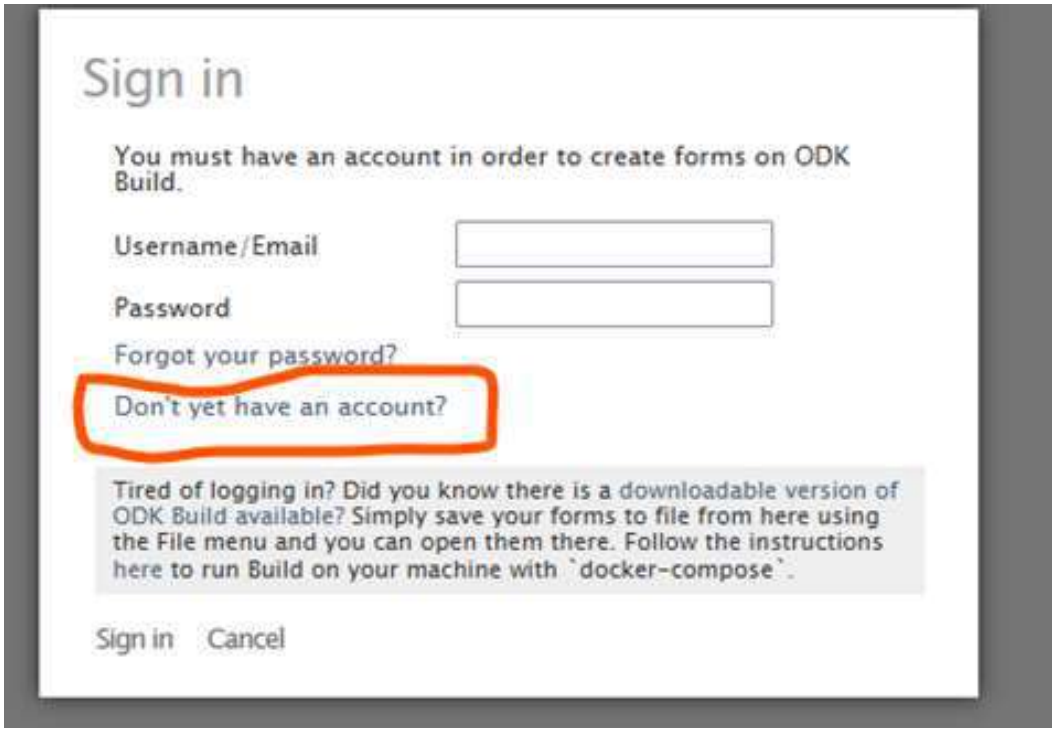
dateTime	Accepts a date and a time input.
image	Take a picture or upload an image file.
audio	Take an audio recording or upload an audio file.
background-audio	Audio is recorded in the background while filling the form.
video	Take a video recording or upload a video file.
file	Generic file input (txt, pdf, xls, xlsx, doc, docx, rtf, zip)
barcode	Scan a barcode, requires the barcode scanner app to be installed.
calculate	Perform a calculation; see the Calculation section below.
acknowledge	Acknowledge prompt that sets value to "OK" if selected.
hidden	A field with no associated UI element which can be used to store a constant
xml-external	Adds a reference to an external XML data file

For guidance on using XLSForm: https://xlsform.org/en

Using ODK Build

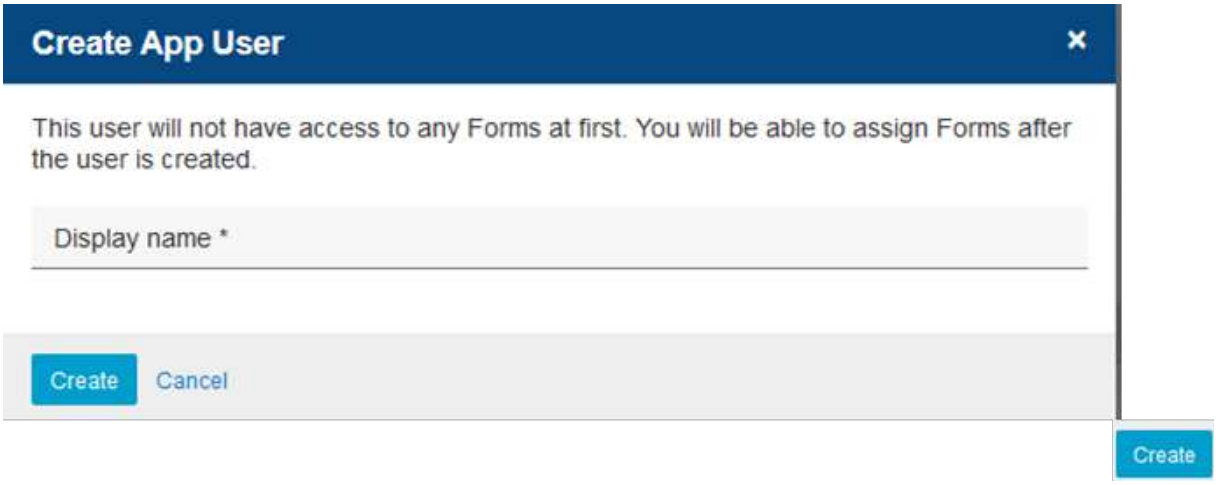
ODK Build is a web-based, drag-and-drop service for creating forms used with data collection tools such as ODK Collect and ODK Central. ODK Build is part of ODK, a free and open-source set of tools which help organizations author, field, and manage mobile data collection solutions.

How to use it:
Sign up through https://build.getodk.org/ by clicking the link as below:



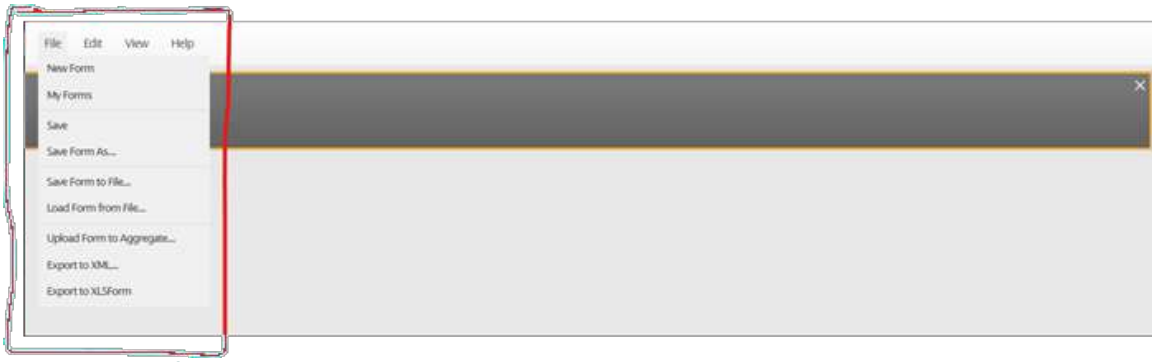
Enter the name of the form as below:

Click on the question type you would want to add e.g. Text, Numeric, Date/Time etc.



An interface will appear where you enter the Label, name Hint among others as below.

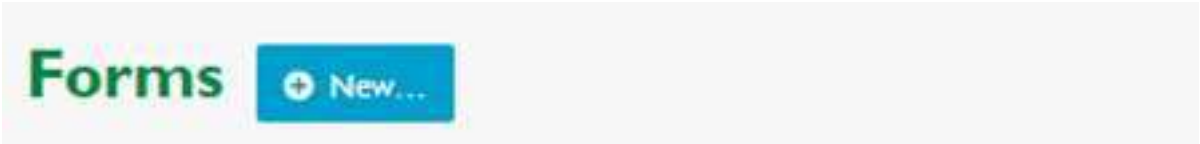
After you have completed the design, you will need to export the design as; **Export to XML** or **Export to XLSForm** as shown below.



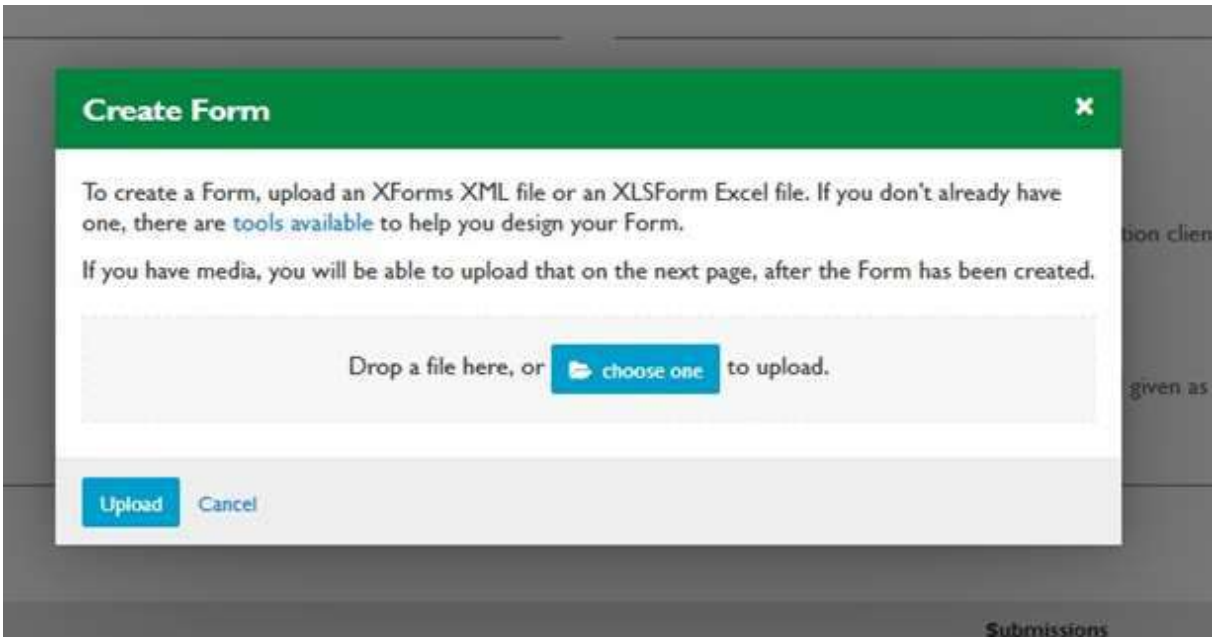
Note

Navigate to ODK Website and click on the project name as below:

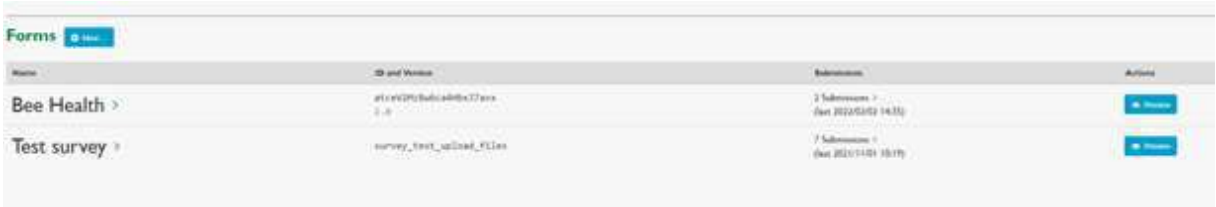
This will navigate you to project forms as below. Click on **New.**



A popup will appear where you will upload your exported XML or XLSFORM as shown below



After a successful upload the form will appear in the list of your form. **Please note that this can only be done by the administrator or project manager role.**



You can preview your form and give access to app users who are data collectors.

ODK MOBILE APPLICATION ACCESS

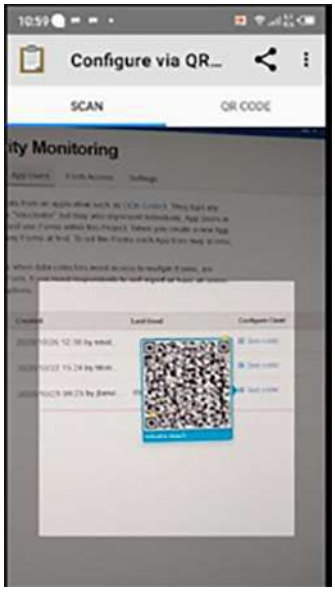
Download ODK mobile application from google play store. On your mobile device, search for **Odk** as shown.

Click on the Application and you will see the below screen.

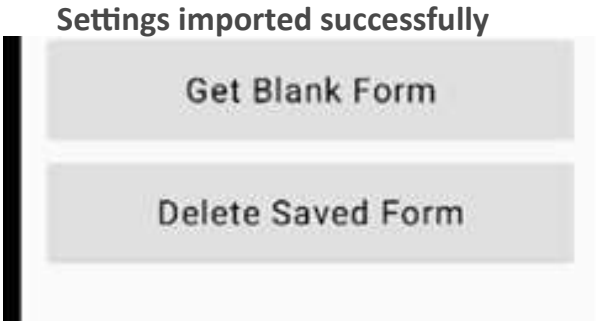
To enable created App User(s)/Group to access project form click on the 3 dotted icon at the top right. You will see a list as shown.

Click on **Configure via QR code**

You will be requested to **Allow ODK Collect to take pictures and record video.** You will need to Allow. Navigate to **App Users** tab within the ODK **website** (remember when we added App User(s)/Group) App Users you will see the App User(s) list we created. We will give them access by Scanning the QR Code as shown below.

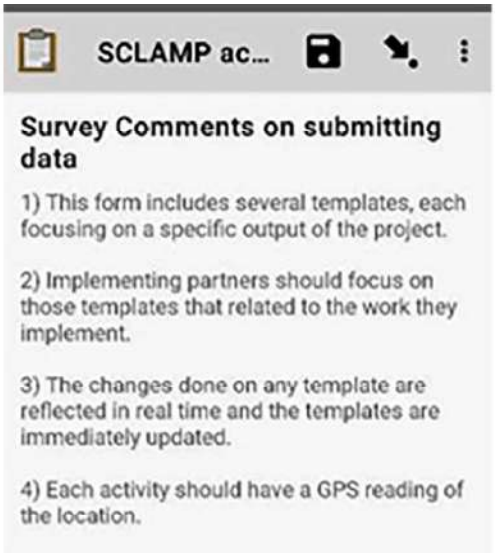


Once the QR code has been scanned you will see below Message



Project Form list will Appear as shown below. Click on **Get Blank Form** as shown below

Click on the project form and the questionnaires will show on your mobile device screen as below.



ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

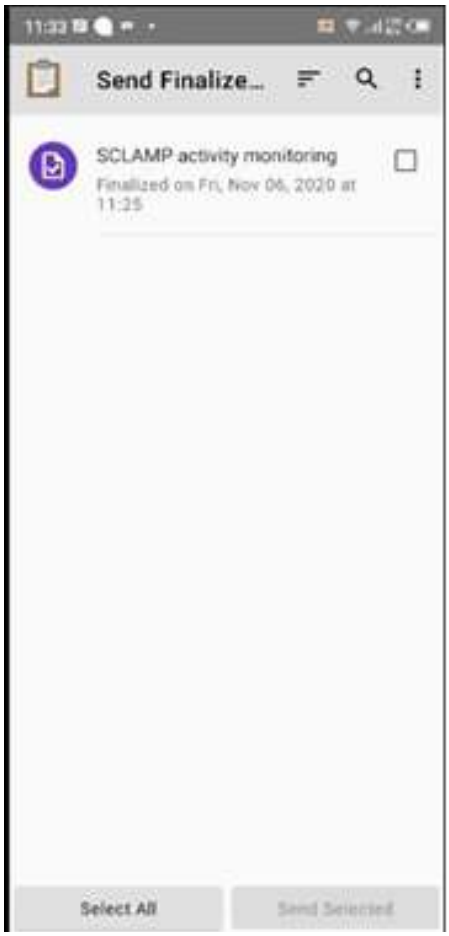
Swipe to left to navigate through different questions/survey as you fill them. Once you have finished collecting data. Click on **Save Form and exit** as shown below.

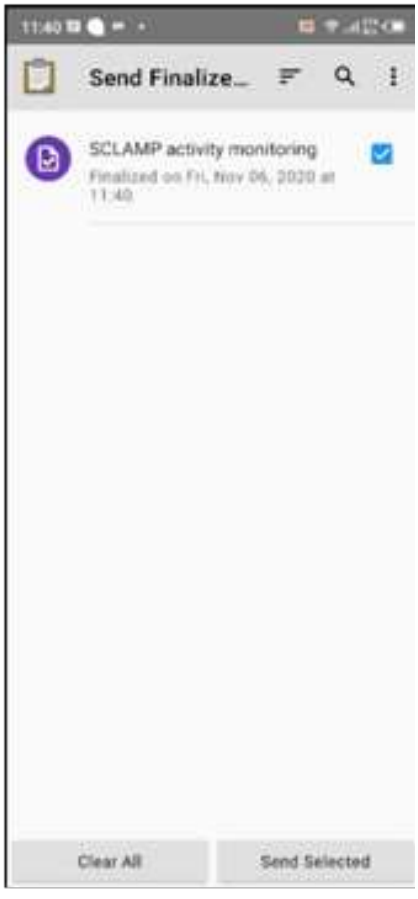
You can **Edit Saved** Form by clicking on 

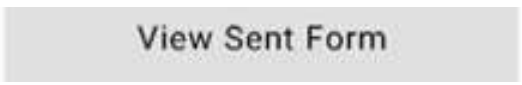
once you have completed filling the form, click on **Send Finalized Form** 

you will see the list of Saved Forms as below. Check all the forms you would like to send and click on **Send Selected** 

as below.

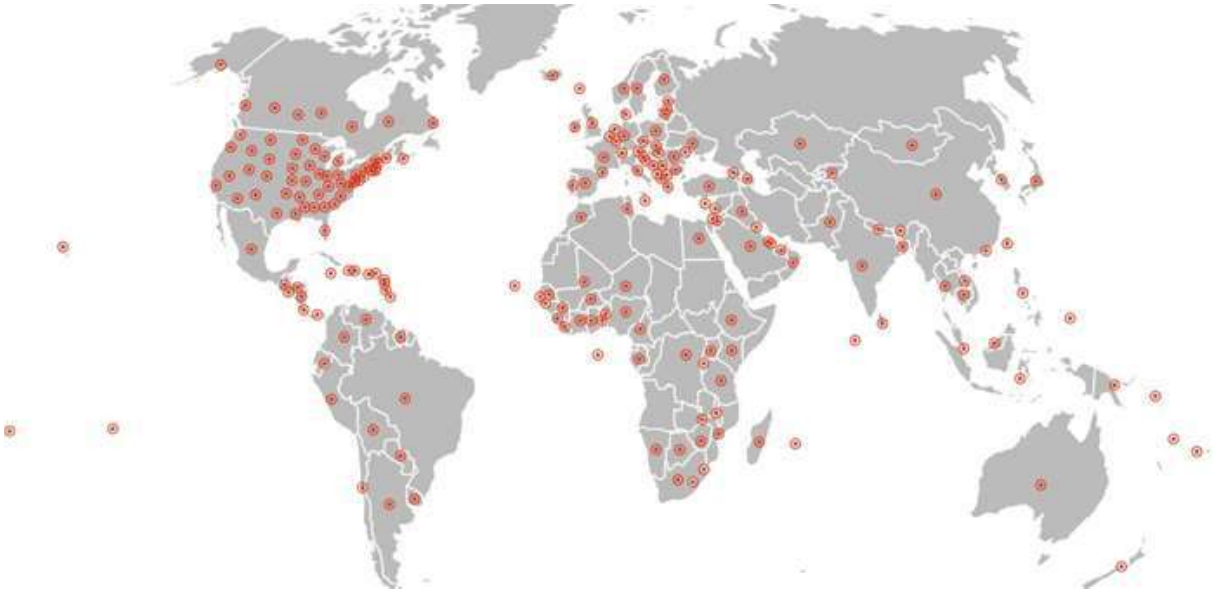




You can also View Sent Form by clicking on 

Introduction to REDCap

REDCap is a secure web application for building and managing online surveys and databases. REDCap is given to institution which are the consortium, a vast support network of collaborators composed of thousands of active institutional partners in over one hundred countries who utilize and support their own individual REDCap systems.

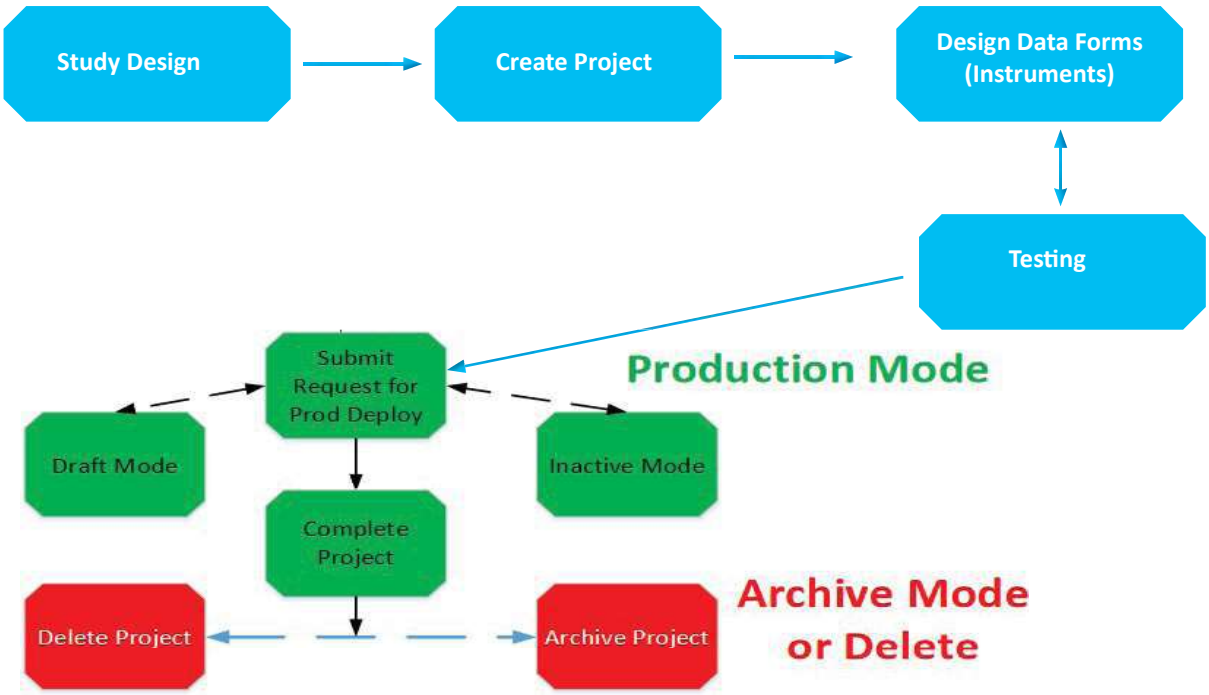


Overview of Workflow

Why use REDCap?

- **Secure** – Provides full user authentication (log-on/password), customizable user rights restrictions, real-time data validation, centralized & secure data storage, data de – identification options, and a full audit trail.
- **Web-based** – One can enter data or build their database from anywhere in the world over a secure web connection with authentication and data logging.
- **Fast** – Quick project start –up digital forms can be implemented without the need for a programmer. Concept to production-level database is possible in less than one day.
- **Easy** – Intuitive user interface and workflow, readily available online training materials, and assistance from the Centre for Health Insights (CHI) make it easy to get started.
- **Fully customizable** – You are in total control of shaping your database.
- **Autonomous utilization** – Research groups have complete autonomy and control to add new users and set several levels of specific user rights.
- **Data export** – Seamless data downloads to common statistical packages (including SPSS, SAS, Stata, and to the .csv (comma separated values) format, the most common import and export format for spreadsheets and databases.
- **Data import** – Data import capability through Microsoft Excel but has to confirm to data dictionary
- **Advanced features** – File uploading, auto – validation, branching logic, calculated fields, signature, Dynamic Query (SQL) and more.

REDCap Workflow



Study Design: Before beginning a REDCap project, you should formulate a general study design. Example: Who or what are you planning to study? What kind of data are you measuring?

Request New Project: Upon request to REDCap administrator, a project is created within REDCap. Design Data Forms: To effectively collect and order your data, you must first design the data collection forms to do so. This step is the highlight feature of REDCap: immensely customizable, expandable, fluid data forms.

Testing: You should test data collection forms to verify all needed data are collected correctly before REDCap administrator to production mode.

Deployment: Once your study enters Production Mode, you may enter, review, and analyse real data. In Production Mode, it is more difficult and riskier to make major changes to your data entry forms, which is why thorough testing is strongly encouraged.

Draft Mode: If you enter production and find that you do need to modify an element of your data entry forms, you may enter Draft Mode and submit changes to be approved by a REDCap Administrator. Data activities can continue during this mode.

Inactive Mode: No data entry or update may take place in this mode, although you may view and analyse data. You can initiate this mode if you want to ensure that no new data entry will occur, but you would still like to access all your data easily.

Archived Mode: If you have completed data analysis, moved your project to indefinite hiatus, or simply decided you no longer wish to use it, you may move the project to archived status as an alternative to full deletion. Archived projects incur fee as well. You can un-archive your project at any time.

REDCap Terminology

Arms: groups of events. You may want to employ multiple arms when using different treatment groups (control, experimental) or conducting a multi-site study, for instance.

Branching Logic: may be employed when fields/questions need to be hidden for data entry under certain conditions. For instance, you may want to hide the question "How many hours per week do you watch TV?" until a "Yes" answer is checked for a previous question, "Do you watch TV?"

Data Collection Instrument: a form created to capture data. This term is essentially interchangeable with "data entry form."

Data Dictionary: a specifically formatted .csv spreadsheet containing the metadata used to construct data collection instruments and fields.

"Development" vs. "Production" Modes: study status modes. In Development Mode, you are still working through the design of your data forms and testing them with mock data; you may make any changes to the forms at any time. In Production Mode, you have deployed your forms and you are collecting real data; changes to your forms are more difficult to implement once you have launched into Production Mode.

Field: a singular data entry, such as age or height.

Form Status: status of the record's data form completeness, denoted with a color; red – incomplete. yellow – unverified; green – complete.

Logging: the audit trail of modification occurrences in the project.

Record: the set of information for a unique participant or subject. Each record is composed of a number of fields (pieces of data), which can be spread across multiple forms (instruments) per record. Record ID: a unique key that can identify each record in the database. (You may label this differently in your project, but the ID must remain the first field in the first data form.) User Rights: the customized privileges that research team members have in terms of data form modification, data entry, and data access. P.I.s may create "Roles" for groups of team members to ensure consistency in specified user rights.

Variable Name: the name of the variable that is stored in the REDCap database (not visible during data entry).

REDCap WEBSITE

Begin your Project.

Signing into REDCap for the first time. If not registered, contact your REDCAp administrator.

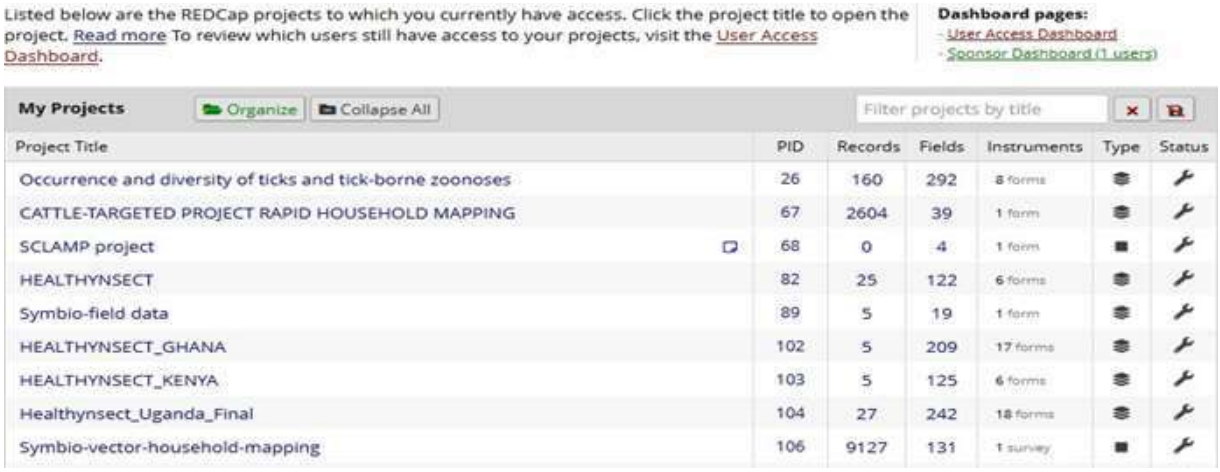
The first time you log in to https://redcap.icipe.org/ with username: ai4afs.training and password: Ai4afs.training123

If you have forgotten your password, click on **Forgot your password?** this will navigate you to page below

An email will be sent to the email address you registered.

Initial Project Set-Up

Log into REDCap (https://redcap.icipe.org/) using your username and Password, after successful login, you can start creating new projects as **REDCap administrator authorization,** however if you are assigned to a project you will be able to view the projects that you are assigned as below.



Project Title	PID	Records	Fields	Instruments	Type	Status
Occurrence and diversity of ticks and tick-borne zoonoses	26	160	292	8 forms		
CATTLE-TARGETED PROJECT RAPID HOUSEHOLD MAPPING	67	2604	39	1 form		
SCLAMP project	68	0	4	1 form		
HEALTHYNSECT	82	25	122	6 forms		
Symbio-field data	89	5	19	1 form		
HEALTHYNSECT_GHANA	102	5	209	17 forms		
HEALTHYNSECT_KENYA	103	5	125	6 forms		
Healthynsect_Uganda_Final	104	27	242	18 forms		
Symbio-vector-household-mapping	106	9127	131	1 survey		

Designing Data Tools Online designer

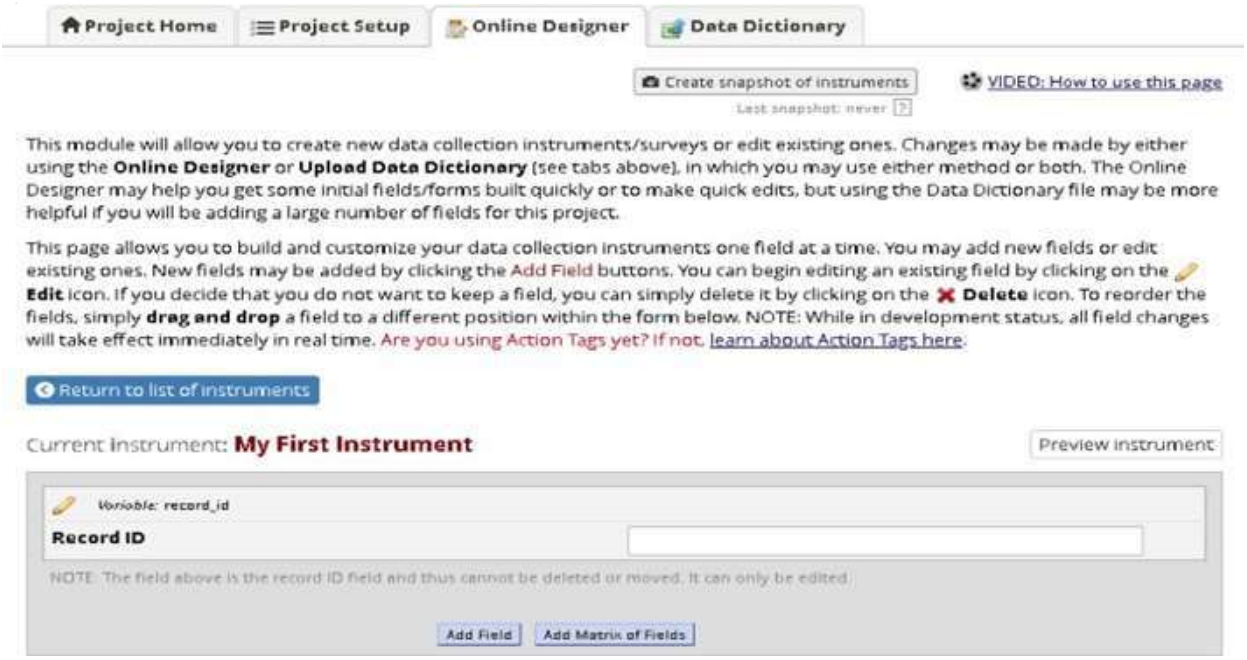
Overview

The Online Designer is the primary tool with which you will design your data forms. Assuming that you started with an empty project (started without using a template), you will see one default form already present in your Online Designer, entitled **"My First Instrument."**

You may rename this form by clicking the **"Rename"** button on the right. To begin editing, click on the instrument name.

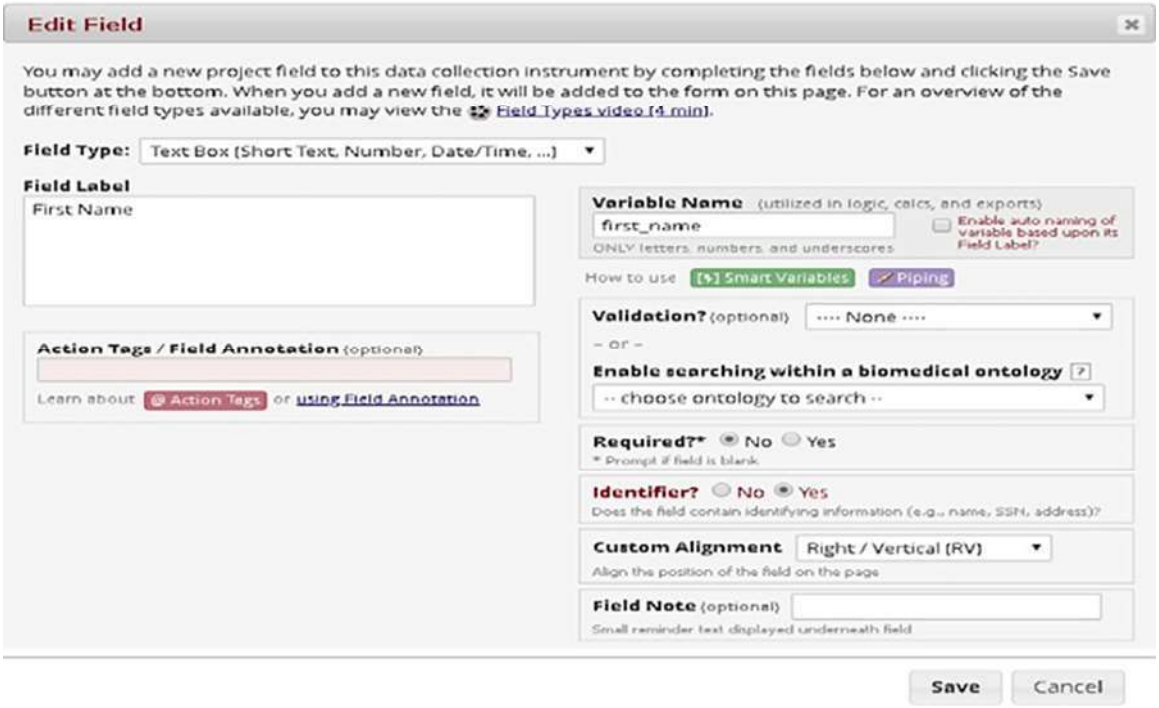
By default, your first form will have only one field, entitled "Record ID." This indicates the unique record/participant identifier and must be preserved. You may change the name of the field by clicking the Edit icon (the yellow pencil). However, whatever you decide to call it ("Participant ID," "Study ID," etc.), its purpose as a unique identifier must remain the same.

This field does not need to be repeated for any other data forms throughout the project; this is the only place you will need to be concerned with it.



You may click the "Preview Instrument" button to preview what your form will look like during actual data entry. Calculated fields and branching logic will not work in this preview; practice data must be entered in records in order to test those particular functionalities. **Adding a new field**

To create a new data field, click the "Add Field" button. There are twelve types of fields you may choose from. Our example in this section will use the "Text Box" field type (essentially a "short answer" field), one of the most common field types in REDCap data entry. The general "new field" addition process is very similar across field types – however, other types may have additional features or nuances associated with them, which is discussed in detail in the Field types section.



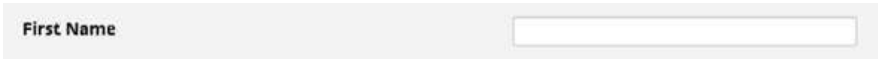
If you are designing a survey, the Field Label will generally be a question, such as “First Name?” If you are designing a research data entry form, your Field Label may look more like a standard label, such as “Baseline heart rate:”.

The **Variable Name** is used by REDCap to store the data. We strongly advise against enabling auto – naming for variables (the checkbox to the right of the Variable Name field). You generally want to keep variable names short but somewhat descriptive, so that if you need to export your data, you will be able to recognize key variables. For instance, “Q1” is not a very descriptive variable name, and is not advised for most situations. “Height” is a good variable name, but “height_in” or “height_cm” is even better, because you are reiterating your measurement unit within the variable name, which is a good practice.

Validation is an extended option which is discussed in detail in the Data validation section.
The Required option, by default, is set to “no.” If changed to “yes,” it will require an answer before a data form can be saved (or before a survey can be submitted, depending on your study set – up). The Identifier option should be marked whenever a field asks for one of the 18 HIPAA identifiers. When you export or view deidentified data, the fields that were marked as identifiers will be omitted.
Concise list of the 18 HIPAA identifiers is listed below, but for an official list and supporting details, see Box 2 on this page from the CDC website:
http://www.cdc.gov/mmwr/preview/mmwrhtml/m2e411a1.htm

The **Custom Alignment** option changes how the question (and answers, if the field is a multiple-choice option) appears in the data entry screen. We don’t recommend adjusting this unless there is an aesthetic need to do so, but you may play around with the functionality as you explore REDCap’s features.

The Field Note option displays a side – note in small text beneath the text entry field (or multiple- choice options) on the data entry screen. It is useful for designating units or clarifying a manner in which the question should be answered (e.g. “Mark all that apply”).
The result of the field creation in this example looks like this:



[TIPS AND TRICKS]:

- Generally, it is acceptable to have REDCap provide the automated coded values for your multiple-choice options, but there may be instances in which you should manually enter or change the coded values. For instance, let’s say you are writing a survey question inquiring about the frequency of a participant’s consumption of fast food, and let’s say you have decided your choices are “Never,” “Once per month or less,” “Two to five times per month,” and “More than once a week.” Since this is a scale with an absolute zero, coding “Never” as 0 and moving upward from there (rather than beginning at 1) is a wise decision.

- If you have many forms, it can be helpful to add a prefix to your field variable names that indicates which form they are on. For instance, a variable representing age in years on your Demographics form might be labeled “dm_age_yrs.”

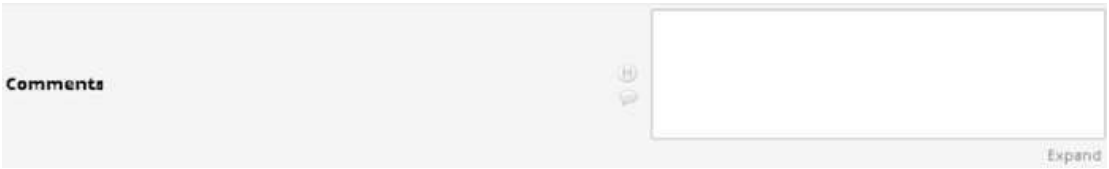
- We strongly advise against numbering your fields within the field label (e.g. “1. How old are you?”). Any branching logic or future decisions to move/delete fields will drop or mix numbers, causing unnecessary work later. The REDCap survey option features auto – numbering and custom numbering abilities, which should be used instead (toward the end of project design).

Field types

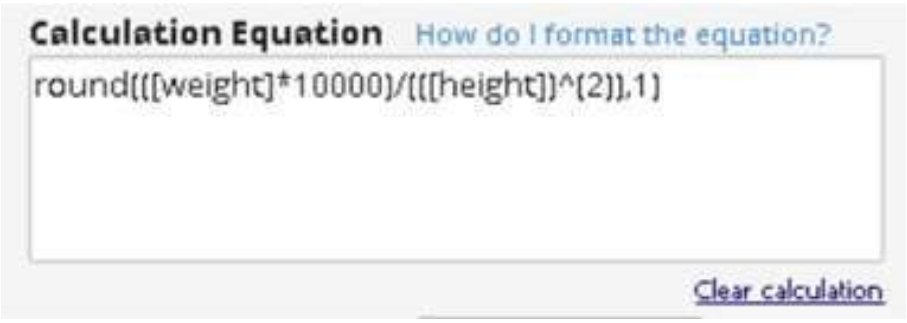
There are fourteen types of fields you may choose from:
Text Box, Notes Box, Calculated Field, Multiple Choice –Drop – down List, Multiple Choice – Radio Buttons, Checkboxes, Yes– No, True – False, Signature, Slider/Visual Analog Scale, File Upload, Descriptive Text, Begin New Section and Dynamic Query (SQL).

1. **Text Box:** a single – line text box for text and numbers. The example in the Adding a new field section is a text box.

2. **Notes Box:** a large text box for a large amount of text. This is convenient for long descriptions and "Additional Comments" boxes.



Calculated Field: a field which performs real –time calculations based on the entries in other fields. The syntax for complicated calculations can be intricate, but REDCap will alert you to any syntax errors, and will refuse to attempt calculations until they are resolved, preventing data errors. Variable names are referred to in [brackets] in the written calculation equation.



In this example, weight and height are two variables from previous questions being utilized to calculate Body Mass Index (BMI). Clicking the "How do I format the equation?" hyperlink will open a dialog box describing some of the nuances and specifications of the calculation syntax, such as the rounding function used in this example.

In data entry, it is impossible to directly edit the value of a calculated field (hence the red text). This ensures the integrity of the calculation procedure.

3 **Multiple Choice** – Drop–down List: a drop–down menu with options. Only one option can be selected. This can help save space on a data form if there are many different choices to display.

4 **Multiple Choice** – Drop–down List: a drop–down menu with options. Only one option can be selected.
This can help save space on a data form if there are many different choices to display.

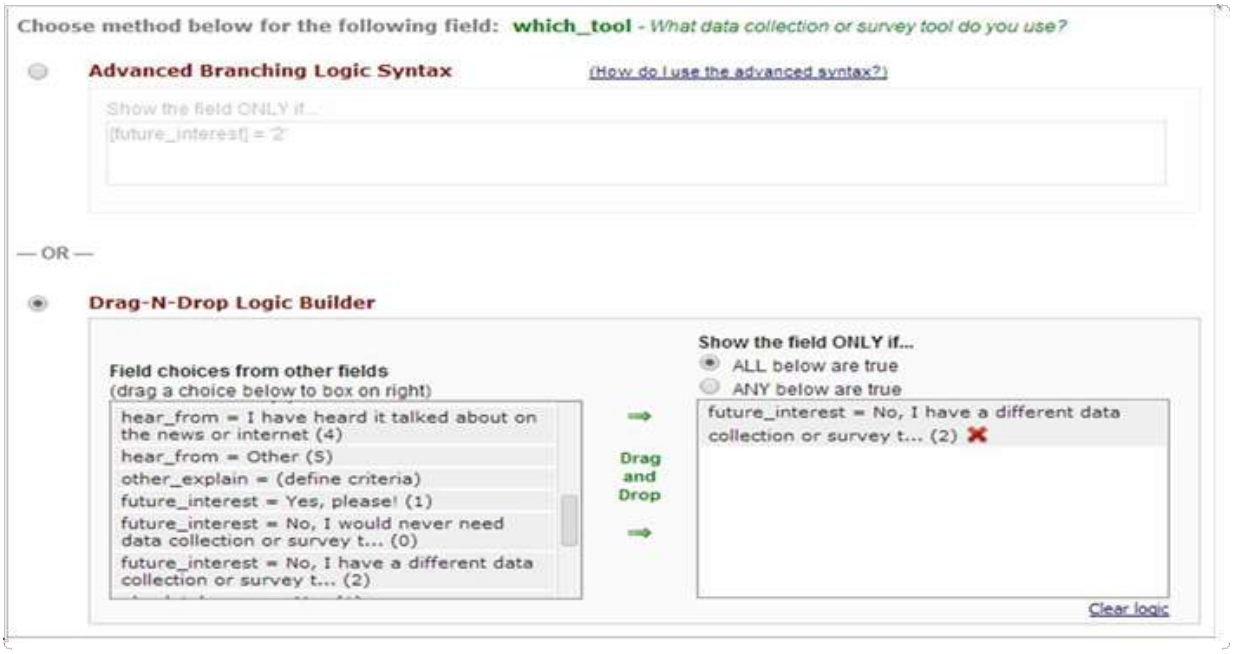
Branching Logic

If you would like for certain questions to appear only under certain conditions, you may employ the REDCap technique "branching logic" to do so. The easiest way to demonstrate branching logic is by walking through an example. Let's say you are working in your Online Designer, and you are concerned with these two questions:

You only want that second question to appear if the participant selects "No, I have a different data collection or survey tool that I prefer." Otherwise, the question does not make much sense in context. Because the appearance of the second question (the variable "which_tool") is dependent on the answer to the first question (the variable "future_interest"), we call future_interest the ***parent*** (or ***independent***) ***question*** and which_tool the ***child*** (or ***dependent***) ***question.***

To begin defining your branching logic, click the branching logic icon (the green arrows) on the child question. The Branching Logic dialog box will appear. You may use either the Advanced Branching Logic Syntax box or the Drag–N–Drop Logic Builder box.

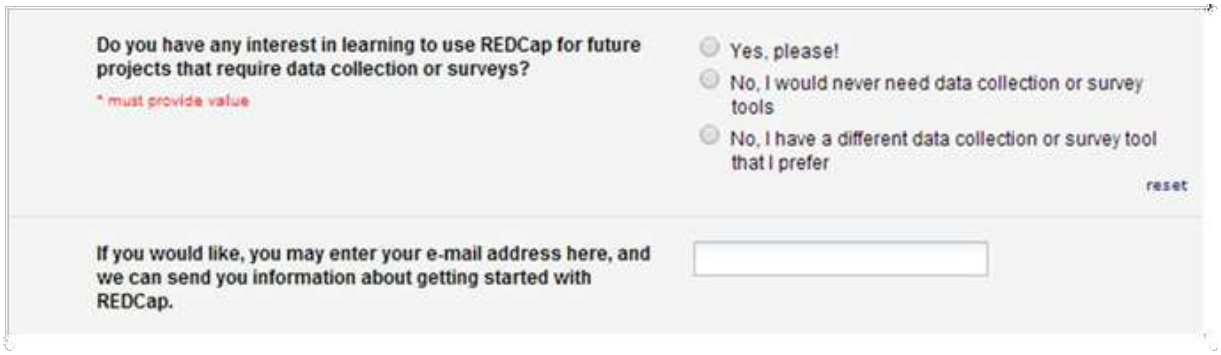
For most branching logic uses, the Drag-N-Drop Logic Builder will be sufficient. We do not recommend using the Advanced Syntax box if you have no experience with computer science or programming syntax. If you have a question which you think may require the Advanced Syntax box, please feel free to contact us for assistance or review of the coding.



Simply drag and drop the appropriate conditions for appearance of the child question, being sure to specify whether you want ANY or ALL of the conditions to be true in order for the child question to appear.

Remember, branching logic is only employed on the child question. Since we want our first question to remain static regardless of any other values on the page, we leave it alone.

Implementation:
Survey appearance **before** choosing any option (or with a non-target option selected):



Survey appearance **after** choosing the logic–dependent option:

[TIPS AND TRICKS]:

- Be sure to thoroughly test any use of branching logic with practice records to ensure that your fields/questions are being displayed exactly as you want them. Recall that the "Preview Instrument" function in the Online Designer will not test branching logic; only actual practice records can do this.

- Try not to include too many conditions in your branching logic. Overuse of branching logic can lead to a higher chance of errors.

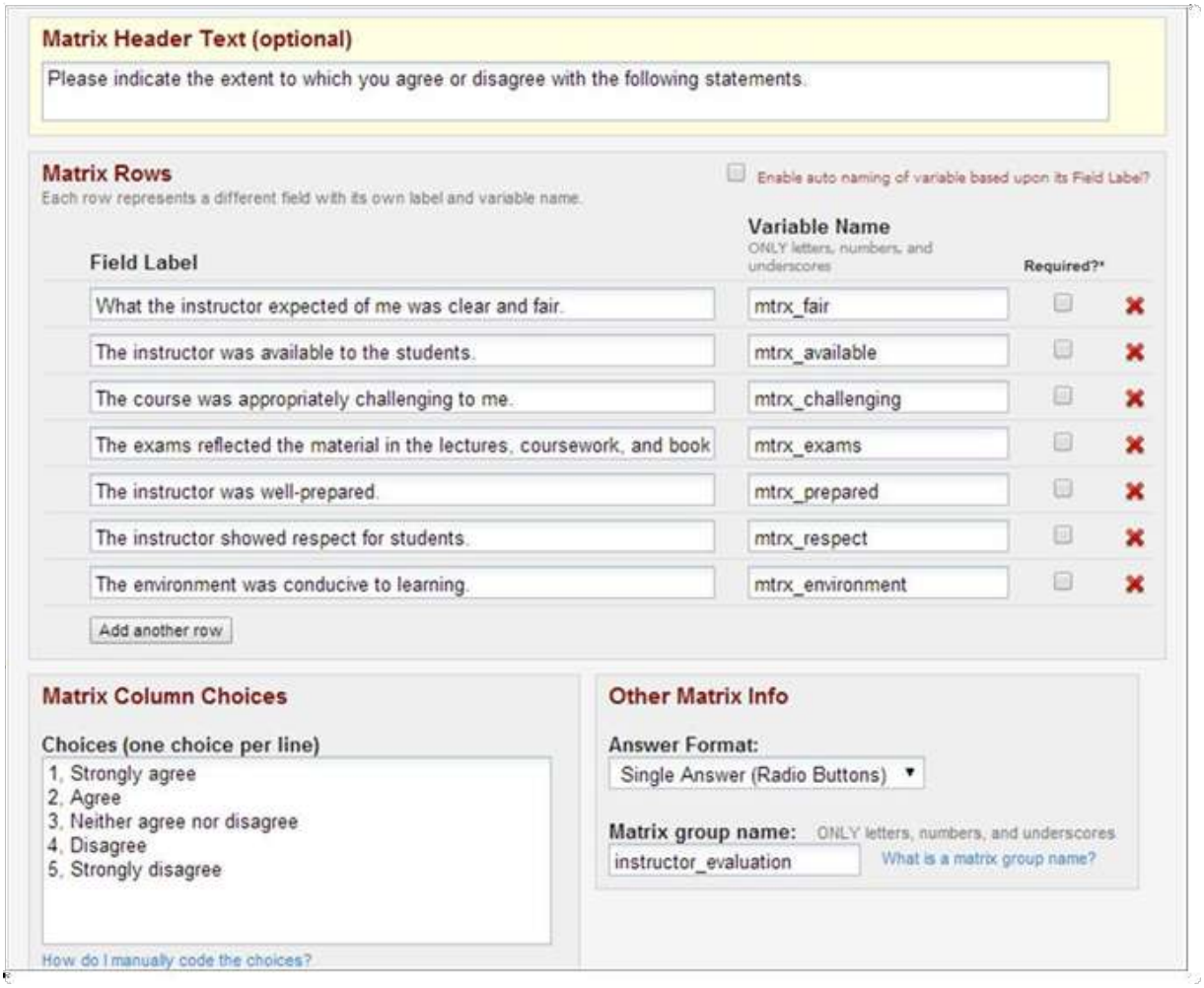
Adding a matrix of fields

For some data forms and surveys, the same set of answers may be used for many questions in a row, such as scales indicating frequency or agreement. To fully grasp the "matrix of fields" concept, it may be easier to view an example of a finished implementation before delving into the specifics of the set–up:

Please indicate the extent to which you agree or disagree with the following statements.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	
What the instructor expected of me was clear and fair.	○	○	○	○	○	reset
The instructor was available to the students.	○	○	○	○	○	reset
The course was appropriately challenging to me.	○	○	○	○	○	reset
The exams reflected the material in the lectures, coursework, and books.	○	○	○	○	○	reset
The instructor was well-prepared.	○	○	○	○	○	reset
The instructor showed respect for students.	○	○	○	○	○	reset
The environment was conducive to learning.	○	○	○	○	○	reset

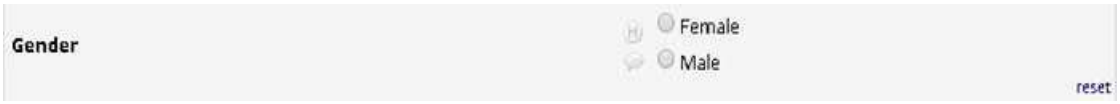
Setting up the matrix is essentially writing many questions at once, all of which use the same set of answers. As such, there is only one section to define column choices, but there are many field labels, each with their own variable names and requirement statuses. You may add as many rows as necessary for your matrix.



There are two answer formats for matrices of fields: Single Answer (Radio Buttons) and Multiple Answers (Checkboxes). For most matrices, Single Answer will be the preferred format.

A matrix group name must be provided. Its naming mechanism is similar to the general variable naming mechanism. The group name itself is basically a coded value which ensures that no matter what display platform the matrix goes through, all of the rows will be displayed together in a single matrix.

5 **Multiple Choice** – Radio Buttons: a set of radio buttons (round buttons), from which only one choice can be selected at a time. The “reset” button in the corner removes any current selection and returns the field to a null (absent) value.

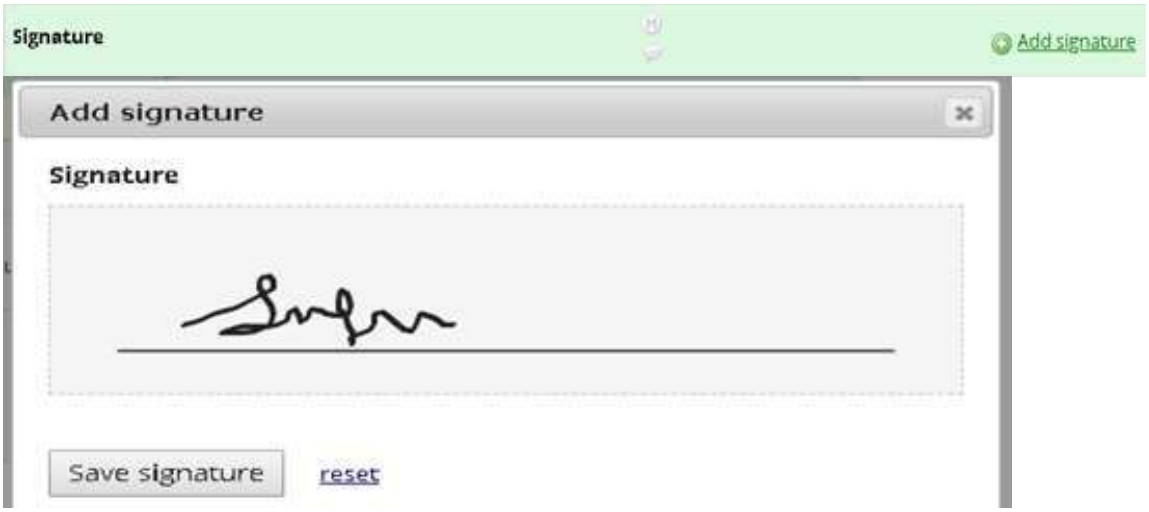


6 **Checkboxes:** checkboxes which allow the selection of multiple options if desired.

7 **Yes–No:** radio buttons with the options “Yes” and “No.” These values are automatically coded: “Yes” = 1, “No” = 0.

8 **True–False:** radio buttons with the options “True” and “False.” These values are automatically coded: “True” = 1, “False” = 0.

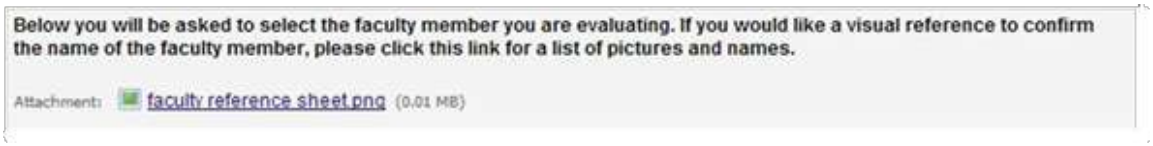
9 **Signature:** Allows a person to draw their signature on a survey or data entry form using a mouse, pen, or finger (depending on whether using a desktop computer or mobile device). Once captured, the signature will be displayed as an inline image on the survey page or data entry form. While this option appears as a "Signature" field type in the Online Designer, it is specified in the Data Dictionary as a "file" type field with validation type of "signature". Thus, it is essentially a special type of File Upload field. Note: The signature image for Signature fields cannot be imported via the API, although they can be downloaded or deleted via the API using the "Export a File" and "Delete a File" API methods, respectively.



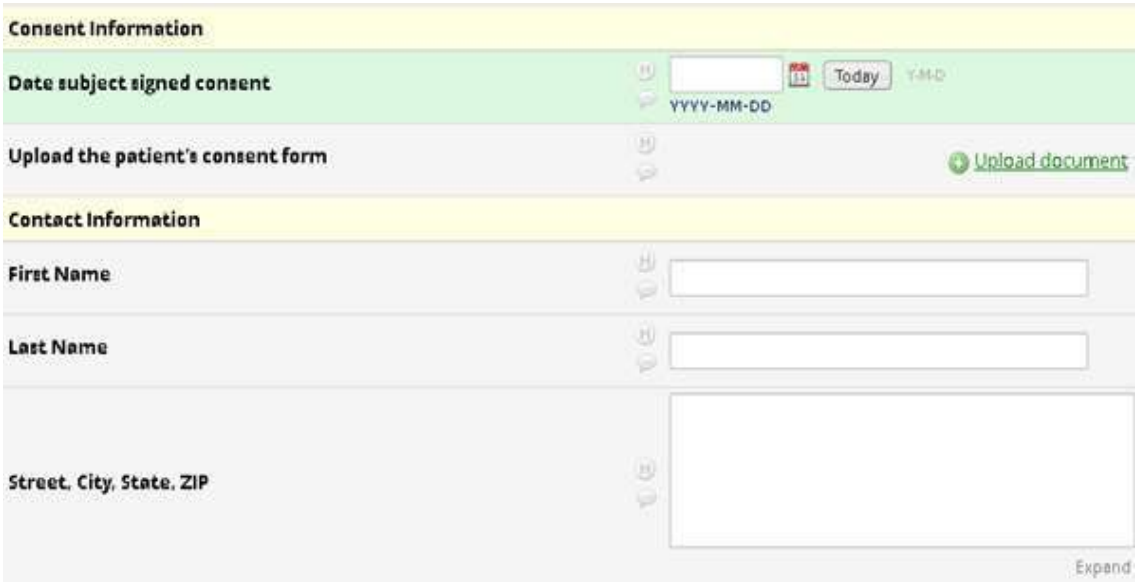
10 **Slider:** visual analogue scale coded as values 0–100. You may provide labels above the left, middle, and right sides of the slider.

11 **File Upload:** an uploading tool for any associated images or documents that may need to be attached to individual records.

12 **Descriptive Text:** text displayed with optional image/file attachment. The file may be displayed as a clickable (downloadable) link, or (if the file is an image) displayed in–line with the text.



13 **Begin New Section:** a field composed of a single line appearing in different color from the rest of your form, indicating separation. This is largely for aesthetic/organization purposes. Adding text (to serve as a header) is optional. When deploying a survey, you have the option to break each section into separate pages, giving these headers a true separation functionality.



14 **Dynamic SQL Query:** A "sql" field allows one to populate a drop-down list on a data entry form or survey by providing an SQL query ("select" queries only) in the Online Designer for a field or in the Select Choices column of the Data Dictionary.

Data Validation

When using the Text Box method of entry, it is best to ensure that the data coming in is the type of data that you are expecting to see. One method of doing this is by employing the Validation option in the field creation screen. By utilizing this feature, REDCap will prompt an error when a field's entry does not meet certain expectations for data type. There are eleven basic data types that you can designate via the Validation option: date (3 formats), date time (6 formats), e–mail, integer, letters only, MRN, number (5 formats), phone (U.S.), Social Security Number (U.S.), time (2 formats), and ZIP code (U.S.).

1. **Date:** The three different formats you can specify for date are Day-Month-Year, Month-Day-Year, and Year-Month-Day. Regardless of which type you choose, a small calendar icon will be visible next to the field in data entry which you can utilize to easily specify a date in the appropriate format. You can also click the "Today" icon to automatically fill in the current date.

2. **Datetime:** Datetime can be recorded with or without a "seconds" count. The three without seconds follow the same formats as the three Date formats (listed above), with an additional H:M to indicate time (Hours:Minutes). The three that do include seconds also follow the same three Date formats, with an additional H:M:S to indicate time (Hours:Minutes:Seconds). Like the Date option, a calendar icon appears next to the field, and in addition, a clock icon appears. You can also click the "Now" icon to automatically fill in the current date and time. An example of usage of the calendar/clock dialog box is below:

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3. **E–mail:** To validate an e–mail address entry, REDCap checks for a singular "@" symbol and an appropriate e–mail domain ending (such as ".com" or ".edu"). The inclusion of other special characters that would not be a part of valid e–mail addresses (such as "$" or "#") will also prompt a data validation error. This is very widely applicable, however, if you are expecting e–mail addresses connected to new or uncommon domains, we do not recommend using this validation option.

4. **Integer:** Integers include all of the negative and positive whole numbers, plus zero. This means that any decimal or fractional values will prompt a validation error, as well as any values outside the designated minimum–maximum range.

5. **Letters only:** This validation type will only accept English alphabetical characters. It will not accept spaces, numbers, special characters, or accented letters.

6. **Number:** This validation type accepts numbers, including decimal values. The five formats are derived from the number of decimal points you choose to allot: 1, 2, 3, 4, or unspecified. If you choose to specify several decimal points, an error will be prompted if that exact number of decimal points is not met. For instance, if you have specified two decimal points, an entry of "3" or "3.0" would not be accepted – only "3.00" is considered a valid entry in this case.

7. **ORCID Number:** This validation type will only accept sixteen numerical digits separated by hyphens in the appropriate ORCID format. Example: 0123–4567-8901-2345.

8. **Phone:** This validation type will only accept a ten–digit U.S. phone number. Not including a valid U.S. area code will prompt an error. It is fairly lenient regarding the input format (spaces, nospaces, hyphens, etc.), but it will change your entry to a standardized "(###) ###---####" format upon field completion.

9. **Time:** This validation type accepts only HH:MM time format. Like the Datetime type, the clock icon and/or the "Now" icon can be used to assist data entry.

10. **UNMC Cost center:** This validation type will accept numerical digits separated by hyphens in the appropriate UNMC cost center format. Example: 12-34-56-7890

11. **ZIP code:** Only five– or nine–digit ZIP codes are accepted. Nine–digit ZIP codes must include a hyphen separating the first five from the final four, or an error will be prompted.

[TIPS AND TRICKS]:

- Many of the data validation types include an option for setting minimum and maximum expected values. We strongly encourage users to employ this wherever applicable. For instance, if a field asks for the age of a participant, you may want to set the minimums and maximums around your study eligibility guidelines, such as 16 to 55. If you do not have study eligibility rules, it is still a good practice to set relatively reasonable limits, such as 4 to 120.

Branching logic

If you would like for certain questions to appear only under certain conditions, you may employ the REDCap technique “branching logic” to do so. The easiest way to demonstrate branching logic is by walking through an example. Let’s say you are working in your Online Designer, and you are concerned with these two questions:

You only want that second question to appear if the participant selects “No, I have a different data collection or survey tool that I prefer.” Otherwise, the question does not make much sense in context. Because the appearance of the second question (the variable “which tool”) is dependent on the answer to the first question (the variable “future interest”), we call future interest the *parent* (or independent) question and which tool the child (or *dependent)* question.

To begin defining your branching logic, click the branching logic icon (the green arrows) on the child question. The Branching Logic dialog box will appear. You may use either the Advanced Branching Logic Syntax box or the Drag–N–Drop Logic Builder box. For most branching logic uses, the Drag-N-Drop Logic Builder will be sufficient. We do not recommend using the Advanced Syntax box if you have no experience with computer science or programming syntax. If you have a question which you think may require the Advanced Syntax box, please feel free to contact us for assistance or review of the coding.

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Simply drag and drop the appropriate conditions for the appearance of the child question, being sure to specify whether you want ANY or ALL of the conditions to be true in order for the child question to appear.
Remember, *branching logic is only employed on the child question.* Since we want our first question to remain static regardless of any other values on the page, we leave it alone.

Implementation:

Survey appearance **before** choosing any option (or with a non-target option selected):

Survey appearance **after** choosing the logic–dependent option:

[TIPS AND TRICKS]:

- Be sure to thoroughly test any use of branching logic with practice records to ensure that your fields/questions are being displayed exactly as you want them. Recall that the "Preview Instrument" function in the Online Designer will not test branching logic; only actual practice records can do this.
- Try not to include too many conditions in your branching logic. Overuse of branching logic can lead to a higher chance of errors.

Adding a matrix of fields

For some data forms and surveys, the same set of answers may be used for many questions in a row, such as scales indicating frequency or agreement. To fully grasp the "matrix of fields" concept, it may be easier to view an example of a finished implementation before delving into the specifics of the set–up:

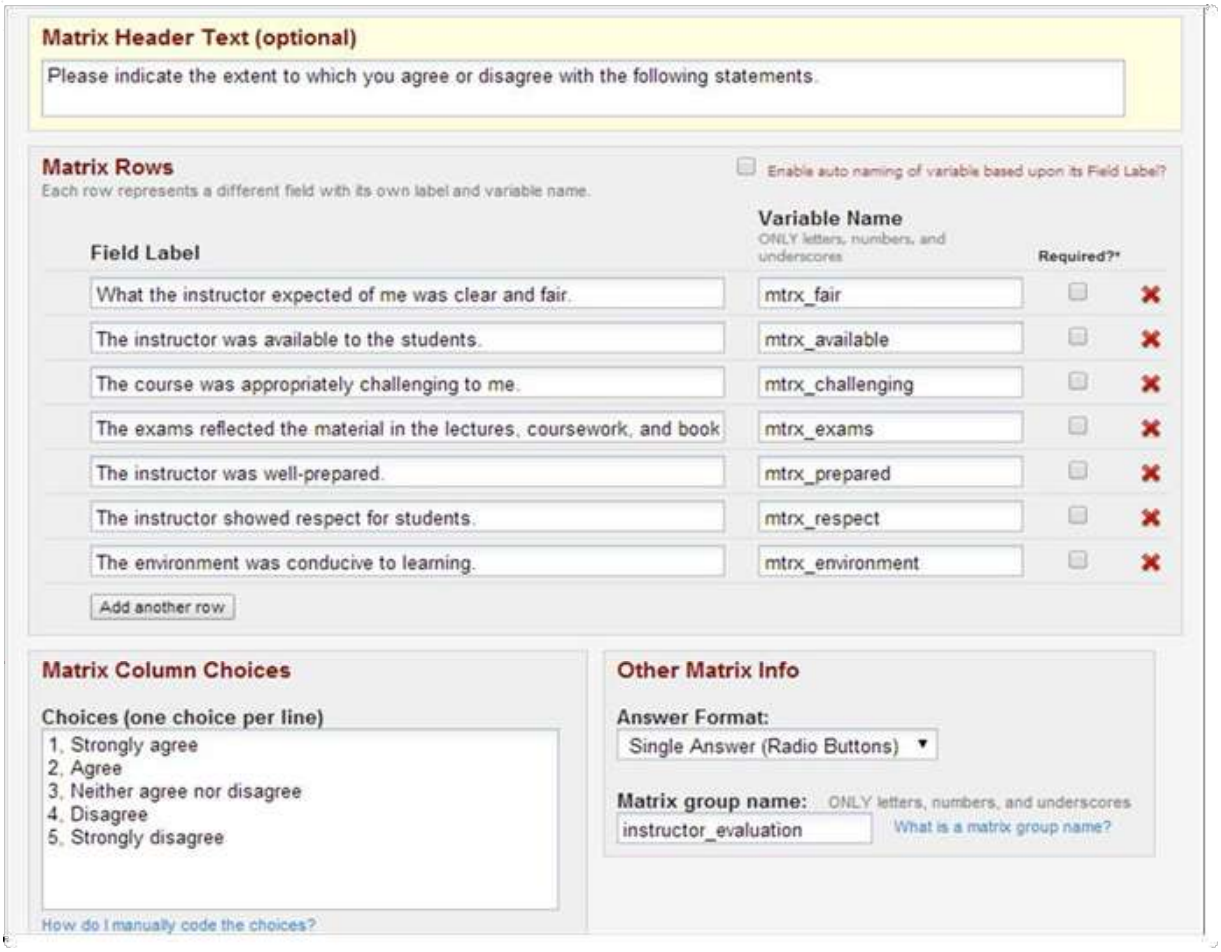
Please indicate the extent to which you agree or disagree with the following statements.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	
What the instructor expected of me was clear and fair.	○	○	○	○	○	reset
The instructor was available to the students.	○	○	○	○	○	reset
The course was appropriately challenging to me.	○	○	○	○	○	reset
The exams reflected the material in the lectures, coursework, and books.	○	○	○	○	○	reset
The instructor was well-prepared.	○	○	○	○	○	reset
The instructor showed respect for students.	○	○	○	○	○	reset
The environment was conducive to learning.	○	○	○	○	○	reset

Setting up the matrix is essentially writing many questions at once, all of which use the same set of answers. As such, there is only one section to define column choices, but there are many field labels, each with their own variable names and requirement statuses. You may add as many rows as necessary for your matrix.

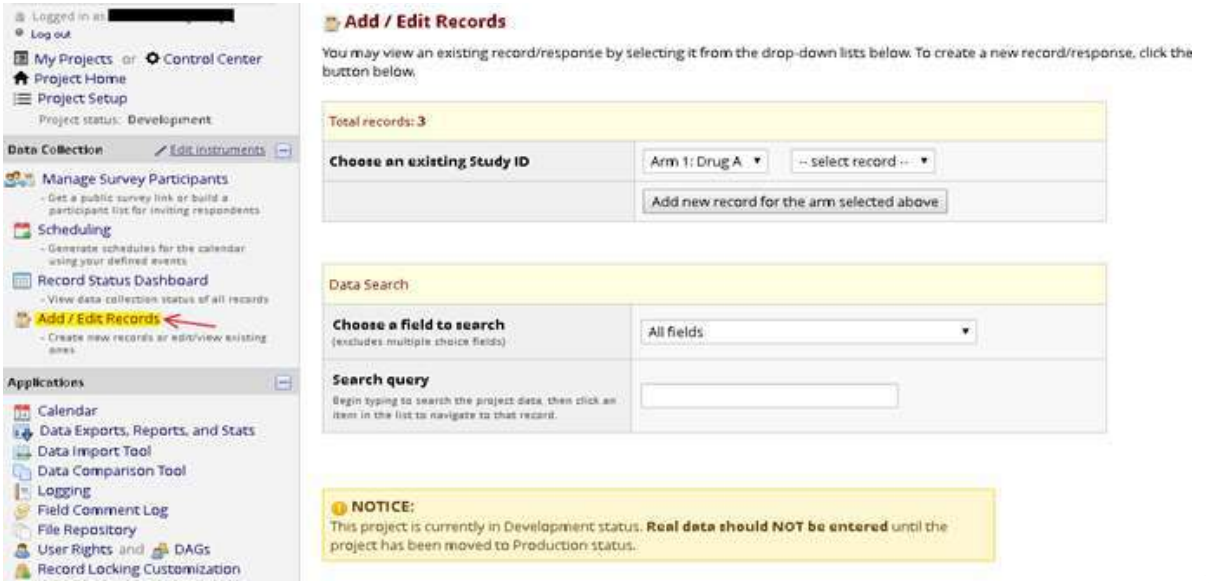
There are two answer formats for matrices of fields: Single Answer (Radio Buttons) and Multiple Answers (Checkboxes). For most matrices, Single Answer will be the preferred format.

A matrix group name must be provided. Its naming mechanism is like the general variable naming mechanism. The group name itself is basically a coded value which ensures that no matter what display platform the matrix goes through; all the rows will be displayed together in a single matrix.

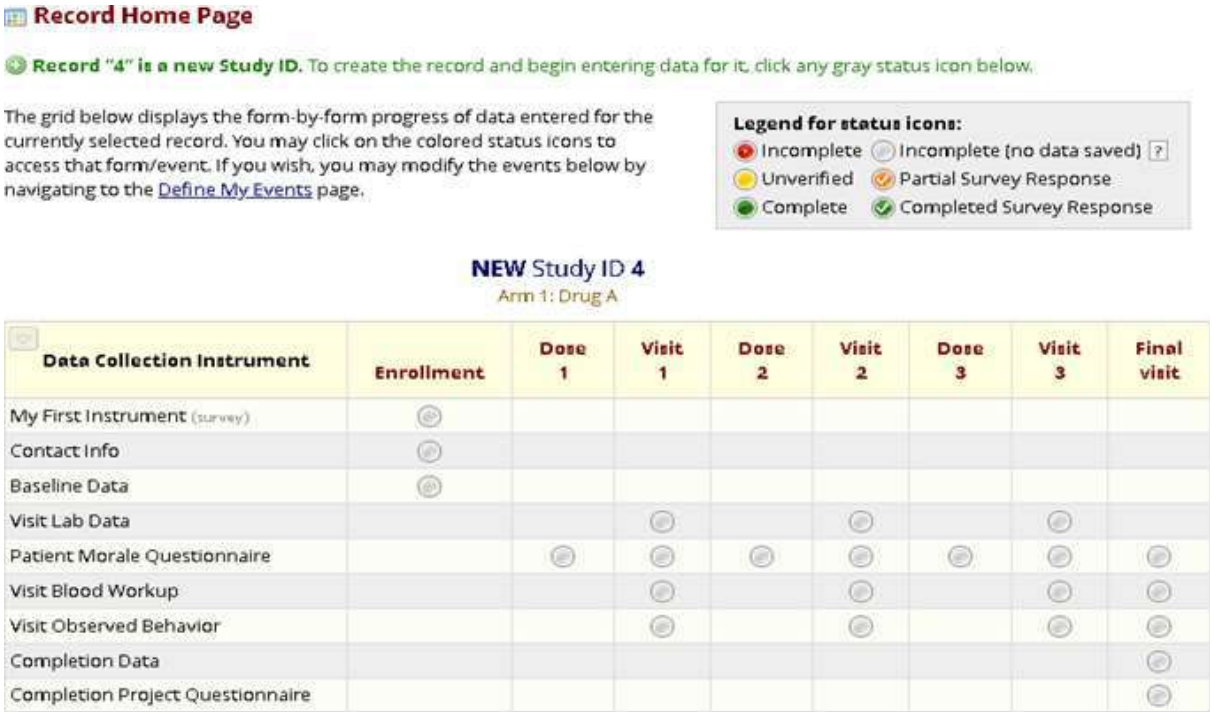


Practice Records

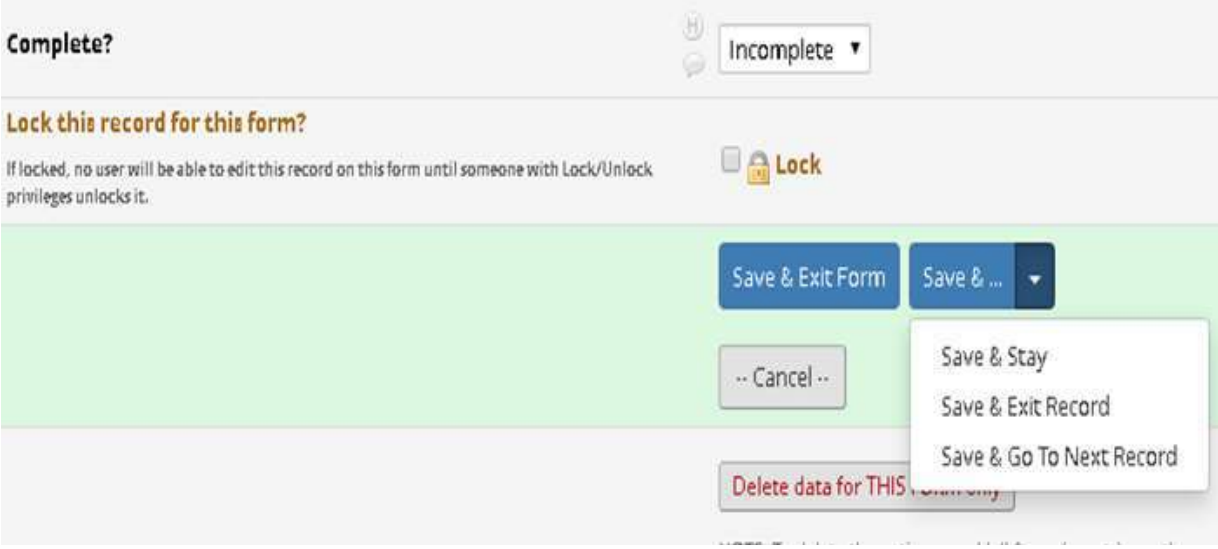
An important part of any project, big or small, is the testing phase. Whether you are using surveys or traditional data entry, REDCap allows you to create practice records to test the full functionalities of your forms. This is especially crucial for testing branching logic, calculated fields, and survey appearance (if applicable). For more information about practice records for surveys, see the Survey–based studies section.



Once you are in the main “Add/Edit Records” page, you may choose an existing record to edit, create a new record by typing in a new Record ID, or search for a particular record by a field value (for instance, using the search field “Name” and typing “Jane Doe” into the search query). If you are employing multiple Arms in your study, the first two options sort the records into groups by Arm. To search for a record whose Arm you are not certain of, using the Data Search option is best.



If your study is not employing multiple Events (i.e., if it is not a longitudinal study), your first data entry form will appear immediately, ready for data input. If your study does employ multiple Events, you will see a screen similar to the one above. Records are edited one Event at a time; clicking on the first form of an Event and filling it out will lead you through the forms assigned to that specific Event and then return you to this screen. To learn more about longitudinal studies and Events, see the Longitudinal studies section.



At the bottom of your data entry form, you have the option to mark the form as Incomplete, Unverified,or Complete. Incomplete forms will display a red icon, which is the default status for all forms in a new record; the yellow icon indicates Unverified, and green indicates Complete.

Clicking “Save and Stay” will save your progress and keep you on the current page. Clicking “Save and goto Next Form” will save all data and take you immediately to the next form for that record. Clicking “SaveRecord” will save all data and return you to the “Add/Edit Records” main page. You may also lock forms for a record to prevent other users from editing existing information.

The most important thing to remember about **practice** records is that they are intended for practice. This means that **no real data** should ever be entered into REDCap while your study is still in **Development mode**. Real data entry will occur once you deploy your project into Production mode, where your forms are finalized and data is more securely protected.

Importing data\

If you are conducting a study for which you already have some partial data, or if you are simply importing data from an additional source, using the Data Import Tool is one of the easiest ways to accomplish this task. First, you will be prompted to download one of two .CSV templates: one arranging separate records into rows, and another into columns. Whichever you choose may depend on how your other data is already arranged, and/or whichever you aesthetically prefer.

Once you have downloaded the template, use a program (generally Excel) to fill in the records, ensuring that the correct variables are slotted into the correct places. Then, on the same Data Import application page, you may re–upload the .CSV file and import your new data records.

NOTE: This section deals with importing data ***records*** into your project. For more information on importing your data dictionary (i.e. your data ***forms***), see the Data Dictionary section.

[TIPS AND TRICKS]:

- For ease of data transfer, ensure that the order of the variables is the same on both your external source and your REDCap data forms.

Exporting data

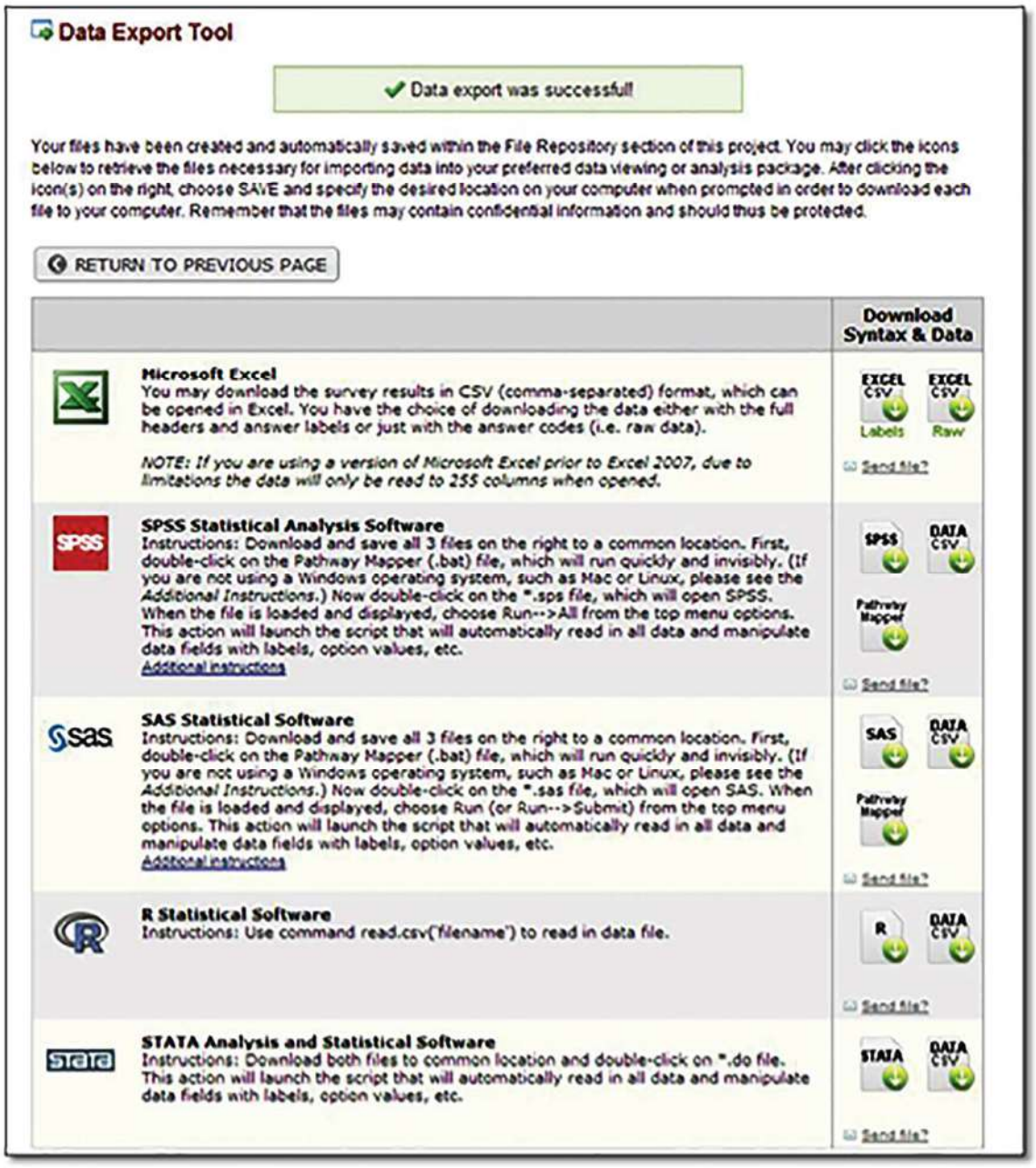
When accessing the Data Export Tool, you can either choose the “Simple Data Export” or “Advanced DataExport” option. If you only want to export certain fields or forms, or if you want to de– identify the data before exporting, select “Advanced Data Export.” If you wish to export all of the data you have access to,“Simple Data Export” is the best route.

Exporting your data “Raw” will export coded values. For instance, in a yes/no field type, data coded in that column will either be “1” or “0” – not “yes” or “no.” In addition, field titles will be the coded versions of the variable names, rather than the field labels. The “Labeled” data option is precisely the opposite – exporting clear, labeled versions rather than coded values.

For efficiency and compatibility with statistical analysis tools, we often recommend exporting raw values. The Data Export Tool is compatible with many analysis programs: Excel, SPSS, SAS, R, and Stata.

[TIPS AND TRICKS]:

- Exporting data to programs other than Excel produce syntax files, which are not always the easiest to deal with. Often, exporting to .CSV and then using your preferred statistical analysis program to import the .CSV is the ideal option. If you do choose this option, to ensure you are getting the data precisely the way you want it, be sure to download one of the .CSV files listed next to "Excel"rather than the one listed next to your program of choice.



REDCap Mobile Application

REDCap mobile app allows for offline data collection for your REDCap projects. You can create your project in REDCap, securely download your project to the REDCap mobile app on your iPad or iPhone, collect data on the device (with or without an Internet connection), and then securely send your data back to your project on a REDCap website.

Features

- Multi-user interface with secure login that allows each user account to collect data for multiple REDCap projects in the app.
- In addition to text and structured data, you can store and transmit photos, videos, signatures, and audio to REDCap.
- When collecting data in the app from a participant, for security purposes you can easily restrict access to the rest of the app as they enter their data.
- All user activity in the app is logged for audit purposes. The full logging history can be sent to your project on the REDCap website.

Downloading a Project

New project creation is not possible in the REDCap Mobile App itself. The app's purpose is to collect data offline that will later be added to an existing project in the web based REDCap application. In order to do so, a copy of the project's data collection instruments must be reconfigured in the REDCap Mobile App.

Admin interface

With the specially created password, the admin user can log in. This will result in accessing a special interface that enables the admin to do just about everything in the app but collect data. This allows projects the ability to separate data collection from app administration through user rights management. Or if full access is desired for users, then full rights can be given, and the admin interface need not be used - which is the default.

An admin can add users and customize user rights. User passwords can be reset here. When a user is created, full rights are automatically given. The admin (and only the admin) can revoke rights. If all rights are revoked, the user can only collect data for new records. This allows a sort of user management for projects depending on the trust and the ability of the data collector.

Projects can be managed by the admin interface for each user. One can set up a mobile app project. One can also send any data for a project. Data can be dumped to the Mobile App File Repository on REDCap, logs can be sent, and projects can be refreshed. Everything but data collection is possible through this interface.

User Responsibilities

REDCap Administrator (Project Creator):

- Create and design the REDCap project.
- Grant mobile rights access to the appropriate REDCap users.

REDCap User:

- Create a token for the project so that it can be distributed to the App User.
- Coordinate data reception from the app(s). No action is required other than monitoring the project.

App (Device) User:

- Download the project onto the app.
- Collect data on the app.
- Send data from the app to the website at an appropriate time.
- Keep the project up to date by reinitializing the project after data is sent.

Accessing and downloading REDCap

To access REDCap mobile application on google play store and search for REDCap Mobile App and install, on iPhone download from apple play store. Tap on the downloaded REDCap mobile application.

The next step is to create two users:

Admin Account: This account will grant app function rights for data collectors which will allow them to setup/remove projects, send data, delete records, view/modify existing records and reset passwords. The admin account can also perform all of these functions with the exception of data collection. The admin account will not have any projects associated. The data collector passwords can be recovered via the admin account but the Admin password cannot be reset.

Data Collection: Allows a user to setup/remove projects, send data, delete records and view/modify existing records. The user will have their normal login for the REDCap server and a separate unique login for the REDCap Mobile App.

Note to Administrator

Enable User Rights for Mobile App

Once you have set up your users, you can then set up your mobile project. To set up your project, open your project on the external REDCap and navigate to User Rights and grant Mobile App Rights.

Request Mobile App API Token

Log into REDCap and navigate to your project. Click on REDCap Mobile App and then click on Request API Token. An email will be sent to REDCap Support for approval and you will be notified via email when your request is approved.

How to Use the REDCap Mobile App

Set Up Mobile Project on Device

Launch the REDCap mobile app and log in as your data collection user (not the admin account) and click “Set Up Mobile Project”. Click “Scan QR code” from the REDCap Mobile App screen in your REDCap project and use your mobile device to scan the code. If you experience any issues you may click “Can’t get the QR code to work” and then enter the Initialization code in the code box on your mobile project.

Click on the project name to confirm and to begin its download configuration. The download may take a few minutes depending on how large your project is. There are additional settings you may choose such as Download all records, get a partial set of data or do not download records.

Collect Data

To begin collecting data offline, click collect data. Select an instrument and then either click “Create New Record” or click on an existing record. Enter the data and then click Save Record or Save and Continue or Save and go to Next Instrument.

How to Use the REDCap Mobile App

Check for Other Records on the Server

To check to see if there are records that exist in your project that do not exist on your mobile device, click “Check for other records on the server”.

Send Data to Server

When you have an internet connect and you are ready to send your offline data to the REDCap server, click “Send Data to Server” and then click “Begin Send”. You will receive a message letting you know if your data was successfully sent to the REDCap server. Check your project on the REDCap server to ensure data was transferred correctly.

Refresh Setup & Data

If records exist in your project and you would like to sync them to your mobile device, click “Refresh Setup and Data”. This will delete your local copy of the project data and configurations as well as any offline data you have not transferred over to the project on the REDCap server. **Be sure to transfer your offline data first!** Once deleted, the mobile app will install the current version.

There will be two messages asking you to confirm that you want to delete your data.

MODULE 3

Intellectual Property Rights (IPR) Training in Responsible AI for Agriculture and Food Systems in Africa

Introduction to this Module

The manual was developed for IPR training in responsible AI for agriculture and food systems in Africa, the theme being 'The role of intellectual property rights in incentivizing responsible AI innovation for agriculture and food systems in Africa.

The overall objective of this training course is to provide a quick and comprehensive overview of the role of Intellectual Property (IP) laws and Intellectual Property Rights (IPRs) as tools to incentivize Artificial Intelligence (AI) inventions in Agriculture. The participants will gain a relevant and up-to-date landscape about IPRs related to the developing AI in agriculture and the incentives as well as challenges. The training also aims to share case studies, ideas, experiences and know-how in the field from different countries in Africa where successful AI Innovations in Agriculture and Food Systems have fostered AI innovations in agriculture.
The course is broken down into seven (7) modules as indicated below.

1. Introduction to the Training Manual
2. Understanding Intellectual Property Rights (IPRs)
3. Responsible AI Innovation in Agriculture and Food Systems
4. Intellectual Property Rights and AI Innovation in Agriculture and Food Systems
5. IP Management and Strategies for Agricultural Institutions and Stakeholders
6. Case Studies and Best Practices
7. Conclusion and Next Steps

Mode of delivery

Delivery will be through a mix of interactive lectures/presentations; group work; Problem-based learning.
Participants will be required to read recommended materials, discuss in groups and answer questions issued in each module/ session.

1.1 The rationale for IPR in AI in agriculture and food systems

AI has gained a lot of attention and increasing usage in many fields. The ability of machines to operate without the infallibility of human error has attracted the attention of both researchers and investors. For the larger public, AI-driven machines are providing much-needed solutions in almost all fields. In agriculture, AI-driven machines find usage in ploughing, planting, spraying, irrigation, harvesting, grinding and packaging, to name but a few. The challenges of climate change with the concomitant floods and long dry spells of drought expose Africa to vagaries of food insecurity. The continent has not attained food sufficiency. Food production, processing and storage are areas that could benefit from AI interventions. Researchers in AI in agriculture have a broad area of engagement.

Research in AI is likely to come up with new and innovative products, whose use on a large scale can benefit a larger segment of society. Once a scientist has come up with an invention, it takes a lot of capital to convert that into a product that can be commercialized. This is where investors come in. Both the inventor and the investor have an interest in making some financial

gain from their 'labours'. Hence, the need for protection of an invention. This protection is afforded through granting of monopoly rights to inventors for a limited period before the invention is open for all to work it. It is presumed that this period of 'protection' would enable an inventor to recoup their investment. The 'protection' also serves as an incentive for other researchers to devote their time and energy to working out new 'products' for the market. In the long run, both the inventor/investor and the wider society benefit from the invention. Concerning AI in agriculture - Africa can – in the long run become 'food sufficient'.

Objectives to be achieved

At the end of the training, participants should be able to:

1. Describe various forms of intellectual property.
2. Differentiate the period of protection of various forms of intellectual property.
3. Distinguish ways of protecting intellectual property.
4. Analyse ways of protecting intellectual property at national and international levels.
5. Explain ways of moving the invention from the 'lab' to the 'market'.
6. Discuss modalities of valuation of intellectual property.

Methodology for the training

The problem-based learning approach will be used.
Participants will be presented with specific questions that they will be required to tackle in groups. They will then present their 'findings' and corrections made thereto where necessary.

Expected outputs and outcomes

- An enhanced understanding of the various forms of intellectual property
- A better understanding of ways of protecting intellectual property.
- Improved knowledge of available institutions for protecting intellectual property
- An appreciation of the need to work with an institutional set-up in registering and commercializing an innovation.
- An understanding of how intellectual property can be valued.

UNIT 1: UNDERSTANDING INTELLECTUAL PROPERTY RIGHTS (IPR)

Intellectual Property (IP) as a conception of the human mind, is found almost everywhere in any society's day to day life.

Learning objectives-

At the end of the session, the participant shall be able to –

1. Define and describe various forms of intellectual property.
2. Determine how each type of intellectual property is acquired and enforced.
3. Differentiate the period of protection of various forms of intellectual property.
4. Distinguish ways of protecting intellectual property.
5. Analyse ways of protecting intellectual property at national and international levels.
6. Explain ways of moving the invention from the 'lab' to the 'market'.
7. Discuss modalities of valuation of intellectual property

This module covers:

Session 1

a. Definition and Importance of Intellectual Property Rights
b. Types of Intellectual Property Rights
c. Patents
d. Utility models
e. Industrial designs
f. Copyright & neighbouring rights
g. Trade secrets
h. Breeders/ Plant variety protection
i. Trademarks
j. Geographical indications

Session 2

k. Overview of Intellectual Property Rights Laws and relevant institutions in Africa
l. Commercialization of IP- moving the invention from the 'lab' to the 'market'.
m. Valuation of IP- modalities of valuation of intellectual property

WIPO defines Intellectual property (IP) as intangible creations of the human intellect that are protected by law[1]. These creations can include inventions, literary and artistic works, designs, symbols, names, and images used in commerce. Intellectual property rights grant exclusive ownership and control over these creations to the individuals or entities responsible for their creation, enabling them to benefit financially and protect their innovations from unauthorized use.

There are several types of intellectual property, each with its distinct characteristics and protection mechanisms. WIPO classifies IP into two main categories: Copyright and industrial Properties.

IP is territorial in nature, and it is therefore advisable to check the specific laws and regulations of the country where one wishes to obtain protection to understand the exact term of protection for utility models in that jurisdiction.

Types of Intellectual Property Rights (IPRs)

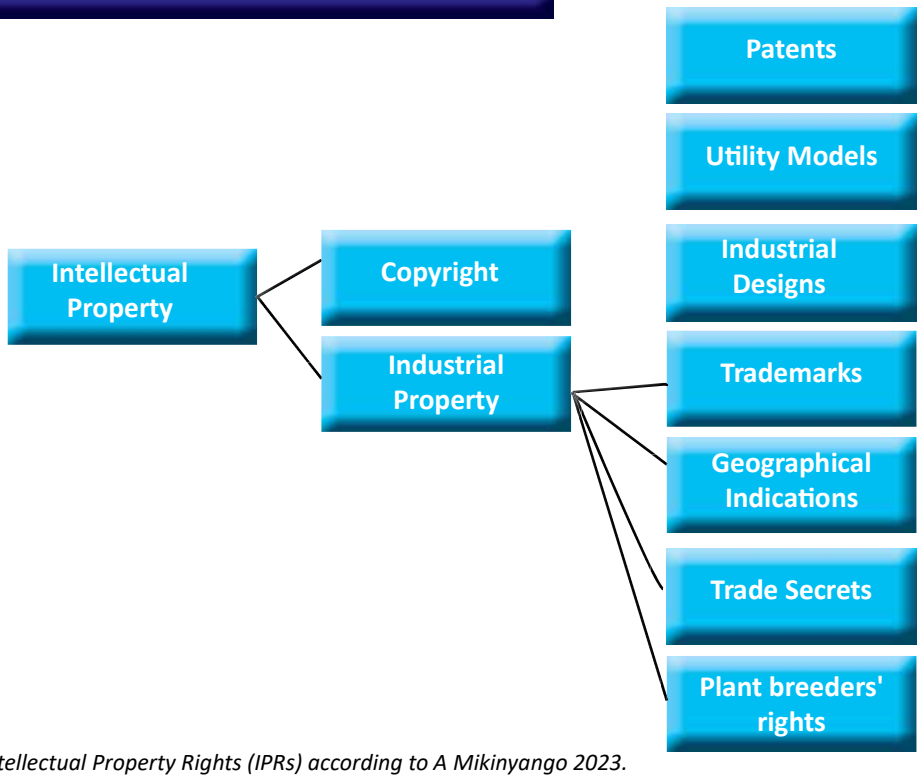


Fig 1: Types of Intellectual Property Rights (IPRs) according to A Mikinyango 2023.

Importance of IP:

- Encourages innovation and creativity.
- Provides legal protection for inventors and creators.
- Drives economic growth and competitiveness.
- Facilitates technology transfer and collaboration.

Activity

In your groups, read through the recommended readings and define each type of IP listed and its function- i.e., what it protects.

1.1 Overview of Intellectual Property

Definitions and noted derived from recommended readings.

a Copyright and Neighbouring Rights

Copyright is a form of intellectual property that grants exclusive rights to authors and creators of original works for a limited duration. Covered works include literary works, music, artistic works, films, software, architectural designs, databases, and more. Copyright protection is automatic; there is no need for registration in many countries, but this will vary from one country to another. The requirements for copyright protection vary depending on the country's laws, but generally, the following elements are necessary for a work to be eligible for copyright protection:

- **Originality**: The work must be original and the result of the author's creativity and intellectual effort. It should not be a direct copy or derivative of someone else's work.

- **Fixed Form:** The work must be fixed in a tangible form, which means it has been recorded or saved in some physical or digital medium, such as written on paper, recorded on audio or video, or saved in a digital file.

AI uses largely computer programmes and large data to produce desired projections/analyses and or to function in a specific way. In many countries - including African countries - these puts rights in AI under copyright. Other rights mentioned below may be applicable depending on other uses and related innovations beyond the data and computer programmes.
Rights granted to the copyright holder include the right of reproduction, distribution, adaptation, public performance and public Display: Exclusive right to display the work publicly.

Neighbouring rights

Neighbouring rights, also known as related rights, are a set of intellectual property rights granted to individuals and organizations who are involved in the performance, recording, broadcasting, or dissemination of copyrighted works. These rights are distinct from copyright but are related to it as they protect the interests of specific parties involved in the creative process. The concept of neighboring rights varies between different countries, and the scope of protection can differ, but the underlying principles remain similar. Here are some key points to understand neighboring rights.

b Patents

A patent is a legal document or protection granted by a government to inventors for their new and unique inventions or discoveries. It gives the inventor exclusive rights to control how their invention is used or sold for a limited period of time.
All the requirements for protection must be met:

- **Novelty:** The invention must be new and never publicly disclosed or known before. It should be something that has not been done or created by anyone else.
- **Non-obviousness:** The invention should not be obvious to someone with knowledge and experience in the related field. It should involve a significant improvement or a unique combination of existing ideas.
- **Industrial Applicability:** The invention must be capable of being used or applied in an industrial or commercial setting.
- **Usefulness:** The invention must have a practical use or function. It should not be something abstract or purely theoretical.
- **Adequate Description:** The application should include a clear and detailed description of

the invention, enabling someone skilled in the relevant field to understand and replicate the invention.

Once the patent is granted, the inventor gets the exclusive rights to produce, manufacture, and sell products or processes that incorporate the protected invention. The inventor can also prevent others from importing the invention into a country where the patent is granted.
However, it's important to note that a patent is not an indefinite right. It usually lasts for a specific period, typically 20 years from the date of filing the patent application. After the patent expires, the invention enters the public domain, and anyone can use or build upon it without the need for permission.

Patents are meant to encourage innovation by providing inventors with an incentive to disclose their inventions to the public in exchange for temporary exclusivity. This allows inventors to protect their creations and potentially profit from them, while also sharing knowledge that can further advance technology and society.

c Utility Models

A form of Intellectual Property protection granted to inventions that are novel and industrially applicable but may not require the same level of inventive step or non-obviousness as required for standard patents. Utility models are intended to provide a faster and less stringent way to protect inventions that are improvements or modifications to existing products or processes.
Utility models protect new and useful inventions that have an industrial application. Unlike standard patents, utility models may not require a high level of inventiveness or non-obviousness. They usually cover incremental improvements or modifications to existing technology.

They provide a shorter and less expensive route to obtain intellectual property protection compared to regular patents. The scope of protection granted by utility models is generally narrower than that of patents.

The specific requirements for registering a utility model vary from one country to another, as each country has its own laws and regulations governing utility models. However, the general requirements typically include:

- **Novelty:** The invention must be new, i.e., not known or publicly disclosed before the date of filing the utility model application.
- **Non-obviousness (or Inventive Step):** Although the threshold for inventive step is generally lower for utility models than for patents, there still needs to be some degree of novelty or improvement over existing technology.
- **Industrial Applicability:** The invention must be capable of being used or applied in an industrial or commercial setting.
- **Adequate Description:** The application should include a clear and detailed description of the invention, enabling someone skilled in the relevant field to understand and replicate the invention.

The utility model holder is granted the exclusive right to use, make, and sell the invention covered by the utility model. This means that no one else can commercially exploit the protected invention without the holder's permission.

The term of protection for utility models also varies from country to country. In many jurisdictions, utility models offer shorter protection periods compared to standard patents.

The term of protection for utility models is typically measured from the filing date and lasts for a fixed number of years, usually between 6 to 15 years, depending on the country.

d Trademarks

A trademark is a unique sign, symbol, name, or logo that distinguishes products or services from one source or origin to another. Trademarks play a crucial role in the business world by creating brand identity, establishing consumer trust, and preventing confusion among consumers. Trademark protection allows the owner to have exclusive rights over the mark and helps safeguard their brand from unauthorized use. Trademarks are also known as trade names. It is the name given to a specific product and which is used to market the said product. Trademarks needs to be registered with the appropriate government authority provides stronger protection and nationwide coverage.

To successfully register a trademark, certain elements must be fulfilled. These include;

- **Distinctiveness:** The mark must be distinctive and capable of identifying the source of the goods or services. The stronger and more unique the mark, the easier it is to register and protect.
- **Non-functionality:** The mark must not be functional; it should not be essential to the product or service itself. For example, the shape of a container that affects the function of the product cannot be registered as a trademark.
- **Non-confusing:** The mark should not cause confusion with an existing registered trademark in the same industry or sector.
- **Use in Commerce:** To register a trademark with the USPTO, the mark must be used in commerce, meaning it must be used in connection with the sale or advertising of goods or services across state lines.

Once a trademark is registered successfully, it grants the owner exclusive rights to use the mark for a specified period. The term of protection varies depending on the country, but generally, it lasts for ten years, with the option of renewal.

Innovators in AI need to give names to their products and have the same registered as trademarks.

e Trade secrets

Trade secrets are a type of intellectual property that refers to valuable and confidential information used by a business to gain a competitive advantage over others. Unlike patents, trademarks, or copyrights, trade secrets are not publicly disclosed or registered with the government.

The conditions of protection for trade secrets are relatively simple:

- **Secrecy:** To be protected as a trade secret, the information must be kept a secret. This means the company must take reasonable measures to ensure it is not known to the public or competitors. If the secret becomes widely known, it loses its protection.
- **Economic Value:** The information must have economic value because it's a secret. It should give the business an advantage over its competitors, and the company should actively use it to remain competitive.
- **Reasonable Efforts:** The owner of the trade secret should take reasonable steps to keep it confidential. This might involve restricting access to the information, using confidentiality agreements with employees and partners, and implementing security measures.

- **Independent Creation:** Trade secrets are not protected if someone else independently develops or discovers the same information without misappropriation or theft.

If these conditions are met, trade secrets can be protected indefinitely, allowing companies to safeguard valuable knowledge and strategies from competitors. However, it's essential to be cautious and maintain secrecy actively, as once the secret is revealed or leaked, its protection is lost. It is up to the individual innovator or company to keep secrets.

f Industrial Design

Industrial Design refers to the appearance or aesthetics of a product resulting from its shape, configuration, pattern, or ornamentation.

Requirement for protection;

- **Novelty:** Designs must be new and not disclosed to the public before filing the application.
- **Originality:** The design should not be a common or ordinary shape but possess unique visual features.
- **Non-obviousness:** The design should not be an obvious variation of existing designs.
- **Industrial Applicability:** Designs must be capable of being mass-produced.

In order to gain protection, registration is necessary. The steps involved in registering an industrial design include filing an application, examination by national IP authorities, and granting protection upon meeting requirements.

The duration of protection for industrial designs varies by country but generally lasts for 10 to 25 years. Renewal is required periodically to maintain protection. Failure to renew can lead to loss of rights.

g Geographical Indications

Geographical Indication (GI) is a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. They are a type of intellectual property right that aims to protect the names of products originating from specific geographical areas, which possess qualities, reputation, or characteristics attributable to their place of origin.

The primary objective of GI protection is to promote and preserve the unique identity and qualities of products linked to specific geographical regions. GIs help consumers identify genuine products and ensure quality assurance Examples of GIs include "Champagne" (France), "Darjeeling Tea" (India), and "Roquefort Cheese" (France).

Protection of GIs is often granted under national and international laws. The World Intellectual Property Organization (WIPO) administers the Lisbon Agreement for the Protection of Appellations of Origin and their International Registration, which provides a system for international protection of GIs.

To acquire protection, GIs must have a clear link between the product's quality, reputation, or characteristics and its geographical origin. There should be a defined geographical area, and the product must be produced or processed within that area. In Africa and in some countries like Kenya, there are regions whose climate, soil type and topography make them ideal for producing tea and coffee; others are well suited for wheat production, yet others for maize production on a large scale. It should be observed that Kenyan sugar is produced in the Western part of Kenya. It is these peculiarities of environment that eventually give specific appellations to the products that lead to registration of geographical indications.

Plant Breeders Rights

Plant Breeder's Rights (PBR), also known as Plant Variety Rights (PVR) or Plant Patents, are a form of intellectual property protection granted to plant breeders for new, distinct, uniform, and stable plant varieties they have developed. The objective of PBR is to provide an incentive for plant breeders to invest time and resources in developing new and improved plant varieties, leading to advancements in agriculture and horticulture.

- **Requirements for Protection:** To be eligible for Plant Breeder's Rights protection, a plant variety must meet several criteria:
- **Novelty:** The variety must be new and not be previously available or publicly known before the date of application. It should not have been sold or disposed of with the breeder's consent for more than a specified period (usually one year) before the application.
- **Distinctiveness:** The variety must be distinct from any other existing varieties by at least one significant characteristic, which can be morphological, genetic, or other observable traits.
- **Uniformity:** The variety should demonstrate a high degree of uniformity in its key characteristics when propagated through its typical reproduction methods.
- **Stability:** The essential characteristics of the variety must remain unchanged after repeated propagation or, in the case of a particular cycle, between generations.

The rights holder gains exclusive control over the protected plant variety. This means that no one else can produce, sell, export, import, or stock the protected variety without the breeder's authorization or a licensing agreement. The rights holder can also prevent others from using the protected variety for commercial purposes without permission.

The duration of Plant Breeder's Rights protection varies between countries and regions. Typically, the duration is calculated from the date of grant or registration, and it usually lasts for a specific number of years from that date. In many countries, the standard duration of protection is around 20 to 25 years for most crops. However, this period might differ for trees and vines, where it can be longer.

1.2 Protection of IP Nationally, Regionally and Internationally

Protection of IP can be categorized in national, regional and international protection. Take note that no one international or regional law automatically protects IP.

a National Protection

National IP protection is implemented through laws and regulations established by individual countries. Each country has its own system for granting and enforcing IP rights through national IP offices. By its nature, IP is territorial in nature and the owner of an invention or innovation is advised to seek registration in all countries they wish to sell import their product or process.

b Regional Protection

In certain regions, multiple countries may collaborate to establish unified IP protection mechanisms. One notable example in the African region is the African Regional Intellectual Property Organization (ARIPO) which is for the English-speaking countries and The African Intellectual Property Organization (OAPI) mainly for French speaking African countries.

c International Protection

International IP protection is crucial in a globalized world, where ideas and creations can be easily disseminated across borders. Several international agreements and organizations

help facilitate IP protection worldwide. The main organization being the world Intellectual Property Organization (WIPO), a specialized agency of the United Nations that administers multiple international treaties related to IP. It provides a forum for countries to cooperate and harmonize their IP laws. Countries can adhere to these international agreements, which help to align their IP laws with global standards and facilitate cooperation and enforcement of IP rights on an international scale.

In conclusion, the protection of intellectual property is a multi-layered system that involves national, regional, and international measures. These mechanisms collectively work to incentivize innovation, creativity, and the protection of the fruits of human intellect across different jurisdictions.

Activity

From what you have read about the different types of IP, identify the meaning, purpose and registration requirements of each form of protection.

Type of IP	What is it?	Registration requirements	Purpose

1.3 Commercialization and Valuation of IP

The meaning of commercialization of intellectual property refers to the process of turning intangible assets, such as ideas, inventions, innovations, creative works, and other forms of intellectual property (IP), into commercially viable products or services that can be bought, sold, licensed, or otherwise monetized in the marketplace. This process involves taking an idea or creation and transforming it into a tangible product, service, or technology that generates revenue or adds value to a business or organization (see figure no. 2 next).

Commercialization process

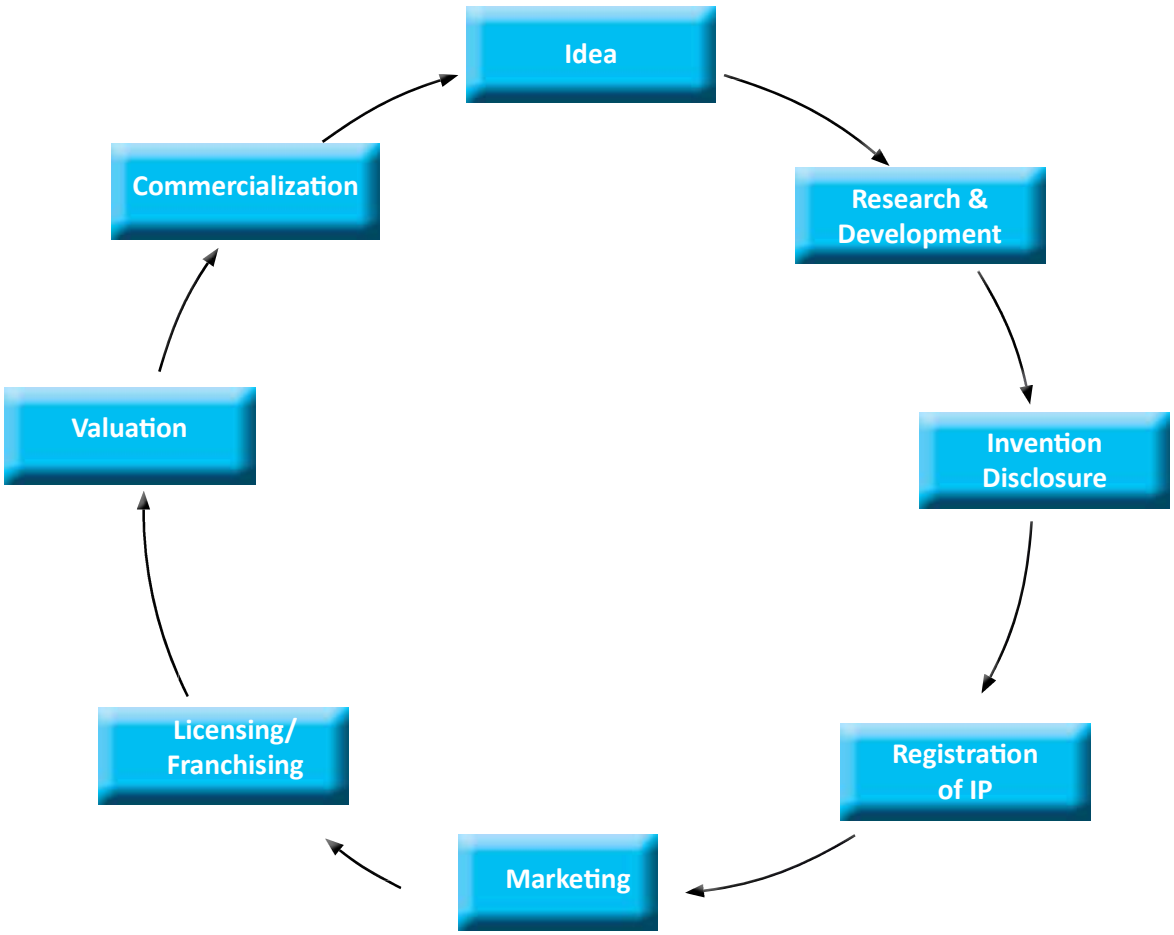


Fig 2: Process of commercialization of an invention from an idea to product/process according to A Mikinyango 2023.

Commercialization involves taking these intellectual assets and transforming them into products, services, or technologies that can be bought or sold in the market. It's not just about having a brilliant idea or creation but also about making it feasible and attractive to potential customers or partners. Commercialization involves taking these intellectual assets and transforming them into products, services, or technologies that can be bought or sold in the market. It's not just about having a brilliant idea or creation but also about making it feasible and attractive to potential customers or partners.

Commercialization involves taking these intellectual assets and transforming them into products, services, or technologies that can be bought or sold in the market.

It's not just about having a brilliant idea or creation but also about making it feasible and attractive to potential customers or partners. The primary goal of commercialization is to add value to the intellectual property by converting it into something that generates revenue. This can be achieved through various means, such as licensing the IP to other companies, selling products based on the IP, or using it as a foundation for new business ventures.

Commercialization entails.

a. **Market Research and Business Development:** Before commercializing intellectual property, thorough market research is essential to understand the demand, competition, and potential customers. Additionally, business development strategies are employed to create a business model that maximizes the IP's commercial potential.

b. **Legal and Contractual Considerations:** Commercializing intellectual property involves navigating complex legal and contractual matters related to IP rights, licensing agreements, royalties, and other legal arrangements. Proper protection and enforcement of IP rights are crucial to prevent unauthorized use or infringement.

c. **Collaboration and Partnerships:** In some cases, commercializing intellectual property may require collaborations with other companies, manufacturers, investors, or partners who can provide resources, expertise, and distribution channels to bring the IP to market effectively.

d. **Valuation of IP;** Determining the value, not just the price is important.

e. **Long-term Strategy:** Commercialization is often part of a broader long-term strategy for businesses and organizations to leverage their intellectual property assets for sustained growth and competitive advantage.

1.4 Valuation of IP

The valuation of intellectual property (IP) refers to the process of determining the monetary worth or financial value of intangible assets that result from human creativity, innovation, and knowledge.

Valuation of intellectual property is essential for various purposes such as mergers and acquisitions, company asset management, licensing agreements, financing, taxation, litigation, and strategic decision-making. There are several methods and approaches used to determine the value of intellectual property, including:

- **Cost Approach:** Calculates the value based on the cost to develop or acquire the IP, considering research and development expenses, legal fees, and other related costs.

- **Market Approach:** Compares the IP's value to similar assets sold in the market or based on royalty rates from comparable licensing agreements.

- **Income Approach:** Estimates the value based on the projected future economic benefits generated by the IP, such as licensing income or cost savings.

- **Relief from Royalty Method:** Determines the value by estimating the cost savings realized by owning the IP rather than licensing it from a third party.

It is important to note that valuing intellectual property can be a complex and subjective process, and the value assigned may vary depending on the purpose of the valuation, the specific characteristics of the IP in question and the market situation. As such, seeking expert advice from qualified professionals such as IP attorneys, appraisers, or valuation experts is often advisable when conducting IP valuations.

1.5 Intellectual Property Management (IPM)

Intellectual Property Management (IPM) refers to the strategic and systematic approach used by individuals or organizations to protect, utilize, and maximize the value of their intellectual property (IP) assets. Intellectual property refers to creations of the mind, such as inventions, designs, trademarks, trade secrets, and creative works, which can be legally protected through patents, copyrights, trademarks, and other forms of IP rights.
IPM involves various processes and practices aimed at managing these IP assets throughout their lifecycle, from conception to commercialization and beyond. The main objectives of IPM include safeguarding the rights of the IP owner, ensuring the proper utilization of the IP assets, generating revenue through licensing or sales, ensuring compliance (such as paying renewal fees) and mitigating the risk of infringement by others.

Here are some key components of Intellectual Property Management:
IP Strategy: Developing a comprehensive IP strategy is fundamental to IPM. This involves identifying the most valuable IP assets, understanding their potential impact on the business, and aligning IP protection efforts with the overall business objectives. The strategy should also address issues such as geographical coverage, enforcement, and potential collaborations or licensing opportunities.

- **IP Protection:** Registering patents, trademarks, and copyrights are essential steps in protecting intellectual property. By securing these legal rights, the IP owner gains the exclusive right to use, sell, license, or enforce the protected assets.

- **IP Portfolio Management:** Organizations often have a portfolio of IP assets. Managing this portfolio involves keeping track of the status of each asset, understanding its value, and making decisions about maintaining, expanding, or divesting certain IP rights based on the business strategy.

- **IP Commercialization:** IP assets can be monetized through various means, such as licensing, joint ventures, strategic partnerships, or outright sales. IPM involves identifying opportunities for commercialization and negotiating favorable licensing agreements or contracts.

- **IP Enforcement:** IPM also includes actively monitoring the marketplace to identify potential infringements of the IP assets. When infringement occurs, the IP owner can take legal action to protect their rights.

- **IP Valuation:** Determining the value of IP assets is crucial for making informed business decisions, negotiating deals, or seeking funding. IP valuation considers factors such as market demand, competitive landscape, and the potential economic benefits the IP assets can bring.

- **IP Policy and Education:** Organizations often establish internal policies to govern how employees handle intellectual property. Educating employees about IP rights and the importance of safeguarding them helps create a culture of IP awareness and compliance.

- **Effective IPM can provide numerous benefits**, including increased competitiveness, enhanced market position, revenue generation, and protection against potential IP infringement. As technology and business landscapes continue to evolve, managing intellectual property strategically becomes increasingly crucial for organizations to succeed and thrive.

UNIT 2: RESPONSIBLE AI INNOVATION IN AGRICULTURE AND FOOD SYSTEMS

This module introduces participants to the concept of Artificial Intelligence and AI innovations in agriculture.

At the end of the session, the participant shall be able to –

1. Define AI and explain the significance.
2. Define and identify Principles of Responsible AI Innovation
3. Outline ethical issues in AI for Agriculture and Food Systems
4. Identify public policy matters in Privacy and Data Protection in AI Innovation
5. Determine measures of accountability and responsibility in AI Development and Deployment

This module covers the following;

1. Definition and Principles of Responsible AI Innovation
2. Implications of IPRs for AI Innovation in Agriculture and Food Systems
3. Ethical issues in AI for Agriculture and Food Systems
4. Bias, Fairness, and Transparency in AI Applications
5. Privacy and Data Protection in AI Innovation
6. Accountability and Responsibility in AI Development and Deployment

Responsible AI innovation in agriculture and food systems refers to the application of artificial intelligence (AI) technologies in a manner that prioritizes sustainability, ethics, and equitable outcomes. It involves leveraging AI to address various challenges faced by the agricultural sector, such as increasing productivity, reducing environmental impacts, ensuring food security, and promoting social fairness.

AI can aid farmers in making data-driven decisions to optimize resource utilization, including water, fertilizers, and pesticides. Through the analysis of sensor data and satellite imagery, AI- powered systems can offer valuable insights into crop health, pest detection, and irrigation scheduling. This leads to more efficient farming practices, minimizing waste and promoting sustainable agriculture.

Responsible AI innovation enables precision agriculture, which involves tailoring farming techniques to specific field areas. AI algorithms can process data from various sources to create detailed maps of soil fertility, moisture levels, and plant health. By precisely targeting inputs and interventions, farmers can improve yields while reducing costs and environmental impact.

AI also plays a crucial role in optimizing the food supply chain. From automated harvesting and sorting in farms to predictive demand forecasting and logistics optimization in distribution, AI-driven technologies can reduce food loss, spoilage, and transportation inefficiencies, ensuring food reaches consumers efficiently and sustainably.

2.1 Definition of Artificial Intelligence (AI)

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines, enabling them to perform tasks that typically require human intelligence. AI systems are designed to learn, reason, and solve problems independently, adapting and improving their performance based on experience and data. The ultimate goal of AI is to create machines capable of perceiving their environment, understanding natural language, learning from experience, and making decisions to achieve specific objectives.

AI can be broadly categorized into two types:

a. **Narrow AI (Weak AI):** This type of AI is designed to perform specific tasks or solve particular problems within a limited domain. Examples include virtual personal assistants like Siri or Alexa, recommendation systems used by streaming services, and autonomous driving systems. Narrow AI can excel at its designated tasks but lacks the broader cognitive abilities of human intelligence.

b. **General AI (Strong AI):** General AI refers to machines that possess human-like intelligence and can understand, learn, and apply knowledge across various domains. These hypothetical systems would be capable of performing any intellectual task that a human can do. However, creating true General AI remains a complex and elusive goal, as it requires solving profound challenges related to consciousness, self-awareness, and ethical considerations.

2.2 Ethical Considerations in AI for Agriculture and Food Systems

AI applications have become prevalent in various fields, including natural language processing, computer vision, robotics, healthcare, finance, and more. As AI continues to advance, its potential impact on society, economics, and human life becomes increasingly significant. Therefore, the ethical and responsible development of AI is crucial to ensure its benefits are maximized while minimizing potential risks and challenges.

AI has made significant contributions to agriculture and food systems, revolutionizing various aspects of the industry, from crop management to food distribution. While AI brings numerous benefits, it also raises important ethical considerations that must be addressed to ensure its responsible and sustainable implementation.

a. **Data Privacy and Security:** AI in agriculture relies heavily on data collection from various sources, including sensors, drones, and satellite imagery. Ensure the protection of farmers' and consumers' data from unauthorized access, breaches, or misuse. The solution here is to Implement strong data encryption, access controls, and cybersecurity measures to safeguard sensitive information and comply with relevant data protection laws and standards to respect individual privacy rights.

b. **Bias and Fairness:** AI algorithms learn from historical data, which may contain inherent biases based on past decisions, social structures, and cultural norms. Avoid reinforcing biases in agricultural practices and food systems, which could perpetuate inequalities. Solution is to regularly audit AI systems to identify and mitigate bias and involve diverse teams in the AI development process to ensure a more balanced perspective. Encourage transparency in AI decision-making, allowing stakeholders to understand the factors influencing outcomes.

c **Environmental Impact:** AI-driven agricultural practices can improve efficiency, but they may also have environmental consequences. Balance the positive impact of AI in agriculture with its potential negative effects on the environment and natural resources. The solution here is to promote AI applications that contribute to sustainable farming, water conservation, and reduced greenhouse gas emissions. Also, to encourage research on AI technologies that support biodiversity and ecological preservation.

d **Farmer Autonomy and Dependence:** AI adoption may lead to increased reliance on technology, potentially affecting farmers' autonomy and decision-making power. Prevent technology from replacing human judgment and farmers' traditional knowledge, leading to loss of agricultural heritage. Solution here is to provide training and education to farmers to understand AI systems, enabling them to make informed decisions and use AI as a tool rather than a replacement. Also foster a supportive ecosystem that empowers farmers and ensures their active participation in AI adoption.

e **Food Safety and Quality:** AI is increasingly used in food processing, quality control, and supply chain management. Ensure that AI applications maintain high standards of food safety and quality. The solution here would be to regularly monitor and assess AI algorithms to guarantee accurate and reliable results, preventing contaminated or substandard food from reaching consumers. Further, collaborate with regulatory authorities to establish guidelines for AI adoption in food safety management.

f **Impact on Rural Communities:** The implementation of AI in agriculture may have significant social implications for rural communities. Address the potential displacement of labor, especially in traditional farming communities, and promote equitable distribution of AI-driven benefits. The solution here is to support workforce reskilling programs to prepare rural communities for the changing job landscape. Also encourage inclusive policies and investments that empower rural communities to participate in and benefit from AI advancements.

Embracing AI in agriculture and food systems offers exciting possibilities for increased efficiency and sustainability. Addressing ethical considerations is crucial to ensure responsible and equitable AI adoption. Collaborative efforts from stakeholders, policymakers, and the AI community are essential to build an ethical framework that promotes the responsible use of AI for the betterment of agriculture and food systems.

2.3 Ensuring Accountability and Responsibility in AI Development and Deployment

This section covers key principles, challenges, and strategies to promote ethical AI practices and maintain accountability in AI systems.

- Accountability refers to the obligation of developers and organizations to take responsibility for the consequences of AI systems' actions.
- Responsibility entails ensuring that AI systems act in a manner that aligns with ethical guidelines and legal requirements.
- Stakeholders must consider the social, ethical, and legal implications of AI technologies.

2.4 Challenges in Ensuring Accountability and Responsibility

Bias and Fairness: AI systems can perpetuate existing biases present in training data, leading to discriminatory outcomes. Fairness should be a priority in AI development to avoid discrimination based on race, gender, or other protected characteristics.

Transparency and Explainability: AI systems are often complex, making it challenging to understand their decision- making processes. Transparency and explainability mechanisms are crucial to gaining user trust and understanding how AI arrives at particular conclusions.

Data Privacy and Security: AI systems often require vast amounts of data, raising concerns about data privacy and the potential for data breaches. Developers must implement robust security measures and comply with privacy regulations to safeguard user information.

Accountability for Autonomous Systems: As AI evolves, autonomous systems may make critical decisions without human intervention. Assigning responsibility for actions taken by fully autonomous AI systems becomes a significant challenge.

Unintended Consequences: AI systems can have unintended consequences in real-world scenarios, potentially causing harm. Preemptive measures should be taken to anticipate and mitigate these risks.

2.5 Promoting Accountability and Responsibility in AI

Ethical Frameworks and Guidelines: Developers should adhere to established ethical frameworks, such as those developed by organizations like IEEE and ACM. Implementing ethical guidelines helps ensure that AI aligns with societal values.

Diverse and Representative Development Teams: A diverse team can provide unique perspectives and insights to identify and mitigate biases during AI development. Representation from various backgrounds helps create AI systems that cater to a broader user base.

Auditing and Certification: Independent audits and certification processes can assess AI systems for fairness, transparency, and compliance with ethical standards. Certification can help build trust among users and stakeholders.

Explainable AI (XAI): Developing AI models that provide explanations for their decisions can enhance transparency and facilitate understanding. Techniques like model interpretability and post-hoc explanations can be employed.

Continuous Monitoring and Feedback Loops: Regularly monitoring AI systems in real-world scenarios allows for the identification of potential biases and unintended consequences. Feedback loops facilitate continuous improvement and prompt responses to emerging issues.

Responsible AI Impact Assessments: Before deploying AI systems, conduct impact assessments to evaluate potential ethical, social, and legal implications. Address identified risks and concerns before releasing the AI system into production.

Ensuring accountability and responsibility in AI development and deployment is crucial for building trustworthy and beneficial AI systems. By embracing ethical guidelines, promoting transparency, and adopting responsible practices, developers can create AI technologies that benefit society while minimizing potential harm.

UNIT 3: INTELLECTUAL PROPERTY RIGHTS AND AI INNOVATION IN AGRICULTURE AND FOOD SYSTEMS

This module covers;

a. Intellectual Property Protection for AI Innovations
b. Licensing and Commercialization of AI Innovations
c. IP Strategies for Startups and SMEs in Agriculture and Food Systems
d. Collaborations and Partnerships in AI Innovation

Intellectual Property Rights (IPRs) play a crucial role in fostering AI innovation in agriculture and food systems. IPRs provide legal protections for the creators and innovators of new technologies, ensuring that they can reap the benefits of their investments in research and development. This protection encourages companies and individuals to invest in the development of AI technologies for agriculture, leading to advancements that can enhance food production, sustainability, and overall efficiency.

Here's how Intellectual Property Rights and AI innovation intersect in agriculture and food systems:

Patents: Patents are a key component of IPRs that grant inventors the exclusive rights to their inventions for a specific period. In the context of AI innovation, companies and researchers can file patents for novel AI algorithms, systems, and applications used in agriculture and food production. This encourages them to invest in developing and deploying AI solutions in this sector, as they know they will have a competitive advantage and the ability to license their technology to others.

Data and Software Protection: Intellectual Property Rights also cover software and data protection. As AI in agriculture relies heavily on sophisticated algorithms and data analysis, IPRs protect proprietary AI software and datasets from unauthorized use or distribution. This safeguards the hard work invested in creating and collecting valuable data, thereby incentivizing further data-driven AI innovation in the sector.

Trade Secrets: In some cases, companies may choose to protect their AI innovations in agriculture as trade secrets rather than obtaining patents. Trade secrets refer to confidential information that gives a company a competitive edge. By keeping their AI technology secret, companies can prevent others from using or reverse engineering it, encouraging continued investment in AI research and development.

Technology Licensing: IPRs also enable technology transfer through licensing agreements. Companies that hold patents or other IPRs related to AI in agriculture can license their technology to others, fostering collaboration and dissemination of knowledge. This can lead to increased adoption of AI technologies throughout the industry.

Research Funding: IPRs can provide a financial incentive for research and development in AI for agriculture. Companies and researchers who secure IPR protection for their innovations may attract more funding and investment from various sources. This influx of capital can lead to further advancements and improvements in AI applications for agriculture and food systems.

However, it is essential to strike a balance between protecting intellectual property and promoting innovation. Overly restrictive IPRs could hinder research and collaboration, limiting the potential benefits of AI in agriculture. Therefore, policymakers need to consider how to strike the right balance between providing incentives for innovation and ensuring that the technology's benefits reach the broader agricultural community and society at large.

In summary, Intellectual Property Rights are a crucial driver of AI innovation in agriculture and food systems. By providing legal protections and financial incentives, IPRs encourage companies and researchers to invest in the development of AI technologies that can revolutionize the way we produce, manage, and distribute food, ultimately leading to a more sustainable and efficient global food system.

3.1 Licensing and Commercialization of AI Innovations

Today, the field of Artificial Intelligence (AI) is advancing rapidly, with innovative solutions and technologies emerging across various industries. The successful commercialization of AI innovations plays a crucial role in driving economic growth, enhancing productivity, and improving our overall quality of life. In this lecture, we will explore the concepts of licensing and commercialization of AI innovations and their significance in the contemporary business landscape.

3.2 Licensing AI Innovations

Licensing is a legal agreement between two parties, where the owner of a technology or intellectual property (licensor) grants permission to another party (licensee) to use, modify, or distribute the technology under specific terms and conditions.

Types of Licenses:

- **Exclusive License:** Grants the licensee sole rights to use the AI innovation within a specific field or territory.
- **Non-Exclusive License:** Allows multiple licensees to use the AI innovation simultaneously.
- **Perpetual License:** Provides the licensee with the right to use the AI innovation indefinitely. Limited Term License: Sets a fixed duration for the license agreement.

Benefits of Licensing AI Innovations:

- **Rapid Market Penetration:** Licensees can quickly adopt and deploy AI innovations without significant upfront investment in research and development.
- **Revenue Generation:** Licensors can generate revenue through licensing fees, royalties, or profit-sharing arrangements.
- **Risk Mitigation:** By partnering with experienced licensees, licensors can reduce the risks associated with market uncertainty.

Challenges and Considerations:

- **Intellectual Property Protection:** Ensuring strong IP protection is essential to prevent unauthorized use or replication.
- **Licensee Selection:** Licensors should carefully evaluate potential licensees' capabilities, reputation, and alignment with their business goals.
- **Negotiating Terms:** Both parties must negotiate terms that are mutually beneficial and cover aspects like exclusivity, royalties, and support.

3.3 Commercialization of AI Innovations

Commercialization refers to the process of introducing AI innovations into the market, making them available to end-users, and creating business value from the technology.

Steps in Commercialization:

- Market Research: Understanding the target market, potential customers, and competitors.
- Product Development: Refining the AI innovation to meet market demands and user requirements.
- Marketing and Promotion: Creating awareness and interest in the AI product or service.
- Sales and Distribution: Establishing channels to reach customers effectively.
- Customer Support: Providing post-sales support and addressing customer needs.

Commercialization Strategies:

- Direct Sales: Selling AI products or services directly to end-users or businesses.
- Partnerships and Alliances: Collaborating with other companies to leverage their market presence and distribution networks.
- White Labeling: Allowing other companies to rebrand and sell AI products as their own.
- Freemium Model: Offering a basic version of the AI innovation for free and charging for premium features.

Benefits and Challenges of Commercialization:

- Benefits: Revenue generation, market expansion, increased visibility, and opportunities for further innovation.
- Challenges: Market competition, scalability, regulatory compliance, and managing customer expectations.

Licensing and commercialization are vital strategies for AI innovators to bring their creations into the market, capitalize on their inventions, and foster further research and development. As AI continues to shape our world, finding the right balance between protecting intellectual property and facilitating widespread access will be crucial for a sustainable and innovative future.

3.4 IP Strategies for Startups and SMEs in Agriculture and Food Systems

Intellectual Property (IP) strategies are crucial for startups and small to medium-sized enterprises (SMEs) in the agriculture and food systems sector. IP protection can provide a competitive edge, secure market positions, attract investment, and foster innovation.

Here are some key IP strategies for startups and SMEs in this industry:

Patents: These protect new and useful processes, machines, compositions of matter, or improvements thereof. Startups and SMEs can seek patents for novel agricultural machinery, food processing technologies, or genetically engineered crops.

Trademarks: Create a strong brand identity for agricultural products or food items. Trademarks protect names, logos, or symbols that distinguish products or services, giving them a unique presence in the market. Register trademarks with relevant authorities to prevent others from using similar marks that could cause confusion among consumers.

Trade Secrets: Keep confidential information related to agricultural processes, recipes, or technologies as trade secrets. It's essential to have non-disclosure agreements (NDAs) with employees, partners, or vendors to safeguard sensitive information.

Copyright & Neighbouring Rights: Consider copyright protection for original creative works such as marketing materials, product packaging designs, and software used in food processing or farm management.

Open Innovation and Licensing: Collaboration with research institutions, universities, or other startups in the industry can lead to valuable innovations. Consider licensing or cross-licensing IP to access new technologies and expand market reach.

Geographical Indications (GI): For startups and SMEs producing region-specific food products with unique characteristics or qualities, obtaining geographical indications can protect against imitation and ensure product authenticity.

IP Monitoring and Enforcement: Continuously monitor the market for potential IP infringement. Be prepared to take legal action if any unauthorized use of your IP is detected.

Customization of IP Strategies: Tailor IP strategies according to the specific needs and goals of the startup or SME. Not every IP protection type may be relevant for each company, so it's crucial to assess what is most valuable for the business.

Early IP Evaluation: Evaluate IP opportunities and risks early in the startup's development. This can help align IP strategies with business plans and ensure timely protection.

IP Education and Training: Educate employees and stakeholders about the importance of IP and how to identify and protect it. Building IP awareness within the organization can prevent accidental disclosure of critical information.

Remember, IP strategies should align with the overall business strategy of the startup or SME. Seeking advice from IP professionals or attorneys specialized in the agriculture and food systems sector can help navigate the complex landscape of IP protection and ensure the best approach for each company's unique needs.

3.5 Collaborations and Partnerships in AI Innovation

Collaborations and partnerships play a crucial role in driving AI innovation. In the rapidly evolving field of artificial intelligence, no single organization or entity can possess all the necessary expertise, resources, and data to tackle the complex challenges and opportunities that arise. By collaborating and forming partnerships, different stakeholders can combine their strengths, pool their resources, and leverage diverse perspectives to accelerate progress in AI research, development, and deployment.

Here's a closer look at how collaborations and partnerships foster AI innovation:

a. **Knowledge Sharing and Cross-Pollination:** Collaborations allow researchers, engineers, and experts from different organizations, academia, and industries to come together, share their knowledge, insights, and experiences. This cross-pollination of ideas can lead to breakthroughs and novel approaches that might not have been possible in isolated environments.

b. **Access to Complementary Expertise:** AI research and development require a wide range of expertise, such as machine learning, computer vision, natural language processing, hardware engineering, and domain-specific knowledge. Collaborations enable partners to

access each other's specialized skills and knowledge, filling gaps and enhancing the overall capabilities of the project.

c **Resource Sharing:** AI projects often require substantial resources, including computational power, datasets, and funding. Collaborating partners can share these resources, making it more feasible to undertake ambitious projects that might be beyond the capacity of individual entities.

d **Data Access and Diversity:** Access to diverse and large datasets is critical for training and fine-tuning AI models. Partnerships between organizations can facilitate the exchange of datasets, ensuring that AI systems are trained on representative data, reducing biases, and enhancing generalization.

e **Risk Sharing:** AI research and development can be risky, with uncertain outcomes and significant investments. By forming partnerships, the risks can be distributed among the collaborators, making it less burdensome for any single participant.

f **Standardization and Interoperability:** In fields where AI technologies need to interact or work together, collaborations can help establish standards and promote interoperability. This allows different AI systems to function seamlessly, leading to more effective and efficient AI solutions.

g **Addressing Ethical and Social Concerns:** AI raises numerous ethical and societal concerns, such as privacy, bias, and the impact on jobs. Collaborations between industry, academia, and policymakers can address these concerns collectively and work towards developing responsible AI solutions.

h **Faster Development and Deployment:** By working together, collaborators can divide tasks and parallelize development efforts. This can lead to faster prototyping, testing, and deployment of AI technologies.

i **Industry-Academia Collaboration:** Partnerships between academic institutions and industry players foster an environment where theoretical research can be translated into practical applications, driving real-world innovation and advancing the state-of-the-art.

j **Global Collaboration:** AI innovation benefits from a global perspective. International collaborations allow researchers and organizations from different countries to bring diverse viewpoints, cultural knowledge, and unique challenges to the table, leading to more robust and inclusive AI systems.

In conclusion, collaborations and partnerships in AI innovation enable organizations and experts to combine their strengths, resources, and expertise to address complex challenges, develop cutting-edge AI technologies, and foster responsible and impactful AI applications for the benefit of society as a whole.

UNIT 4: IP MANAGEMENT AND STRATEGIES FOR AGRICULTURAL INSTITUTIONS AND STAKEHOLDERS

This module covers;

a. IP Management in Agricultural Research and Development

b. Commercialization of IP
   - IP Policies and Technology Transfer Offices
   - IP Protection in Public-Private Partnerships for AI Innovation
   - Use of Open Access and Intellectual Property Rights in AI for Agriculture

c. **Transfer agreements: Types & content**
   - Technology transfer licensing agreements
   - Confidentiality agreements
   - Contract research agreements
   - Material transfer agreements
   - Joint venture agreements

Intellectual Property (IP) management is crucial for agricultural institutions and stakeholders to protect and leverage their innovations, research, and developments in the agricultural sector.

4.1 IP Management in Agricultural Research and Development

IP (Intellectual Property) management in agricultural research and development (R&D) refers to the process of identifying, protecting, and utilizing intellectual property assets that arise from innovations and advancements in the field of agriculture. These intellectual property assets may include patents, plant variety protection, trade secrets, copyrights, and trademarks. Effective IP management plays a crucial role in encouraging innovation, incentivizing investment in research, and facilitating the transfer of technology to benefit farmers, consumers, and the agricultural industry as a whole.

Here are the key aspects of IP management in agricultural research and development:

a. **Identification of Intellectual Property:** The first step in IP management is identifying potentially patentable or protectable innovations and discoveries arising from agricultural R&D. This includes new plant varieties, improved crop cultivation techniques, innovative agricultural machinery, biotechnological processes, and other agricultural-related inventions.

b. **Patents and Plant Variety Protection (PVP):** Researchers can seek patent protection for novel and non-obvious inventions, such as new crop varieties or genetically engineered organisms. Patents grant exclusive rights to the inventor for a limited period, allowing them to control the commercialization, use, and licensing of the patented technology. Similarly, plant breeders can protect new plant varieties through Plant Variety Protection certificates, which provide similar rights but are specifically designed for protecting plant varieties.

c **Trade Secrets:** In some cases, agricultural R&D may lead to valuable confidential information, such as proprietary breeding methods or agricultural formulations. Keeping such information as a trade secret can offer protection as long as it remains confidential and meets the criteria of a trade secret.

d **Copyright:** Copyright protection may apply to creative works related to agricultural research, such as software programs used for crop modeling or educational materials. Copyright grants the creator exclusive rights to reproduce, distribute, and publicly display their work.

e **Technology Transfer and Licensing:** Universities, research institutions, or private companies involved in agricultural R&D may license their intellectual property to third parties, such as seed companies or agricultural technology manufacturers. Licensing allows others to use the technology under specific conditions, which can promote wider adoption and utilization of innovations.

f **Access and Benefit Sharing (ABS):** In the context of agricultural biodiversity and genetic resources, there may be legal and ethical considerations related to access to genetic materials, traditional knowledge, and the fair sharing of benefits arising from their utilization. International agreements like the Nagoya Protocol address ABS concerns.

g **Collaboration and Partnerships:** IP management in agricultural R&D often involves collaboration between different stakeholders, including researchers, public and private institutions, farmers, and policymakers. Clear agreements about IP ownership and rights are essential when multiple parties are involved in the research process.

h **Enforcement and Monitoring:** Effective IP management also requires monitoring and enforcing IP rights to prevent unauthorized use or infringement. This may involve legal actions against infringing parties or ensuring compliance with licensing agreements.

IP management in agricultural research and development is a balancing act between fostering innovation and ensuring access to technology for wider societal benefits. Properly managed, IP can incentivize further investment in research, promote technology dissemination, and contribute to sustainable agricultural practices and food security.

4.2 IP Policies and Technology Transfer Offices

IP Policies and Technology Transfer Offices play crucial roles in managing intellectual property (IP) and facilitating the transfer of technology from academic and research institutions to the commercial sector. **Let's delve into each of these concepts:**

IP Policies: IP Policies, short for Intellectual Property Policies, are guidelines and rules set by organizations, typically academic and research institutions, to define how intellectual property generated by their faculty, researchers, and students will be protected, managed, and commercialized.

The main objectives of IP Policies are:

a) **Protection of Intellectual Property:** These policies outline the steps to protect the intellectual property, which may include patents for inventions, copyrights for creative works, trademarks for branding, and trade secrets for confidential information.

b) **Ownership and Sharing:** IP Policies clarify who owns the intellectual property created within the institution. In many cases, the institution itself retains ownership, but creators might also have certain rights.

c) **Commercialization and Technology Transfer:** They define the mechanisms for transferring intellectual property to the commercial sector, enabling collaboration with industry partners or starting new ventures based on the innovations.

d) **Revenue Sharing:** If the commercialization of IP leads to financial gains, the policies often describe how the revenues will be distributed among the creators, the institution, and sometimes funding agencies.

e) **Ethical Considerations:** IP Policies might address ethical issues related to the research and its impact on society, ensuring responsible innovation and equitable access to technologies.

Technology Transfer Offices (TTOs): Technology Transfer Offices are specialized units within academic and research institutions responsible for managing the transfer of technology and intellectual property from the institution to the commercial sector. Their primary functions include:

a) **IP Evaluation and Protection:** TTOs assess the innovations generated by researchers and faculty to determine their commercial potential and the appropriate forms of IP protection, such as filing patents.

b) **Licensing and Contracts:** TTOs negotiate and draft licensing agreements with external parties interested in utilizing the institution's IP for commercial purposes. These agreements specify the terms and conditions of use and any financial considerations.

c) **Industry Collaboration:** TTOs act as intermediaries between the academic institution and industry partners, facilitating research collaborations and joint projects that can lead to technology development and commercialization.

d) **Startup Support:** In cases where researchers or faculty want to start their own ventures based on their innovations, TTOs may provide support, resources, and guidance to help them establish spin-off companies.

e) **Knowledge Transfer:** TTOs assist in disseminating knowledge and technologies from academic and research settings to benefit the broader society and economy.

f) In summary, IP Policies and Technology Transfer Offices play a critical role in managing intellectual property, fostering innovation, and ensuring that valuable research and technology generated within academic and research institutions have the potential to benefit society and the economy.

4.3 IP Protection in Public-Private Partnerships for AI Innovation

Definition of Public-Private Partnerships (PPP): PPPs are collaborative arrangements between public entities (government, research institutions, etc.) and private companies to jointly develop and commercialize AI innovations.

Benefits of PPPs:

- Access to diverse resources: Combining public sector funding and expertise with private sector agility and resources.
- Faster development and deployment: Reduced bureaucracy and streamlined decision-making processes.
- Shared risks and rewards: Both parties share the risks associated with innovation and benefit from its commercial success.

Challenges of PPPs:

- Aligning interests and objectives of public and private stakeholders.
- Balancing IP protection with open access to knowledge and technology.
- Ensuring fair distribution of benefits and responsibilities.

UNIT 5: CASE STUDIES AND BEST PRACTICES

This module covers;

a. Successful AI Innovations in Agriculture and Food Systems in Africa
b. Examples of IP Strategies and Commercialization Models
c. Lessons Learned and Challenges Faced
d. Ethical and Legal Considerations in Real-World AI Projects

There have been several successful AI innovations in agriculture and food systems in Africa that have shown promise in addressing various challenges faced by farmers and the agricultural sector in the region. These innovations have the potential to improve crop yields, increase efficiency, reduce losses, and enhance food security. Some IA innovations in agriculture include;

Farm Mapping and Monitoring: AI-driven technologies have been used to map farmland and monitor crop health using satellite imagery and drones. This helps farmers identify areas of concern, such as pest infestations, nutrient deficiencies, or water stress, and take timely action to mitigate potential issues.

Crop Disease Detection: AI-powered applications have been developed to detect crop diseases accurately and early. These applications use image recognition and machine learning algorithms to analyze images of diseased plants taken with smartphones or other devices. Early detection allows farmers to respond promptly and limit the spread of diseases, minimizing crop losses.

Precision Agriculture: AI is being used to enable precision agriculture techniques, where farmers can optimize inputs like water, fertilizers, and pesticides based on real-time data and analysis. This reduces resource wastage and improves overall efficiency in agricultural production.

Climate and Weather Prediction: AI models have been employed to analyze historical weather data and predict future weather patterns more accurately. These predictions help farmers make informed decisions about planting and harvesting times, manage irrigation, and prepare for extreme weather events.

Market Price Prediction: AI-powered applications have been developed to forecast market prices for agricultural commodities. By having access to price predictions, farmers can make strategic choices about what crops to grow and when to sell them, maximizing their profits.

Crop Yield Prediction: Using historical data, weather information, and satellite imagery, AI models can predict crop yields for specific regions. These predictions are valuable for planning and resource allocation, ensuring food supply stability.

Automated Farming Machinery: AI-driven automation is being integrated into farming machinery, such as tractors and harvesters, to enhance precision and reduce labor demands.

These automated systems can optimize planting and harvesting processes, leading to increased productivity.

Smart Irrigation Systems: AI-powered irrigation systems can monitor soil moisture levels, weather conditions, and crop water needs. This information helps farmers apply water precisely where and when it's needed, reducing water waste and energy consumption.

Agricultural Chatbots: AI-driven chatbots and voice-based assistants are being used to provide real-time advice and support to farmers. Farmers can get information about best practices, pest control methods, and weather updates through their mobile phones.

Crop Sorting and Quality Control: AI-based sorting machines are used to categorize, and grade harvested produce based on quality attributes. This ensures that only high-quality produce reaches the market, reducing food waste and increasing profitability.

These are just a few examples of AI innovations that have shown promise in transforming agriculture and food systems in Africa. It's important to note that the landscape of AI applications is continually evolving, and there may be even more advancements and successful case studies beyond my last update. Nevertheless, these innovations serve as valuable stepping stones to address the unique challenges faced by African farmers and enhance the overall agricultural productivity in the region.

a Case Study 1: Blue River Technology (USA)

- Started in 2011 by two postgraduate students at Stanford University
- They set out to see how computer vision, machine learning and robotics could be applied in agriculture.
- They tested their ideas in Central California Valley.
- Presently the company has a team of researchers that creates intelligent machinery to change agriculture.
- Creates first-of-its-kind technology that solves global-scale problems.
- Creates and iterates on computer vision, machine learning, and robotics to
- Create intelligent machinery.
- Their products aim to-
    - optimize chemical usage,
    - reimagine routine processes,
    - improve farming yields year after year.
    - Capture data on crop yields

b Case Study 2: The Lettuce Bot machine

- Used for lettuce thinning - a difficult task if manually done.
- Involves identifying and removing unwanted lettuce seedlings.
- This machine automated this process by taking images, identifying which plants to remove, spraying them, and verifying the accuracy and performance of the system, all in real time.

https://bluerivertechnology.com/wp-content/uploads/2020/08/timeline-2.jpg

c Case study 3: See & Spray™ Technology

- Accurately identify crops and weeds with accuracy
- Enables spraying of weeds and therefore crop management.
- Powerful software ensures faster execution of these tasks.
  https://bluerivertechnology.com/wp-content/uploads/2020/11/mission-timeline-3.jpg. https://youtu.be/L0nGUSPDnUU

d Case Study: Association of Cooperatives in Argentina (ACA)

- Has intelligent machines that can load 2,800,000 tonnes of grain per hour.
- It keeps data of all cereals and grains throughout Argentina.
- Has a management platform for producers, clients and suppliers in Argentina?
- Digital agriculture platform to facilitate decision making.
- It is an online store of the field with all info at a click.
- Leading national actor in commercialization of cereals and oilseeds
  https://www.acacoop.com.ar/grain-origination.html

Conclusion and Next Steps

a Summary of Key Takeaways

- Digitization is sweeping over the entire world and taking over from manual processes.
- AI has an important role to play in agricultural processes such as ploughing, planting, weeding, spraying, harvesting, storage, processing, and marketing.
- The use of AI is not yet widespread in Africa.
- Researchers in AI need to protect their creations and inventions.
- Protection of inventions and creations can be achieved through patents, industrial designs, utility models, copyright, neighboring rights, trademarks, trade secrets, geographical indications and plant breeders' rights.
- Such protection is beneficial to both the scientist and the society at large.
- It is important for a creator or inventor to know whom to collaborate with in registering, licensing and or otherwise commercializing their IP.
- Institutions/companies need to keep a valuation of their IP assets as these count as part of the total portfolio of a company/institution.

b Final Remarks and Acknowledgments

c Evaluation and Feedback

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MODULE 4

Product Development for Scale Up/Commercialization

Introduction

This document describes the processes and activities necessary to take an existing or new idea to market in a scalable manner. These activities are grouped into 3 major categories as seen below.

a. Product Design
   - Design Thinking
b. Planning and Logistics
c. Marketing Strategy & Business Analysis

How to get the most out of the Module

- Try to read one area or topic and put that to use before moving on to the next.
- Spend some time talking with your team about each stage to determine how it relates to your products/services.

4.1 Product Design 101

Product design (also known as Industrial design) is all the work that comes between the initial idea for a new product, through to the point where the design is ready to be handed off to a manufacturer

4.2 Product Design 101

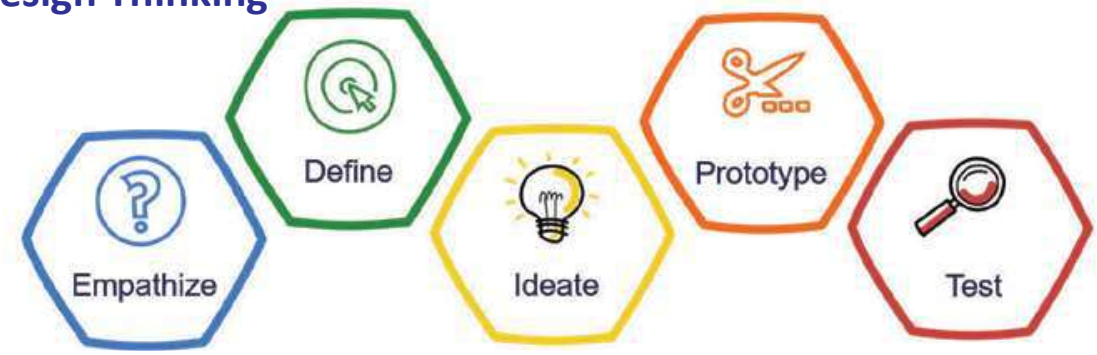
In the case of an entrepreneurial product designer, the work continues even after the customer is holding the product in their hands

4.3 Design Brief

While being concise as possible, explain:

- Problem
- Proposed Solution
- How the solution fits into the desired users life

4.4 Design Thinking



4.5 Empathy

Empathy simply refers to learning all there is about the user(s) in question through:

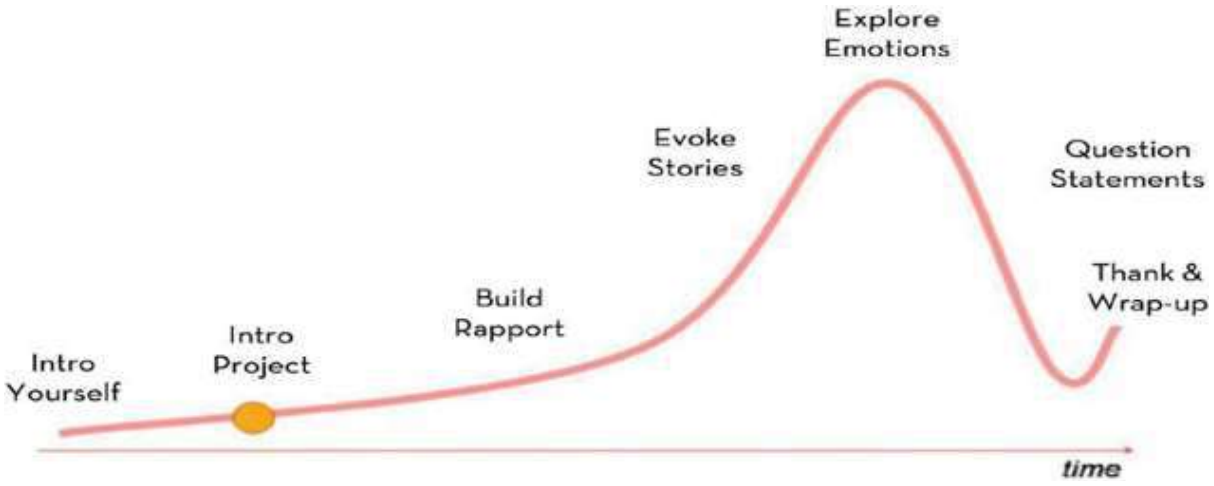
- Observation
- Engagements by Interactions and interviews
- Experience by immersing oneself

Empathy - Beginner's Mindset

Your assumptions may be misconceptions and stereotypes that can restrict the real empathy you can build. A beginners' mindset helps eliminate these biases. How to assume a beginners mindset:

- Don't judge.
- Question everything.
- Be truly curious.
- Find patterns.
- Listen. Really.

By understanding the choices that person makes and the behaviours that person engages in, you can identify their needs, and design to meet those needs.



Define

After collecting volumes of user information, it is time to distil down to one specific user group, their need and the insight behind that need.

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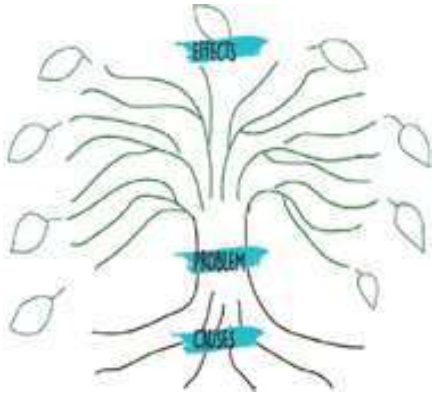
Define - Problem Tree

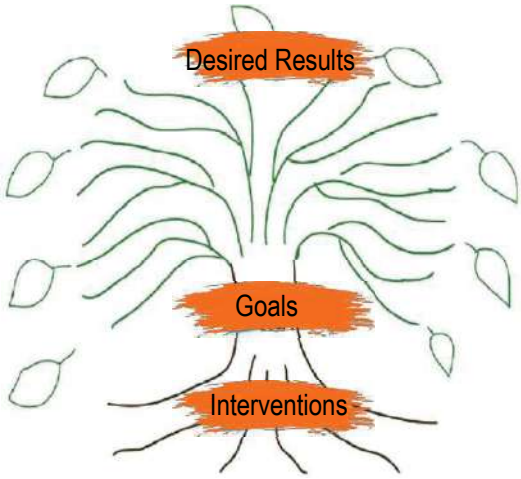
A problem tree provides an overview of all the known causes and effects to an identified problem.

- Settle on the core problem
- Identify the causes and effects



Define - Solution Tree

- Develop a solution tree Make everything on the problem tree positive
- Select the preferred intervention



Solution Tree

Define - Stakeholder Analysis

Identifying key stakeholders and their interests in connection to the design of the solution.

Stakeholder	User	Buyer	Influence	Success
Stakeholder 1				
Stakeholder 2				
Stakeholder 3				

Fill with H- High Rank, M – Middle Rank, L – Lowest Rank

Ideate

Ideation is the process of idea generation. Mentally it represents a process of "going broad" in terms of concepts and outcomes for building prototypes and driving innovative solutions.

Methods of ideas generation

- Design Requirements
- Brainstorming

Ideate - Design Requirement

Designing a baseball bat

- Less than 1.5 Kg.
- Made out of a material approved by the league.
- Able to hit a baseball without breaking.

Cost
Cost to purchase, use or repair
Geometry
Size, overall dimensions
Physical Characteristics
Weight, density, melting point, texture, color
Input
Energy consumption
Output
Undesirable side effects

Ideate -Brainstorming

1. **Individual and Group Brainstorming:** Individuals in the team develop 3 ideas for a solution and merge the best features through discussions

2. **Building on existing ideas/solutions**
The whole team is tasked with finding existing solutions and learning from them

Ideate – Preferred Idea

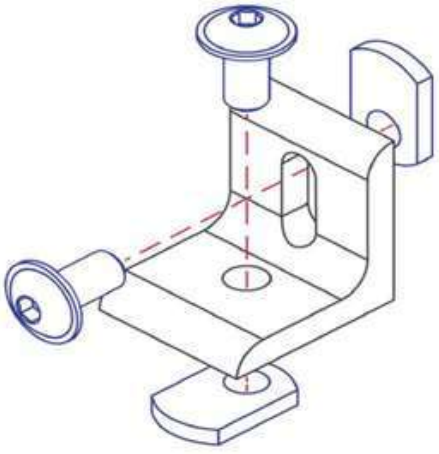
Select a solution by comparing your design ideas against your design criteria using pugh's chart

Problem Area: Many elderly people have difficulty with balancing while showering and while transferring into and out of the tub.

Design Criteria	Weight	Shower Steps	Swivel Chair w/ Hinge Leg	Hydraulic Swivel Chair	Pivoting Tub	Shower Grips	Tub Door
Aesthetics	2	+	D	0	-	++	+
Cost	2	+	A	-	---	+++	0
Installation	2	—	T	0	---	-	—
Safety	2	-	U	-	---	-	++
Ease of Use	2	-	M	+	-	++	++
Maintenance	1	+	.	-	---	+	-
Speed	1	-	D	-	---	0	+
Comfort	2	-	A	+	+	-	0
Noise	1	0	T	-	—	0	0
Space	2	—	U	0	---	++	++
Universal	1	-	M	0	—	++	+++
			.				
	+	5	0	4	2	21	18
	0	1	18	7	0	2	5
	-	18	0	7	40	6	5
		-13	0	-3	-38	15	13

Prototyping

A prototype is an early sample, model, or release of a product built to test a concept or process. It is usually made to act as a thing to be replicated or learned from



Prototyping

Hardware-based Prototype

- Paper prototype -preliminary drawings
- Visual prototype-cardboard models
- Proof of concept model - 3D models/simulation
- Functional prototype

Prototyping
Software based Prototype

- Paper prototype – mockups – low fidelity
- User Experience prototype – Adobe XD/Figr models etc – high fidelity
- Functional prototype - working prototype

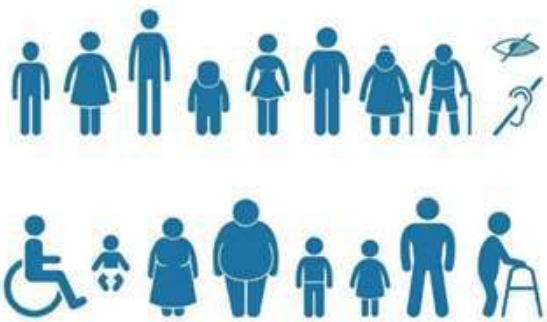
Testing

The goal at this point is to ensure the final product serves the preferred intervention selected in the solution tree stage.

This is to also ensure the products has no bugs or undesired features

Universal Design

When employed, the "universal design" principle produces systems, services, and environments that are as accessible, understandable, and practical for everyone, regardless of their age, size, ability, or disability.

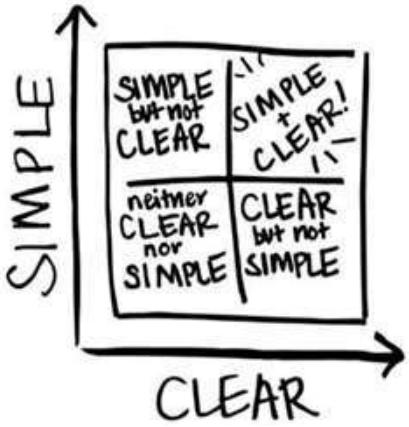


Circular Design

- Choosing materials that are either sustainable or recycled
- Awareness of how the materials you choose are created
- Accepting responsibility for what happens to your products after they are no longer useful
- Planning for your products' afterlife: Recyclable? Re-usable?

Planning and Logistics - DOM

Design for Manufacturing (DFM) is the practice of creating parts that are simple to produce high-quality goods at a cheaper cost. Redefining the product and reducing complexity all help to achieve this.



Planning and Logistics - Budget

- Item
- Description/Justification/Need
- Quantity
- Unit Cost
- Total Cost

Planning and Logistics - Implementation Plan

- Activity (with sub activities where necessary)
- Start and End Time
- Key Resources Needed
- Personnel for Key Activities
- Key Deliverables/Expected Outcomes

ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

Planning and Logistics - Sourcing

At this point the goal is to secure partners needed for production or manufacturing and gather the corresponding materials needed.

4.5 Product Implementation

After identifying your potential products and opportunities, determining your goals, and analyzing your environment, it is now time to implement your product and get it out into the market.

You need to ensure that you have:

- Enough time to implement your product; Product quality
- Budget requirements
- All relevant people and stakeholders Markets (existing and potential) Structure requirements
- Limiting factors (regulations, laws, etc.)

Implementation Stages

This section will give you an overview of the stages you may have to go through to take your product from a plan to a real product.

No.	Stage
1	Involve the community, stakeholders, and investors to gain support
2	Check regulations and obtain licenses
3	Establish other administrative information including staffing, insurance, pricing, promotions, advertising, and booking systems
4	Adapt product to meet the acceptable regulatory standards
5	Coordinate advertising and promotion
6	Prepare promotional materials
7	Conduct an initial test of your product
8	Monitor feedback and response
9	Make changes if necessary

What you should try to Achieve in the Successful **Implementation of your Product:**

- Have appropriate quality standards
- Complete tasks in the planned time frame
- Execute in line with cost requirements

Business Plans

This section will give you a guide to designing a Business Plan for your product/business
Steps in creating a business plan

- **Establish a business objective**
  As mentioned earlier, you need to have an aim for your business, whether it be to earn a certain amount of profit or to be the most used product worldwide, etc.

- **Carry out internal and external research**
  You need to find out all you can about creating your product.

- **Prepare your own SWOT Analysis**
  In analyzing your environment, you need to know your strengths, weaknesses, opportunities, and threats.

- **Plan what needs to be done and when**
  Have a written plan showing a step-by-step process leading to your results for this product.

- **Think about how to adapt the product to customer needs**
  From information gathered in your external and internal research, you should make sure that your product meets the needs of your customers.

- **Find additional sources of financing, advice and training**
  Always be on the lookout to improve your product, whether through looking at training programs on offer or through ways of helping you find certain parts of your product.

- **Devise a marketing strategy**
  You cannot expect to create a product and just wait for customers to come, you have to find your customers. This is done through marketing (see the section on marketing).

- **Write up a business plan**
  After you have gone through each specific step in creating your business plan, you now have to write this plan.

- **What do I put in my business plan?**
  In a Business Plan, there are five important elements. Included below are questions you should answer for each element to ensure you have a sound business plan.

Know your Market

- Who are your customers?
- What have you got to sell?
- Who would want to buy it?
- How much are they willing to pay?
- How do you find them?
- How do you convince them to buy?
- How much does it cost to reach them?
- How long would it take to get enough customers to start making profits?

Know your Competition

- What does your competitor have?
- Who else can sell this product or a similar one?
- How much do they charge?
- Why is yours better & how much can you charge?
- How would they react?
- What advantages do you have?
- What advantages do they have?

Identifying Resources Required

- What resources are you going to use for your product?
- What resources do you have available?
- How would you use these resources?
- How much would you pay for expenses, team, equipment, etc…?
- How long would it take to get enough customers to cover expenses?
- Do you need initial startup capital?
- Can you get additional capital?

Capacity Building Requirements

- What training do you have for your team?
- What skills do you have?
- What additional skills do you need?
- How will you manage the product/project, are you alone or sharing responsibility?
- What team do you need?
- Can you offer them training or career development?
- How will you take slow periods in business?
- How will you assess progress and get feedback?

Developing a Financial Plan

- What is your projected cash flow?
- Do you have a profit and loss statement?
- Can you list your assets and liabilities?
- Do you have a balance sheet?

The SMART Method

After you have written your plan, one tool for designing and managing your plan is the SMART method.
The SMART method says that your business plan should be specific, measurable, appropriate, and reliable and it should be time-bound.

Specific	Know what exactly you want to happen for your product and business
Measurable	Set clear targets for your product
Appropriate	Be customer oriented, reflects the resources available, and fits within the local environment
Reliable	It has a good chance of success compared to the investment that will go into it
Time-bound	Links to a timeline which says when each objective or activity will be completed

Market Research

It is the collecting, recording, and analyzing of all information relating to the identification and satisfaction of consumer needs. Market research can help recognize current customers and identify markets you would like to attract.

Answering questions like:

- Who is the target customer?
- Why do they use/buy similar products and services?

Market Information

- Having a good idea is only the start
- You have to bring that idea to commercial reality
- You do not know how good your idea is until you investigate it
- Good business people are risk takers but they are measured risk takers
- The more research you do the lower the risk will be
- Because there is no use in developing a product that no one wants

Market Segments

- Segmenting your market means to further focus on the customers you want to attract
- The research you have conducted will be useful in segmenting
- Identifying the size of your market areas is the first stage of segmentation
- The size will depend on several factors including how many people would want to use your product

Marketing Plan

A successful business marketing plan needs to be consumer orientated. Understanding customer needs and what they think as well as knowledge of who they are, the services they want and the experience they are seeking.

Building a Marketing Plan

A marketing plan is an overall process where decisions are made for the selling of a product/ service offering. You start with collecting marketing background information (situational analysis/marketing audit) and from this identify problems and key issues that will make your future business decisions.

Steps in Building a Marketing Plan

- Situational Analysis
- SWOT Analysis
- Tactical Marketing Strategy
- Marketing Budget
- Performance Timeline
- Performance Evaluation

Situational Analysis

A situational analysis involves scanning your environment. But for a marketing plan, a situational analysis involves scanning your marketing environment. You need to do this to measure your marketing performance.

In a marketing situational analysis you need to include:

Company and product review	What are your key selling points and competitive advantage?
Corporate Philosophy	What is your company's belief? Eg. Short-run profit-driven or long-run business growth?
Financial-based performance measures	How will you measure or record the financial performance? Eg. Revenues, costs, profits, profitability? ▪ This measures internal efficiency
Market-based performance	▪ How will you measure or record market performance? Eg. relative quality, customer satisfaction, retention, market growth? ▪ This measures external effectiveness
Research, Development, and Marketing investments	▪ What types of research, development and marketing investment do you have for the future of your product?

SWOT Analysis

A SWOT Analysis for a marketing plan will focus on marketing strengths, weaknesses, threats & opportunities.

Some examples are:

Strength	Weakness	Opportunities	Threats
A recognized leader in product/service	High costs of marketing	Exchange rate changes	Increase government regulation efforts of major competitors
Increase in technology	Limited resources	Growing market demand	Competitors
Team with marketing knowledge	High team turnover	New tax incentives	Market restructuring

Tactical Marketing Strategy

Here you want to be specific in how you are actually going to market your product/service. So certain tools are used to assess your potential market as you have to be product and market-specific. These tools are:

Sales objectives	▪ How many products are you aiming at selling?
Target market segments	▪ Who are you selling your product to?
Marketing objectives and strategies	▪ How are you selling your product?
Positioning and image strategies	▪ What is the picture you want to send to potential customers about your product/service and how will you do that?
Marketing mix	▪ These are the tools used in the marketing of products (what you are offering?) **Price -** What price are you offering for the experience or products **Place -** Where will you distribute or place the product **Promotion** - How will you sell your product? (Personal selling / operations, Advertising message, Publicity, Merchandising)

Creativity in Product Design Promotion

It's crucial to use a creative approach while designing your product. Users are contrasting your offering with numerous others. Your product needs to be distinctive enough to be noticed. Developing a theme is a wise move. Something that will convey the kind of experience you are providing. Make sure your product is trustworthy, and appealing to people who sell comparable goods, such as retailers, distributors, and other business entities.

Price

Set a reasonable price for your product

You must determine an appropriate pricing; it must correspond to what the buyer anticipates paying for the product. You should be aware that you could utilize a lot of resources to manufacture your product and charge less for it. This could imply that you won't get paid enough to cover your expenses.

Place

One question facing businesses is what way to best distribute and sell the product to customers. You can do this directly to the customer or through a distribution agent, sales points, e-commerce, etc.

Marketing Budget

How much are you planning to spend for each of your marketing campaigns? Give amounts of how much is going to go to promotion, placing, etc.

Performance Timeline

You need to set a timeline to know when your product will be marketed. A good idea is to set key dates when you will achieve each aim. This will give you an idea of what you need to complete.

Performance Evaluation

You need to review your marketing plan after a period of time to see whether it was of any use.

Example of Marketing Plan Outline

Marketing Strategy Strategic Focus and Plans Marketing/Service - Focus Marketing Program Marketing Research

Evaluation of a Product

Overview

You must monitor and assess your product's performance in relation to the intended goals and specifications. Check comments from clients, stakeholders, and the community to see whether any adjustments are needed, then make any necessary adjustments.

Monitor and evaluate new product

Profitability

- Is the product achieving the amount you have budgeted for?
- Are costs in line with estimates you have made?
- Is the promotion you used attracting the numbers needed to achieve profit?

External Environment

- Are there any changes/events that may affect the profitability of your product?
- Operating considerations
- Are team skills enough to allow them to grow?
- Will further training be needed?
- Are more resources needed?
- Is more equipment needed?

Customer satisfaction

- Are there any concerns that need to be addressed?

Checklist

- ✓ **Before your product is launched here is a checklist to ensure you have completed the necessary stages.**
- ✓ **Do you have a business plan?**
- ✓ **Have you selected specific markets to focus on?**
- ✓ **Have you thought about who your customers will be?**
- ✓ **Have you talked to other people about their current product?**
- ✓ **Is your product suitable to include certain features?**
- ✓ **Have you completed a SWOT Analysis?**
- ✓ **Do you know how you will spread the word about your product?**
- ✓ **Do you have a way for customers to purchase your product?**
- ✓ **Does your pricing structure provide for commission?**
- ✓ **Have you considered a range of marketing opportunities?**

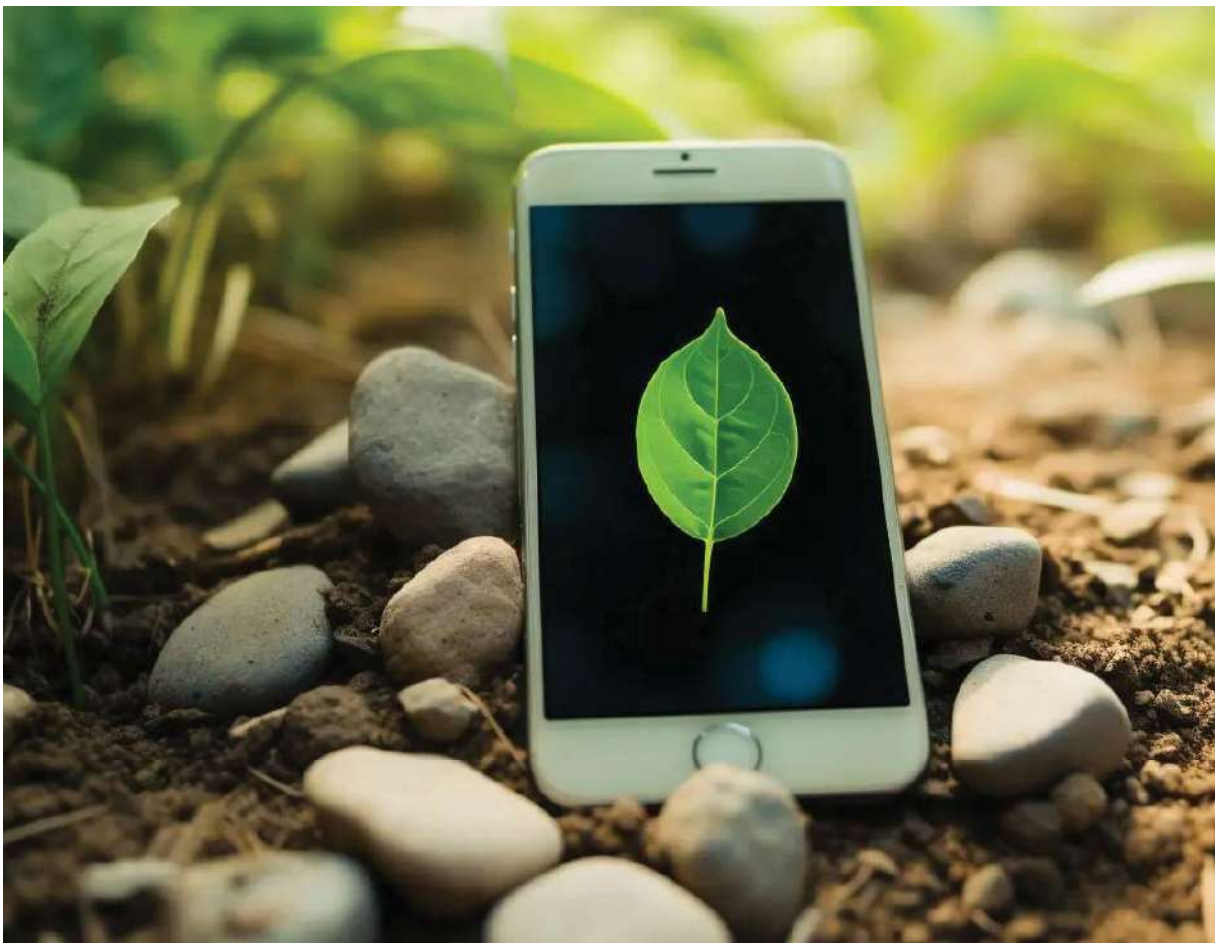
Resources for Further Reading

- The product development process: https://www.shopify.com/blog/product-development-process
- Product development strategies: https://smallbusiness.chron.com/examples-product-development-strat egy-3219.html

- Books
  - ✓ INSPIRED: how to create tech products customers love by Marty Cagan, 2008
  - ✓ The Lean Product Playbook: How to Innovate with Minimum Viable Products and Rapid Customer Feedback by. Dan Olsen

MODULE 5

Tracking Carbon Footprint in AI Models for Responsible Artificial Intelligence in Agriculture and Food Systems



5.1 Overview of Carbon Footprint

Carbon footprint is a measure of the amount of greenhouse gas emissions, particularly carbon dioxide, that are produced by an individual, organization, or activity. It is expressed in terms of the amount of carbon dioxide equivalent (CO_2e) that is emitted into the atmosphere.
The carbon footprint is usually calculated by considering various sources of emissions, such as electricity consumption, transportation, heating and cooling, food and agriculture, and waste management. These emissions are then converted into their equivalent amount of carbon dioxide, based on their global warming potential, and added up to determine the total carbon footprint.
Reducing your carbon footprint can involve making changes in various aspects of your life, such as reducing energy consumption, using renewable energy sources, using public transportation or carpooling, eating a plant- based diet, reducing waste, and supporting businesses that have a low carbon footprint. By reducing your carbon footprint, you can help mitigate the impacts of climate change and contribute to a more sustainable future.

5.2 Principles of the Carbon Footprint and its goals

The principles of the carbon footprint are based on the concept of measuring and reducing greenhouse gas emissions to mitigate the effects of climate change. The primary goals of the carbon footprint are to:

i. **Measure greenhouse gas emissions:** The first step in reducing carbon emissions is to measure them accurately. This involves determining the amount of carbon dioxide (CO_2) equivalent emissions generated by an activity, organization, or product.

ii. **Identify sources of emissions:** Once the carbon emissions are measured, it is essential to identify the sources of emissions. This helps in understanding which activities are contributing the most to the carbon footprint and identifying opportunities to reduce emissions.

iii. **Reduce emissions:** The ultimate goal of measuring the carbon footprint is to reduce greenhouse gas emissions. This can be achieved by adopting sustainable practices, such as reducing energy consumption, using renewable energy sources, improving transportation efficiency, and implementing waste reduction strategies.

iv. **Offset emissions:** In some cases, it may not be possible to reduce emissions completely. In such cases, carbon offsets can be used to compensate for the remaining emissions by investing in projects that reduce or remove carbon emissions elsewhere.

The principles of the carbon footprint and its goals are based on the concept of sustainability, which aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. By measuring and reducing carbon emissions, we can help mitigate the effects of climate change and create a more sustainable future for ourselves and future generations.

5.3 Assessing a personal/organization's carbon footprint and identifying areas for improvement

Assessing a personal or organization's carbon footprint involves several steps, including:

i **Determine the scope:** The first step is to define the scope of the assessment. This involves identifying the activities, processes, or products that are being assessed, and the time frame for the assessment.

ii **Collect data:** The next step is to collect data on the energy use, transportation, waste, and other activities that contribute to greenhouse gas emissions. This can be done by reviewing bills and records, conducting surveys, or using carbon footprint calculators.

iii **Calculate emissions:** Once the data is collected, the next step is to calculate the carbon footprint. This involves converting the energy use, transportation, waste, and other activities into CO_2e emissions.

iv **Identify areas for improvement:** The carbon footprint assessment can help identify areas where emissions can be reduced. This could include improving energy efficiency, using renewable energy sources, reducing waste, optimizing transportation, and changing behaviour.

v **Develop an action plan:** Once the areas for improvement are identified, an action plan can be developed. The action plan should prioritize the most effective and feasible measures for reducing emissions, set goals and timelines, and assign responsibilities.

vi **Monitor and evaluate progress:** Regular monitoring and evaluation are essential to determine if the action plan is achieving the desired results. This can be done by regularly reviewing energy bills, waste reports, and other relevant data.

Assessing a personal or organization's carbon footprint and identifying areas for improvement is an essential step in reducing greenhouse gas emissions. It can help individuals and organizations identify opportunities to become more sustainable and take actions to mitigate their impact on the environment.

5.4 Measuring and tracking the impact of carbon reduction initiatives in all activities

Measuring and tracking the impact of carbon reduction initiatives is an essential part of reducing greenhouse gas emissions. The following are the steps involved in measuring and tracking the impact of carbon reduction initiatives:

-Set a baseline: The first step in measuring the impact of carbon reduction initiatives is to establish a baseline of greenhouse gas emissions before any changes are made. This baseline can be established using the data collected during the carbon footprint assessment.

-Set goals: Once the baseline is established, the next step is to set goals for reducing greenhouse gas emissions. The goals should be specific, measurable, and time-bound.

- **Implement initiatives:** After the goals are set, it's time to implement carbon reduction initiatives. These initiatives may include improving energy efficiency, using renewable energy sources, optimizing transportation, reducing waste, and changing behaviour.

5.5 Best practices for continuous improvement and reporting on carbon emissions

Some of the best practices for continuous improvement and reporting on carbon emissions includes:

a. Establish a baseline: To track progress and continuous improvement, it is essential to establish a baseline of carbon emissions. This baseline provides a starting point for understanding emissions and identifying areas for improvement.

b. Use accurate measurement methods: It is essential to use accurate and consistent measurement methods to track carbon emissions over time. This includes using standardized emission factors and tracking data from all relevant sources.

c. Set reduction targets: Once the baseline is established, set reduction targets to guidecontinuous improvement efforts. These targets should be ambitious but achievable and reflect the organization's commitment to reducing carbon emissions.

d. Identify areas for improvement: Use the baseline and reduction targets to identify areas for improvement in emissions. This could include energy efficiency, transportation, waste reduction, or other areas that contribute to carbon emissions.

e. Develop and implement reduction strategies: Develop and implement reduction strategies to achieve the established targets. These strategies could include adopting renewable energy sources, improving energy efficiency, promoting sustainable practices, or investing in carbon offsets.

f. Monitor progress: Continuously monitor progress towards the established reductiontargets to track improvements and identify areas for additional improvement. Thisincludes regularly measuring and reporting on carbon emissions.

g. Engage stakeholders: Engage stakeholders, including employees, customers, and suppliers, to promote a culture of sustainability and encourage continuous improvement efforts.

h. Report on progress: Regularly report on progress towards carbon reduction targets and share this information with stakeholders. This can demonstrate the organization's commitment to sustainability and encourage others to take action as well.

Continuous improvement and reporting on carbon emissions requires accurate measurement, setting reduction targets, identifying areas for improvement, developing and implementing reduction strategies, monitoring progress, engaging stakeholders, and reporting on progress. By following these best practices, organizations can demonstrate their commitment to sustainability and contribute to reducing the impact of climate change.

Exercise 1

the steps involved in measuring and tracking the impact of carbon reduction initiatives, and why is it important to establish a baseline before implementing these initiatives?

5.6 Goals of Measuring Carbon Footprint

The primary goals of measuring carbon footprint cannot be overemphasized, but the major ones are to:

- Raising awareness about the impact of our activities on the environment: Raising awareness about the impact of our activities on the environment is an essential step in promoting sustainable behaviour and reducing our carbon footprint. It involves educating individuals about the environmental consequences of their actions and the importance of reducing their impact on the environment.

One effective way to raise awareness is through education. Formal education programs, workshops, and training sessions can help individuals understand the impact of their activities on the environment and learn how to reduce their carbon footprint. This education can cover topics such as energy use, transportation, waste reduction, and other environmentally conscious practices.

Effective communication is another essential tool for raising awareness about environmental issues. Individuals and organizations can communicate their environmental goals, initiatives, and achievements to stakeholders through various communication channels, such as newsletters, social media, and public announcements. This communication can help individuals understand the importance of reducing their carbon footprint and encourage them to take action.

Behaviour change campaigns can also be effective in promoting sustainable behaviour and raising awareness. These campaigns can encourage individuals to reduce their energy consumption, use public transportation, or recycle. Such campaigns can help individuals understand the impact of their actions on the environment and encourage them to adopt environmentally conscious behaviours.

Community engagement is another effective way to raise awareness about environmental issues. Engaging with the community can involve organizing events, workshops, or volunteering opportunities that promote sustainable behaviour. By participating in such activities, individuals can learn about environmental issues and how to reduce their carbon footprint.

Partnerships with other organizations and businesses can help raise awareness about environmental issues and promote sustainable behaviour. Such partnerships can promote sustainable products and services and encourage customers to reduce their carbon footprint. By working together, organizations and businesses can raise awareness about environmental issues and encourage individuals to take action to reduce their impact on the environment.

In conclusion, raising awareness about the impact of our activities on the environment is crucial in promoting sustainable behaviour and reducing our carbon footprint. Through education, communication, behaviour change campaigns, community engagement, and partnerships, individuals and organizations can promote environmentally conscious practices and reduce their impact on the environment.

- Encourage the reduction of emissions to mitigate the effects of climate change: Encouraging the reduction of emissions is critical to mitigate the effects of climate change. Greenhouse gas emissions, including carbon dioxide and methane, trap heat in the atmosphere, leading

to global warming and climate change. As a result, reducing these emissions is crucial in preventing the most catastrophic effects of climate change.

There are several ways to encourage the reduction of emissions. One approach is to raise awareness about the impacts of climate change and the role of emissions in contributing to it. By educating individuals about the consequences of climate change and the need to reduce emissions, they can adopt environmentally conscious behaviours and make informed choices. Governments can also play a role in encouraging the reduction of emissions. They can implement policies and regulations to incentivize individuals and organizations to reduce their carbon footprint. Policies such as carbon taxes, incentives for renewable energy, and regulations on greenhouse gas emissions can create economic incentives for reducing emissions.

Investing in renewable energy sources such as wind, solar, and geothermal is another way to encourage emission reduction. These sources of energy are cleaner and more sustainable than traditional fossil fuels, reducing dependency on carbon-emitting energy sources.

Another effective way to reduce emissions is by adopting energy-efficient technologies. Energy-efficient appliances, LED lighting, and energy-efficient building materials can reduce energy consumption and decrease emissions.

In summary, encouraging the reduction of emissions is critical to mitigate the effects of climate change. By raising awareness, implementing policies and regulations, investing in renewable energy, adopting energy-efficient technologies, and promoting sustainable practices, individuals and organizations can contribute to reducing greenhouse gas emissions and protecting the planet.

- Identify sources of emissions and implement strategies to reduce them: Identifying sources of emissions and implementing strategies to reduce them is essential to achieving carbon reduction targets. To identify sources of emissions, organizations should conduct a comprehensive inventory of their operations and activities that contribute to carbon emissions. This inventory should include direct and indirect emissions, such as energy use, transportation, waste, and supply chain emissions.

Once the sources of emissions have been identified, organizations can develop and implement strategies to reduce them. Some effective strategies include:

i. Energy efficiency: Improving energy efficiency in buildings and operations can reduce energy consumption and lower carbon emissions. This can be achieved through measures such as upgrading equipment and lighting, implementing smart building systems, and optimizing HVAC systems.

ii. Renewable energy: Investing in renewable energy sources such as wind, solar, and geothermal can reduce reliance on fossil fuels and lower carbon emissions. This can include installing solar panels or purchasing renewable energy credits.

iii. Transportation: Reducing transportation-related emissions can be achieved through promoting the use of public transportation, incentivizing carpooling, and investing in electric or hybrid vehicles.

iv. Waste reduction: Reducing waste through recycling, composting, and reducing consumption can lower carbon emissions and contribute to a more sustainable operation.

v. Supply chain emissions: Organizations can work with suppliers to reduce carbon emissions throughout the supply chain. This could include promoting sustainable practices and reducing the carbon footprint of products or services.

vi. Carbon offsets: Carbon offsets can be used to balance out carbon emissions by investing in projects that reduce carbon emissions or remove carbon from the atmosphere. This can include supporting reforestation projects or investing in renewable energy.

Identifying sources of emissions and implementing strategies to reduce them is essential to achieving carbon reduction targets. By conducting a comprehensive inventory of operations, developing and implementing strategies such as improving energy efficiency, investing in renewable energy, reducing transportation-related emissions, reducing waste, working with suppliers, and using carbon offsets, organizations can effectively reduce their carbon footprint and contribute to a more sustainable future.

Create a more sustainable future and reduce impact on the environment: The concept of sustainability is rooted in the idea that our actions should meet the needs of the present without compromising the ability of future generations to meet their own needs. It is a critical challenge facing us today, given the impact of human activities on the environment.

To create a more sustainable future and reduce our impact on the environment, there are several steps we can take. One of the most important is to reduce our energy consumption. We can do this by adopting energy - efficient practices, using energy-efficient appliances, and insulating our homes and buildings.

Another important step is to use renewable energy. Investing in renewable energy sources such as wind, solar, and geothermal can reduce our reliance on fossil fuels and lower our carbon footprint. This can help to mitigate the impact of climate change and promote a more sustainable future.

Promoting environmental education and advocating for policy change are also critical steps towards a more sustainable future. Educating ourselves and others about environmental issues and sustainable practices can help to build a culture of sustainability and promote positive change. Advocating for policies that support sustainable practices and reduce our impact on the environment, such as carbon pricing, renewable energy incentives, and regulations on harmful pollutants, can also make a significant impact.

Creating a more sustainable future and reducing our impact on the environment requires action at all levels, from individual choices to organizational and policy changes. By adopting sustainable practices, supporting sustainable agriculture and transportation, promoting environmental education, and advocating for policy change, we can work towards a more sustainable future for ourselves and future generations.

Exercise 2

Research and identify sources of emissions that contribute to your carbon footprint. This can include energy use, transportation, waste, and supply chain emissions.

5.7 Calculating Carbon Footprint of Non-Machine Learning Activities

Calculating the carbon footprint of non-machine learning activities involves estimating the greenhouse gas emissions associated with those activities. This can be done by identifying the sources of emissions, estimating the amount of emissions generated by each source, and then using a standard emissions factor to convert those estimates into CO_2 equivalents.
Some common carbon footprint calculator trackers, includes:

a MyEarth (Android/iOS):

MyEarth, an energy-tracking app is a mobile app that allows users to track and monitor their energy consumption in real-time. The app provides users with personalized tips and recommendations for reducing their energy consumption and carbon footprint, based on their usage patterns and behaviour.

To use the app, users input information about their energy usage, such as electricity bills, gas bills, and fuel expenses. The app then analyses the data to provide users with insights into their energy consumption patterns and recommends actions they can take to reduce their carbon footprint and save money on their energy bills.
The MyEarth app is designed to help users understand the impact of their energy usage on the environment and to encourage them to adopt more sustainable practices. By tracking their energy usage and reducing their carbon footprint, users can help mitigate the effects of climate change and contribute to a more sustainable future.

b Carbon footprint and CO_2 tracker (Android/iOS):

The Carbon Footprint and CO_2 Tracker app for Android and iOS is designed to help users monitor and track their carbon footprint, particularly in relation to transportation emissions. The app uses a GPS-based algorithm to track the user's journey modes and estimate the carbon emissions associated with their travel.

By providing insights into CO_2 emissions, the app can help users understand the environmental impact of their transportation choices and motivate them to make more sustainable choices. The app also includes features that encourage users to make carbon-conscious food choices, such as tracking the carbon footprint of the user's diet and suggesting ways to reduce it.

The Carbon Footprint and CO_2 Tracker app is a useful tool for individuals who are interested in reducing their carbon footprint and making more sustainable choices in their daily lives. By providing real-time feedback and suggestions for improvement, the app can help users make more informed decisions about their transportation and food choices, ultimately contributing to a more sustainable future.

c Klima (Android/iOS):

Klima is a carbon offset app available for both Android and iOS devices. The app provides users with suggestions for making dietary, transportation, and lifestyle changes that can help reduce their carbon footprint. Additionally, Klima includes a carbon calculator that measures the user's carbon footprint based on their daily activities.

One of the unique features of Klima is that it allows users to offset their carbon emissions through a variety of projects and initiatives. The app provides users with options for purchasing carbon offsets, which are investments in projects that help to reduce greenhouse gas emissions or remove carbon dioxide from the atmosphere.

Klima also provides users with a dashboard that displays their carbon offsetting progress, allowing them to track their carbon footprint reduction over time. By encouraging users to make more sustainable choices and offset their carbon emissions, Klima aims to help individuals take meaningful action to mitigate climate change and create a more sustainable future.

d Adva (Android/iOS):

Adva is a lifestyle app and carbon impact tracker that is available for both Android and iOS devices. The app uses behavioural insights to estimate the user's yearly carbon emissions.

Adva allows users to track their daily activities such as transportation, food consumption, and energy usage, and provides an estimate of their carbon footprint based on this data. The app also offers personalized recommendations for reducing carbon emissions based on the user's behaviours and preferences.

One of the unique features of Adva is that it allows users to compare their carbon footprint to other users of the app, creating a sense of community and accountability around reducing carbon emissions. The app also provides users with educational resources and tips for reducing their carbon footprint and living a more sustainable lifestyle.

Adva aims to help individuals become more conscious of their daily actions and the impact they have on the environment, encouraging them to make more sustainable choices and reduce their carbon footprint.

e Green Karma (Android):

Green Karma is a sustainability app for Android that provides a fun and interactive way to reduce carbon emissions. The app features a gaming interface that allows users to play and collect CO_2 cards for various environmental projects, which can be used to reduce real-life emissions and earn rewards in the form of top cryptocurrencies.

Green Karma offers built-in wallets to help users keep track of the cryptocurrencies they earn through the app. The app also provides an official certificate to users who successfully reduce 100kg of CO_2 emissions, which can serve as a tangible recognition of their sustainability efforts. The app's focus on gamification makes it engaging and motivating for users, encouraging them to make sustainable choices and take actions to reduce their carbon footprint. Green Karma's

unique approach to incentivizing sustainability through cryptocurrencies is also innovative and could potentially attract a new demographic of users interested in both environmentalism and cryptocurrency.

Overall, Green Karma aims to make sustainable living fun and rewarding while also contributing to real-world environmental projects and helping users reduce their carbon footprint.

Exercise 3

a.) How can the Carbon Footprint and CO_2 trackers apps help users make a more sustainable transportation and food choices?

b.) Identify other CO_2 calculator trackers apps.

5.8 Calculating Carbon Footprint using Machine Learning Activities

Calculating carbon footprint using machine learning activities involves using advanced algorithms and data analysis techniques to estimate the amount of carbon emissions associated with various activities, such as transportation, energy consumption, and waste management.

Machine learning algorithms can be trained on large datasets of historical emissions data to develop predictive models that accurately estimate the carbon footprint of specific activities. These models can take into account a wide range of factors, such as the type of vehicle, distance travelled, fuel efficiency, and other variables that can impact carbon emissions.

One example of using machine learning for carbon footprint estimation is the development of predictive models for energy consumption in buildings. These models can use data from sensors, weather forecasts, and other sources to estimate energy use and identify opportunities for energy efficiency improvements.

Another example is the use of machine learning to optimize transportation routes and reduce emissions associated with logistics and supply chain management. By analysing data on shipping routes, delivery times, and vehicle types, machine learning algorithms can help companies identify more efficient and environmentally friendly ways of transporting goods.
Machine learning can play a critical role in accurately estimating carbon emissions and identifying opportunities for emissions reductions across a wide range of activities and industries. Some of the ways of tracking these activities includes:

a ML CO_2 IMPACT:

The ML CO_2 Impact calculator is a useful tool that can help individuals and organizations better understand the carbon emissions associated with their machine learning activities. By inputting information about the hardware type, the number of hours used in the activity, the cloud service provider used, and the region used in computing, the calculator can estimate the carbon emissions associated with that activity.

This information is provided in kilograms of CO_2 equivalent ($kgCO_2e$), which is a standard unit used to measure greenhouse gas emissions. The calculator also provides a comparison to other common activities, such as driving a car or taking a flight, which can help individuals and organizations put their emissions into perspective.

Using this tool can help individuals and organizations make more informed decisions about their machine learning activities. For example, they may choose to use more energy-efficient hardware, select cloud service providers with lower carbon footprints, or limit the number of hours used in their machine learning activities to reduce their overall carbon emissions.

b CodeCarbon:

CodeCarbon is an open-source tool developed by researchers at the University of California, Berkeley, that measures the carbon emissions associated with running software code. The tool estimates the energy consumption of a code run on a computer and calculates the carbon emissions resulting from that energy consumption, taking into account the location of the data centre, where the code is executed and the energy mix of the local electricity grid.

CodeCarbon provides a simple way for software developers to estimate the carbon footprint of their code and identify opportunities to reduce emissions. The tool is designed to integrate with existing software development workflows and can be used with a wide range of programming languages, but more friendly with python and environments.

By using CodeCarbon, developers can gain insight into the carbon emissions associated with their code and make informed decisions about how to optimize their software to reduce its environmental impact. This can include optimizing algorithms, reducing unnecessary code execution, and choosing more energy-efficient computing environments. Overall, CodeCarbon helps to promote sustainable software development practices and support the transition to a low-carbon economy.

We will now head over to discuss more on how to use codecarbon and python to track carbon emission and likewise visualize the output result.

Exercise 4

How can machine learning algorithms be used to estimate carbon footprint and identify opportunities for emissions reductions in various activities and industries, and what are some tools available, such as ML CO_2 Impact and CodeCarbon, that can help individuals and organizations track their carbon emissions and make informed decisions to reduce their environmental impact?

c Tracking CO_2 Using CodeCarbon 1

Artificial Intelligence, and more specifically Machine Learning, has become remarkably efficient at performing human-level tasks: recognizing objects and faces in images, driving cars, and playing sophisticated games like chess and Go.

In order to achieve these incredible levels of performance, current approaches leverage vast amounts of data to learn underlying patterns and features. Thus, state-of-the-art Machine Learning models leverage significant amounts of computing power, training on advanced processors for weeks or months, consequently consuming enormous amounts of energy. Depending on the energy grid used during this process, this can entail the emission of large amounts of greenhouse gases such as CO_2.

With AI models becoming more ubiquitous and deployed across different sectors and industries, AI's environmental impact is also growing. For this reason, it is important to estimate and curtail both the energy used and the emissions produced by training and deploying AI models. CodeCarbon enables developers to track carbon dioxide (CO_2) emissions across machine learning experiments or other programs.

This package enables developers to track emissions, measured as kilograms of CO_2-equivalents (CO_2eq) in order to estimate the carbon footprint of their work. For this purpose, CO_2-equivalents [CO_2eq], which is a standardized measure used to express the global warming potential of various greenhouse gases is used: the amount of CO_2 that would have the equivalent global warming impact. For computing, which emits CO_2 via the electricity it is consuming, carbon emissions are measured in kilograms of CO_2-equivalent per kilowatt-hour. As a matter of fact, electricity is generated as part of the broader electrical grid by combusting fossil fuels for example.

d Calculation of carbon footprint using codecarbon

Carbon Intensity of the consumed electricity is calculated as a weighted average of the emissions from the different energy sources that are used to generate electricity, including fossil fuels and renewables. In this toolkit, the fossil fuels coal, petroleum, and natural gas are associated with specific carbon intensities: a known amount of carbon dioxide is emitted for each kilowatt-hour of electricity generated. Renewable or low-carbon fuels include solar power, hydroelectricity, biomass, geothermal, and more. The nearby energy grid contains a mixture of fossil fuels and low-carbon energy sources, called the Energy Mix. Based on the mix of energy sources in the local grid, this package calculates the Carbon Intensity of the electricity consumed.

When available, CodeCarbon uses global carbon intensity of electricity per cloud provider or per country, when the global carbon intensity or electricity of a country is not available, but the electricity mix is available, the carbon intensity of electricity is computed using the table next:

Energy Source	Carbon Intensity (kg/MWh)
Coal	995
Petroleum	816
Natural Gas	743
Geothermal	38
Hydroelectricity	26
Nuclear	29
Solar	48
Wind	26

Then, for example, if the Energy Mix of the Grid Electricity is 34% Coal, 25% Petroleum, 16% Natural Gas and 27% Nuclear:

Net Carbon Intensity = 0.34 * 995 + 0.25 * 816 + 0.16 * 743 + 0.27 * 29 = 669.01 $kgCO_2/kWh$

In cases, where there is neither the global carbon intensity of a country nor its electricity mix, a world avarage of 475 gCO_2.eq/KWh is applied.

5.0.1 Pip installation of CodeCarbon

For installation of codecarbon, a virtual environment is first created. This is for easier management of dependencies and packages. The command below is used to create the virtual environment.

```
conda create - - name codecarbon
conda activate codecarbon
```

There are basically two ways to install codecarbon in the virtual environment; 1. From conda repository and 2. From PyPi repository. For the sake of this course, we will use the installation from PyPi repository. The command below is used to install codecarbon from PyPi repository.

```
pip install codecarbon
```

5.9 Training of a machine learning model

The CO_2 tracking tool can be used along with any computing framework. It supports both online (with internet access) and offline (without internet access) modes. The tracker can be used in the following ways:

5.0.2 Online Mode

When the environment has internet access, the “EmissionsTracker” object or the “track_ emissions” decorator can be used, which has offline parameter set to “False” by default.

Explicit Object

In the case of absence of a single entry and stop point for the training code base, users can instantiate a EmissionsTracker object and pass it as a parameter to function calls to start and stop the emissions tracking of the compute section.

```
from codecarbon import EmissionsTracker
tracker = EmissionsTracker() tracker.start()
# Compute intensive code goes here
tracker.stop()
```

This mode is recommended when using a Jupyter Notebook. You call tracker.start() at the beginning of the Notebook, and call tracker.stop() in the last cell.

Context manager

The Emissions tracker also works as a context manager.

```
codecarbon import EmissionsTracker with
EmissionsTracker() as tracker:
# Compute intensive training code goes here
```

This mode is recommended when you want to monitor a specific block of code.

Decorator

In case the training code base is wrapped in a function, users can use the decorator @track_ emissions within the function to enable tracking emissions of the training code.

```
from codecarbon import track_emissions @track_emissions
def training_loop():
# Compute intensive training code goes here
```

This mode is recommended if you have a training function.

5.0.3 Offline Mode

An offline version is available to support restricted environments without internet access. The internal computations remain unchanged; however, a “country_iso_code” parameter, which corresponds to the 3-letter alphabet ISO Code of the country where the compute infrastructure is hosted, is required to fetch Carbon Intensity details of the regional electricity used. A complete list of country ISO codes can be found on Wikipedia.

Explicit Object

Developers can use the OfflineEmissionsTracker object to track emissions as follows:

```
from codecarbon import OfflineEmissionsTracker
tracker = OfflineEmissionsTracker(country_iso_code="CAN")
tracker.start()
# GPU intensive training code tracker.stop()
```

Context manager

The Emissions tracker also works as a context manager.

```
codecarbon import OfflineEmissionsTracker
with EmissionsTracker() as tracker:
# Compute intensive training code goes here
```

Decorator

The track_emissions decorator in offline mode requires following two parameters:

- offline needs to be set to True, which defaults to False for online mode.
- country_iso_code the 3-letter alphabet ISO Code of the country where the compute infrastructure is hosted

```
from codecarbon import track_emissions
@track_emissions(offline=True, country_iso_code="CAN")
def training_loop():
# training code goes here
pass
```

The Carbon emissions will be saved to a emissions.csv file in the same directory.

5.10 Interpretation of carbon footprint results

To interpret the results of CodeCarbon, it's important to understand the various metrics that it provides. Here are some key fields (metrics) and their description (interpretations):

Field	Description
timestamp	Time of the experiment in %Y-%m-%dT%H:%M:%S format
project_name	Name of the project, defaults to codecarbon
run-id	id of the run
duration	Duration of the compute, in seconds
emissions	Emissions as CO_2-equivalents [CO_2eq], in kg
emissions_rate	emissions divided per duration, in Kg/s
cpu_power	CPU power (W)
gpu_power	GPU power (W)
ram_power	RAM power (W)
cpu_energy	Energy used per CPU (kW)
gpu_energy	Energy used per GPU (kW)
ram_energy	Energy used per RAM (kW)
energy_consumed	sum of cpu_energy, gpu_energy and ram_energy (kW)

Field	Description
country_name	Name of the country where the infrastructure is hosted
country_iso_code	3-letter alphabet ISO Code of the respective country
region	Province/State/City where the compute infrastructure is hosted
on_cloud	Y if the infrastructure is on cloud, N in case of private infrastructure
cloud_provider	One of the 3 major cloud providers, aws/azure/gcp
cloud_region	Geographical Region for respective cloud provider, examples us-east-2 for aws, brazilsouth for azure, asia- east1 for gcp
Os	os on the device, example Windows-10-10.0.19044-SP0
python_version	example 3.8.10
cpu_count:	number of CPU
cpu_model	example Intel(R) Core(TM) i7-1065G7 CPU @ 1.30GHz
gpu_count	number of GPU
gpu_model	example 1 x NVIDIA GeForce GTX 1080 Ti
longitude	Longitude, with reduced precision to a range of 11.1 km / 123 km². This is done for privacy protection.
latitude	Latitude, with reduced precision to a range of 11.1 km / 123 km². This is done for privacy protection.
ram_total_size	total RAM available (Go)
Tracking_mode:	machine or process``(default to ``machine)

By analysing these metrics, the codecarbon is able to track the emissions being emitted by the device and thus, developers can gain insights into the carbon footprint of their machine learning workflows which is automatically saved in the default “emission.csv” format and make informed decisions to reduce their impact on the environment. For example, they could consider using more energy-efficient hardware, optimizing their workflows to reduce energy consumption, or offsetting their carbon emissions through carbon offset programs

5.11 Creating visualizations using CometML

CodeCarbon can be automatically integrated with Comet for experiment tracking and visualization. Comet provides data scientists with powerful tools to track, compare, explain, and reproduce their experiments. Now, with CodeCarbon one can easily track the carbon footprint of one’s jobs along with the training metrics, hyperparameters, dataset samples, artifacts, and more.

To get started with the Comet-CodeCarbon integration, comet-ml installed is to be installed in the same virtual environment as codecarbon with the command next:

```
pip install comet_ml>=3.2.2
```

The next step is to go to Comet's website (https://www.comet.com/site/) and create a free account. From your account settings page, copy your personal API key.

In your code, include this line of command:

```
experiment = Experiment (api_key="YOUR API KEY")
```

NB: replace the placeholder code with your API key which can be found in your comet ml profile page, Run your experiment/code and click on the link in stdout to be taken back to the Comet UI. You'll automatically see your metrics, hyperparameters, graph definition, system and environment details, and more.

Comet will automatically create an EmissionsTracker object from the codecarbon package when your code runs. To visualize the carbon footprint of your experiment, go to the tab in the left sidebar and click **"Add Panel".**

From the Panel Gallery click the **"Public"** tab and search for **"CodeCarbon Footprint".** Once you've found it, add it to your Experiment.

Now back in the "Panels" tab you'll see your CodeCarbon Footprint visualization in the Comet UI. To render the visualization by default, save your View. And every time you run your experiments; you'll be able to visualize your CodeCarbon emissions data.

Exercise 5

create a virtual environment, install codecarbon and comet ML in the virtual environment, develop a machine learning algorithm and track and visualize the trained model using codecarbon and comet ML respectively.

5.12 Best Practices for Reducing Carbon Footprint

Sustainability is a crucial issue in today's world, and we all need to play our part in reducing our carbon footprint to create a more sustainable future. Understanding sustainable practices, the impact of lifestyle choices on carbon footprint, and practical ways to reduce carbon footprint can help individuals and organizations make a significant impact in the fight against climate change.

5.13 Overview of sustainable practices

Sustainable practices are those that are environmentally responsible, socially beneficial, and economically viable. They aim to reduce waste, conserve resources, and minimize harm to the environment and society. Some examples of sustainable practices include using renewable energy sources, reducing waste, recycling, and conserving water.

In addition to these practices, there are several sustainable frameworks that can be used to guide individuals and organizations towards a more sustainable future. These frameworks include the triple bottom line (TBL), the circular economy, and the United Nations' Sustainable Development Goals (SDGs).

The TBL framework measures an organization's performance in three areas: social, environmental, and economic. The circular economy aims to minimize waste by designing products and services that can be reused, repaired, or recycled. The SDGs are a set of 17 goals that aim to end poverty, protect the planet, and ensure prosperity for all.

5.14 Understanding the impact of lifestyle choices on carbon footprint

The choices we make in our daily lives have a significant impact on our carbon footprint. Some lifestyle choices that contribute to a high carbon footprint include driving gas-guzzling vehicles, consuming meat and dairy products, and using single-use plastics.

Transportation is one of the major contributors to carbon emissions. Choosing to walk, bike, or take public transportation can significantly reduce one's carbon footprint. In addition, driving an electric or hybrid vehicle can also reduce emissions.

The food we consume also has a significant impact on our carbon footprint. Animal agriculture, including meat and dairy production, is a significant contributor to greenhouse gas emissions. Reducing meat consumption, opting for plant-based alternatives, and supporting local, sustainable agriculture can help reduce one's carbon footprint.

Use of single-use plastics also has a significant impact on the environment. Opting for reusable bags, bottles, and containers can significantly reduce waste and carbon emissions.

5.15 Practical ways to reduce carbon footprint

There are several practical ways that individuals and organizations can reduce their carbon footprint. These include:

a. Reduce energy consumption: This can be achieved by using energy-efficient appliances, turning off lights and electronics when not in use, and using natural light whenever possible.
b. Use renewable energy: Investing in renewable energy sources such as solar, wind, and geothermal energy can help reduce carbon emissions.
c. Reduce transportation emissions: This can be achieved by walking, biking, or taking public transportation. Choosing electric or hybrid vehicles can also significantly reduce emissions.
d. Consume sustainable and local products: Supporting local, sustainable agriculture and reducing meat consumption can significantly reduce one's carbon footprint.
e. Reduce waste: This can be achieved by recycling, composting, and reducing the use of single-use plastics.
f. Promote sustainability in the workplace: Organizations can promote sustainability by using energy- efficient equipment, promoting telecommuting, and encouraging employees to use sustainable practices in their daily lives.
g. Measure and report carbon emissions: Organizations can measure their carbon footprint and report on their progress towards reducing emissions. This can help identify areas for improvement and track progress over time.

Exercise 6

What are some practical ways that individuals and organizations can reduce their carbon footprint, and how do lifestyle choices impact carbon emissions?

5.16 Conclusion

In conclusion, reducing carbon footprint is crucial in mitigating the adverse effects of climate change. Understanding the impact of lifestyle choices on carbon footprint and adopting sustainable practices is essential in reducing greenhouse gas emissions. By taking individual and collective actions towards sustainability, we can create a better future for ourselves and future generations.

MODULE 6

Developing Policy Briefs for Effective Policy Influence and Advocacy Training Module

ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

INTRODUCTION TO THE TRAINING MODULE

The development of Policy briefs is an effective approach in advocacy because they distill complex information into digestible insights that can drive action. They bridge the gap between research findings and policy decisions, translating technical knowledge into practical guidance that can shape public policy. In the context of advocating for the adoption of innovative technologies, such as Artificial Intelligence (AI) tools in agriculture and food systems, policy briefs serve as a critical vehicle for communicating the benefits and potential impacts of these tools to stakeholders at various levels.

The effectiveness of policy briefs in advocacy lies in their ability to succinctly convey critical information while also making a compelling case for change. They can be particularly powerful when they:

a. **Focus on a Specific Issue:** By zeroing in on a single issue, policy briefs can provide a clear and persuasive argument for why that issue matters and what actions should be taken.

b. **Present Evidence-Based Recommendations:** Policymakers are more likely to be influenced by recommendations grounded in robust evidence. A well-crafted policy brief presents data and analysis in a way that supports its conclusions and recommendations.

c. **Tailor Content to the Audience:** Effective policy briefs are tailored to the needs, interests, and knowledge level of their intended audience, whether that be government officials, industry leaders, or community stakeholders.

d. **Leverage Strategic Timing:** Timing the release of a policy brief to coincide with key decision-making moments can significantly enhance its impact.

In the context of AI for agriculture and food systems, policy briefs can be used to advocate for the integration of AI tools into national and regional food policies. By clearly demonstrating the benefits, such as improved efficiency, productivity, and sustainability, these briefs can help secure the necessary buy-in from policymakers, ensuring that AI innovations are effectively deployed to enhance food systems across Africa.

Key Issues Addressed by the Training Module

This training module, designed for grantees of the Artificial Intelligence for Agriculture and Food Systems (AI4AFS) Innovation Research Network, will focus on several critical issues that are essential for developing effective policy briefs:

a. **Understanding the Policy Landscape:** Participants will be guided through the process of analyzing the current policy environment in their respective countries, identifying key stakeholders, and understanding the policy-making process. This knowledge is fundamental to crafting policy briefs that are relevant and impactful.

b. **Evidence-Based Advocacy:** The module will emphasize the importance of using robust data and evidence to support policy recommendations. Participants will learn how to translate complex research findings into clear, compelling messages that resonate with policymakers.

c **Strategic Communication:** Effective communication is at the heart of policy advocacy. The training will cover best practices in crafting messages that are not only persuasive but also aligned with the priorities and language of the target audience.

d **Structuring Policy Briefs:** Participants will be introduced to the standard components of a policy brief, including problem statements, background information, recommendations, and calls to action. The module will provide templates and examples to help grantees structure their briefs effectively.

e **Ethical Considerations in AI Advocacy:** As AI technologies raise unique ethical challenges, the training will address how to incorporate ethical considerations into policy briefs, ensuring that advocacy efforts promote responsible and equitable use of AI in agriculture and food systems.

f **Monitoring and Evaluation:** To measure the impact of policy briefs, the module will cover strategies for monitoring and evaluating the effectiveness of advocacy efforts. This will enable participants to refine their approaches and improve future advocacy initiatives.

TRAINING MODULE OBJECTIVES

This training module on the development of policy briefs for effective policy influence and advocacy has the following general objectives.

- Understanding what a policy brief is and its uses
- Learn about the types, key components, and structure of policy briefs
- Identify the purpose and audience for policy briefs
- Learn formatting guidelines and best practices
- Analyze real-world examples of policy briefs

ASSUMPTIONS

Several assumptions underpin the development of this training module:

a **Familiarity with AI Tools:** It is assumed that participants already have a working knowledge of the AI tools they have developed, allowing the training to focus on the policy and advocacy aspects rather than the technical details of the tools.

b **Policy Engagement Experience:** Participants are assumed to have some experience in engaging with policymakers, even if limited, which will be built upon during the training.

c **Diverse Policy Contexts:** The training assumes that participants operate in diverse policy environments across different African countries, requiring adaptable strategies for policy brief development.

d **Commitment to Advocacy:** It is assumed that participants are committed to advocating for the adoption of their AI tools and are motivated to learn how to do this effectively through policy briefs.

e **Access to Relevant Data:** The module assumes that participants have access to the necessary data and research findings that will be used to support the policy briefs they develop.

This training module aims to equip participants with the skills and knowledge needed to develop persuasive policy briefs that can effectively influence policy decisions, leading to the broader adoption of AI tools in agriculture and food systems across Africa.

OVERVIEW OF THE FACILITATION APPROACHES

Facilitation is a critical component of any training module, particularly when the goal is to build capacity in complex and nuanced areas such as policy brief development for AI tools in agriculture and food systems. The facilitation approaches and techniques adopted in this module are designed to promote active learning, encourage collaboration, and ensure the practical application of knowledge. Given the diversity of participants, with varying levels of experience in both AI and policy advocacy, a blended facilitation approach will be utilized to accommodate different learning styles and contexts.

The key facilitation approaches incorporated into this training module include:

a **Participant-Centered Learning:** This approach places participants at the center of the learning process, recognizing them as active contributors to the training. It emphasizes interactive learning experiences where participants can share their knowledge, ask questions, and engage in discussions. Facilitators will use open-ended questions, group discussions, and interactive exercises to draw out participants' insights and experiences. This approach is particularly effective in ensuring that the training content is relevant and immediately applicable to participants' real-world contexts.

b **Experiential Learning:** Experiential learning involves learning through experience and reflection. This approach is grounded in the idea that participants learn best when they are actively involved in a learning activity that mirrors real-world challenges. This module will incorporate simulations, role-playing, and case studies that reflect the challenges participants might face in developing and advocating for policy briefs. After each activity, participants will engage in reflective discussions to analyze their experiences, draw lessons, and plan for future application.

c **Collaborative Learning:** Collaborative learning fosters a sense of community among participants, encouraging them to learn from each other's diverse perspectives and experiences. It involves working together on tasks, sharing knowledge, and providing mutual support. Group work will be a core component of the training module. Participants will be grouped into teams to work on developing policy briefs, with each team member bringing their expertise to the table. This approach not only enhances learning but also builds networks and partnerships that can extend beyond the training.

d **Problem-Based Learning:** Problem-based learning (PBL) centers on solving real-life problems, encouraging participants to apply critical thinking and problem-solving skills. It shifts the focus from passive receipt of information to active problem-solving. Participants will be presented with specific challenges related to AI in agriculture and food systems and will be tasked with developing policy briefs to address these

challenges. The PBL approach will be supported by facilitated discussions that guide participants in identifying solutions, exploring policy options, and developing evidence-based recommendations.

e **Adaptive Facilitation:** Adaptive facilitation involves tailoring the training process to meet the needs of participants as they emerge. It requires facilitators to be flexible and responsive, adjusting the pace, content, and methods to suit the group. Throughout the training, facilitators will continuously assess participants' understanding and engagement, making real-time adjustments to the content and approach as needed. This could involve breaking down complex concepts into more manageable parts, revisiting earlier topics for clarification, or introducing additional resources.

Techniques for Effective Facilitation

To effectively implement the facilitation approaches described above, a variety of techniques will be employed. These techniques are designed to enhance participant engagement, foster deep understanding, and ensure the practical application of skills and knowledge:

- **Interactive Lectures:** While traditional lectures are limited, they will be used strategically to introduce key concepts, frameworks, and examples. Interactive elements, such as polling, Q&A sessions, and small group discussions, will be incorporated to maintain engagement and encourage active participation.

- **Breakout Sessions:** Breakout sessions will be used to facilitate small group discussions and collaborative work. These sessions allow participants to dive deeper into specific topics, share insights, and work on practical tasks such as drafting sections of a policy brief.

- **Real-Time Feedback:** Facilitators will provide real-time feedback during activities and discussions, helping participants refine their ideas and improve their outputs. This feedback will be constructive, focusing on areas of strength as well as opportunities for improvement.

- **Peer Review:** Peer review will be incorporated as a technique to encourage critical thinking and mutual learning. Participants will review each other's work, offering feedback on the clarity, coherence, and persuasiveness of their policy briefs. This process not only enhances the quality of the work but also deepens participants' understanding of effective policy advocacy.

- **Reflective Practice:** Reflection is a key component of the learning process. Facilitators will encourage participants to regularly reflect on their learning experiences, both individually and in groups. Reflective practice will be supported by guided questions that prompt participants to consider what they have learned, how they can apply it, and what challenges they might face.

- **Use of Digital Tools:** Digital tools such as collaborative platforms, online polls, and virtual whiteboards will be utilized to enhance engagement and facilitate collaboration, especially in a hybrid or online training environment. These tools will enable participants to interact with each other and the facilitators in real-time, regardless of their physical location.

- **Action Planning:** Towards the end of the training, participants will engage in action planning, where they will outline how they intend to apply the skills and knowledge gained from the training in their respective contexts. This technique ensures that the learning is not only theoretical but also practical and implementable.

The facilitation approaches and techniques outlined in this module are designed to create a dynamic and supportive learning environment. By promoting active participation, collaboration, and practical application, the module aims to equip participants with the skills and confidence needed to develop effective policy briefs that advocate for the adoption of AI tools in agriculture and food systems across Africa. The success of the training will depend not only on the content delivered but also on the effectiveness of the facilitation in engaging participants and fostering meaningful learning experiences.

EVALUATION OF TRAINING SESSIONS

Importance of Evaluation

Evaluation is a critical component of any training program, serving as a means to assess its effectiveness, identify areas for improvement, and ensure that the training objectives are met. In the context of this training module, which is focused on developing policy briefs for effective policy influence and advocacy, evaluation will provide valuable insights into how well participants have absorbed the material and how prepared they are to apply the skills and knowledge gained in their respective contexts.

The evaluation of training sessions will be designed to measure both the immediate impact of the training and its longer-term effectiveness. This involves assessing participants' understanding and application of the content, their satisfaction with the training experience, and the relevance of the training to their professional needs.

Evaluation Framework

The evaluation of the training sessions will be structured around Kirkpatrick's Four Levels of Training Evaluation, a widely used framework that offers a comprehensive approach to assessing the effectiveness of training programs.

1. **Reaction:**
   Objective: To gauge participants' immediate reactions to the training, including their satisfaction with the content, facilitation, and overall experience.
   Methods: At the end of each session, participants will be asked to complete a feedback form or survey that includes both quantitative and qualitative questions. These will cover aspects such as the relevance of the material, the effectiveness of the facilitation techniques, and the overall organization of the training. Additionally, facilitators will conduct brief debriefing sessions where participants can voice their thoughts and concerns in an open forum.

2. **Learning:**
   Objective: To assess the extent to which participants have acquired the intended knowledge, skills, and attitudes as a result of the training.
   Methods: Learning will be evaluated through a combination of pre- and post-training assessments, practical exercises, and quizzes. These assessments will measure **participants'** understanding of key concepts, their ability to apply new skills, and their

readiness to develop policy briefs. Facilitators will also use informal methods such as observation during group activities and discussions to assess learning outcomes.

3. **Behavior:**
Objective: To determine whether participants have effectively applied what they learned during the training to their professional practice.
Methods: This level of evaluation will take place after participants have had the opportunity to implement their new skills in their work. Follow-up surveys, interviews, or focus group discussions will be conducted to explore how participants have used the training in developing policy briefs, advocating for AI tools, or influencing policy in their respective countries. Participants may also be asked to submit examples of policy briefs they have developed as a result of the training, which can be reviewed for quality and effectiveness.

4. **Results:**
Objective: To measure the overall impact of the training on broader organizational or sectoral goals, such as the adoption of AI tools in agriculture and food systems.
Methods: The results level of evaluation will involve tracking key indicators related to the goals of the training program. This might include the number of AI tools adopted or integrated into policy frameworks, the success of advocacy efforts, or changes in policy that align with the recommendations made in the participants' policy briefs. This level of evaluation may require collaboration with participants' organizations and could involve longer-term data collection and analysis.

To effectively evaluate the training sessions, a variety of tools and techniques will be employed:

a. **Surveys and Questionnaires:** will be used to collect quantitative data on participants' reactions, learning, and behavior. These tools will allow for the systematic collection and analysis of feedback, making it possible to identify trends and common areas of concern.

b. **Interviews and Focus Groups:** will be used to gather in-depth insights into participants' experiences and the impact of the training. These techniques are particularly useful for exploring complex issues that may not be fully captured by surveys.

c. **Assessments and Quizzes:** To evaluate learning outcomes, participants will complete assessments and quizzes at various points throughout the training. These will test their knowledge of key concepts and their ability to apply what they have learned in practical scenarios.

d. **Observation:** Facilitators will observe participants during activities and discussions to assess engagement, participation, and the application of skills. Observation provides real-time feedback on the effectiveness of the training and can help identify areas where participants may need additional support.

e. **Case Studies and Practical Exercises:** Participants will be asked to develop case studies or complete practical exercises as part of the evaluation process. These exercises will be designed to simulate real-world challenges and will be used to assess participants' ability to apply their learning in a practical context.

f **Follow-Up Assessments:** Post-training follow-up assessments will be conducted to measure the longer-term impact of the training. These assessments will explore how participants have applied the training in their work and the outcomes of their policy advocacy efforts.

Continuous Improvement

The evaluation process will also serve as a basis for continuous improvement of the training module. Feedback from participants and the results of the evaluation will be used to make adjustments to the content, facilitation approaches, and delivery methods. This iterative process will ensure that the training remains relevant, effective, and responsive to the needs of participants.

The evaluation of training sessions is a vital component of this training module, providing insights into its effectiveness and impact. By employing a comprehensive evaluation framework and a range of tools and techniques, the training program will not only measure its success but also identify opportunities for continuous improvement. This approach ensures that participants are well-equipped to develop and advocate for policy briefs that support the adoption of AI tools in agriculture and food systems across Africa.

UNITS COVERED IN THE MODULE

The Units covered in the training module with the topics are covered provided below:

Unit 1: Introducing Policy Briefs

- Introduction to policy briefs
- Purpose and audience
- Formatting guidelines
- Real-world examples and analysis

Unit 2: Crafting a Policy Brief

- Data collection methods
- Data analysis techniques
- Evidence synthesis and interpretation
- Data presentation and visualization
- Crafting compelling recommendations

Unit 3: Policy Briefs as a Tool for Effective Advocacy and Policy Influence

- Clarity and conciseness
- Evidence-based arguments
- Persuasive language
- Visual aids and infographics
- Dissemination strategies
- Case studies and examples

Unit 4: Overview of Policymaking Processes

- Definition and importance of policymaking
- Key actors in the policymaking process
- Stages of policymaking

- Models of policymaking
- Role of evidence in policymaking

Unit 5: Identifying and Engaging with the Target Audience

- Audience segmentation and analysis
- Building stakeholder profiles
- Strategies for effective engagement
- Case studies and role-play scenarios

Unit 6: Disseminating Policy Briefs and Advocating for Changes in Policy and Practice

- Dissemination strategies
- Engaging with traditional and new media
- Building alliances and coalitions
- Strategies for effective advocacy campaigns
- Case studies and simulation: Developing advocacy plans

UNIT 1: INTRODUCING POLICY BRIEFS

Content:	This unit will describe: i) Introduce policy briefs ii) Understanding the purpose and audience iii) Formatting guidelines and best practices iv) Real-world examples and analysis
Objectives:	At the end of this unit, participants will be able to: i) Understand what a policy brief is and its uses ii) Learn about the types, key components, and structure of policy briefs iii) Identify the purpose and audience for policy briefs iv) Learn formatting guidelines and best practices v) Analyze real-world examples of policy briefs
Method of training:	Interactive lectures, short video presentations, brainstorming sessions, case study presentations, reflective discussions and application exercises.
Training material	Flip charts, notebooks and pens, marker pens, whiteboard, whiteboard markers
Duration:	90 mins
Evaluation:	The facilitator to decide the most appropriate evaluation method
Reference materials	Young, E. & Quinn, L. (2017). An Essential Guide to Writing Policy Briefs. International Centre for Policy Advocacy. NIHR Policy Research Unit in Behavioural Science (2021). A Practical Guide to Writing Policy Briefs.

Facilitator's Notes

Topic 1: Definition and Purpose of Policy Briefs

Objective

Participants should be able to define what a policy brief is and explain its primary purpose, especially in the context of advocacy and decision-making for policy uptake of AI tools in food systems.

Facilitator's Instructions

- Start with a definition of a policy brief. Use a concise explanation like: "A policy brief is a short, evidence-based document designed to inform or influence decision-makers and stakeholders about a particular issue, providing clear recommendations for action."
- Emphasize the goal of influencing policy decisions or advocating for specific changes, highlighting that in this training, participants will focus on AI tools for agriculture and food systems.

Key Talking Points:

- Policy briefs bridge the gap between complex research/data and actionable policy recommendations.
- They are typically intended for non-specialist audiences like policymakers, government officials, or institutional leaders, hence the need for clarity and focus.
- In this case, policy briefs will be developed to support the uptake of AI technologies that can address food security challenges in Africa.

Activities

- Interactive Exercise (5–10 minutes): Ask participants to reflect on how policy briefs might differ from other policy documents or research papers. Have them share examples they've encountered in their work and how these influenced decision-making processes.
- Group Discussion (10 minutes): Use a flipchart or whiteboard to note participants' inputs on the purpose of a policy brief. Highlight the advocacy aspect and how these briefs are used to drive policy changes.

Topic 2: Types of Policy Briefs

Objective

Participants should understand the different types of policy briefs and their specific applications, including advocacy briefs, decision-making briefs, and research briefs.

Facilitator's Instructions

Introduce the two primary types of policy briefs:

- Advocacy Briefs – Designed to persuade decision-makers or stakeholders to adopt a specific policy or course of action.
- Decision-Making Briefs – Provide evidence and recommendations to help policymakers make informed decisions on a particular issue.

Highlight the differences in purpose and audience:

- Advocacy briefs are often written in a persuasive style with a strong call to action.
- Decision-making briefs are typically more balanced and objective, providing a range of evidence to guide policy choices.

Example: Provide examples of both types of briefs, particularly in the AI and agriculture sectors. For example, an advocacy brief might push for government support in scaling AI-driven predictive analytics tools for crop management, while a decision-making brief might evaluate the pros and cons of adopting AI tools in specific agricultural regions.

Activities

Small Group Exercise (15 minutes): Provide participants with brief examples (one advocacy brief and one decision-making brief). Ask them to identify the key features of each and discuss how they target their respective audiences. Each group should present their findings, and the facilitator should summarize the key distinctions.

Topic 3: Key Components of a Policy Brief

Objectives

Participants should be able to identify and describe the essential components of a policy brief, including the executive summary, introduction, body, conclusion, and recommendations.

Facilitator's Instructions

Detailed breakdown of key components:

a) Executive Summary – A concise overview that includes the problem, the proposed solution, and key recommendations. It should be brief and compelling.

b) Introduction – Defines the issue, providing necessary context and stating the significance of the problem.

c) Body – Presents the evidence, analysis, and arguments supporting the recommendations. Should be clear, logically structured, and backed by data.

d) Conclusion – Summarizes the main points and reinforces the policy message.

e) Recommendations – Actionable steps or policy measures that should be taken, based on the evidence presented. Must be clear and specific.

- Emphasize the importance of conciseness and clarity throughout the document. Policymakers often have limited time, so each section must be succinct while still providing all necessary information.

- Example Breakdown: Present an example policy brief (with a focus on AI in agriculture), showing each section in detail. Discuss what makes each section effective, particularly how the recommendations tie back to the evidence in the body.

Activities

Practical Exercise (20 minutes): Have participants break into small groups and analyze a sample policy brief. Each group should identify the key components and evaluate their effectiveness. Afterward, have each group present their analysis.
Wrap-Up and Reflection

Objective

By the end of the unit, participants should have a comprehensive understanding of the structure and purpose of policy briefs, enabling them to begin drafting their own briefs with confidence.

Facilitator's Instructions

- Summarize Key Takeaways: Recap the definition, types, and key components of a policy brief.
- Open the floor for questions to clarify any concepts or sections that participants found challenging.

Homework Assignment

Ask participants to draft a short executive summary for a hypothetical policy brief based on an AI tool they are familiar with or currently working on. These drafts will be shared and critiqued in the next session.

UNIT 2: CRAFTING A POLICY BRIEF

Content:	This unit will describe: i. Data collection methods ii. Data analysis techniques iii. Evidence synthesis and interpretation iv. Data presentation and visualization v. Crafting compelling recommendations
Objectives:	At the end of this unit, participants will be able to: i. Develop skills for data collection and analysis ii. Learn to identify reliable data sources. iii. Synthesize and interpret evidence iv. Present data effectively v. Craft compelling recommendations
Method of training:	Interactive lecture, short videos presentations, brainstorming sessions, case study presentations, reflective discussions and application exercises.
Training material	Flip charts, notebooks and pens, marker pens, white board, white board markers
Duration:	90 mins
Evaluation:	The facilitator to decide the most appropriate evaluation method
Reference materials	- Science Policy Initiative (2021). A Collection of Policy Briefs on Artificial Intelligence. Ashoka University. - Antonopoulou, V., Chadwick, P., McGee, O., Sniehotta, F. F., Lorencatto, F., Meyer, C., O'Donnell, A., Lecouturier, J., Kelly, M., & Michie, S. (n.d.). Research engagement with policymakers: A practical guide to writing policy briefs. NIHR Policy Research Unit in Behavioural Science. - Court, J., Mendizabal, E., Osborne, D., & Young, J. (2006). Policy Engagement: How Civil Society Can Be More Effective. Overseas Development Institute.

Facilitator's Notes:

Topic 1: Data Collection Methods

Objective

Participants should understand the range of data collection methods available and know when to apply each method, depending on the policy brief's focus.

Facilitator's Instructions

- **Introduce data collection methods relevant to policy brief creation:**
- **Desk Studies:** Review of existing literature, reports, or previous research.
- **Surveys:** Collecting new data through questionnaires targeted at stakeholders or beneficiaries.
- **Interviews:** One-on-one discussions with key stakeholders or experts to gather qualitative insights.
- **Data Mining:** Extracting patterns and trends from large datasets (especially relevant in the context of AI and agriculture).
- **Emphasize Method Selection:** Highlight how the choice of data collection method depends on the policy issue at hand. For example, desk studies may suffice for reviewing AI tool impact in a general sense, while interviews or surveys may be necessary for understanding local agricultural challenges.

Activities

- Interactive Discussion (10 minutes): Ask participants to reflect on a current AI tool they are working on. Discuss which data collection method would be most appropriate for creating a policy brief about this tool and why.
- Practical Exercise (10 minutes): Provide scenarios (e.g., scaling AI tools for specific crops or regions). Ask participants to outline a data collection plan, identifying which methods they would use and the rationale behind their choice.

Topic 2: Data Analysis Techniques

Objective

Participants should be able to differentiate between quantitative and qualitative data analysis methods and understand how to identify reliable data sources for policy recommendations.

Facilitator's Instructions

- **Introduce Quantitative and Qualitative Analysis:**
  - **Quantitative Methods:** Statistical analysis of numeric data, such as survey responses or data mining results. Focus on how AI tools can generate large datasets, requiring quantitative techniques to analyze trends, effectiveness, and impact.
  - **Qualitative Methods:** Analysis of non-numeric data, such as interview transcripts or survey open responses. Emphasize the value of qualitative insights for understanding stakeholder perspectives.
- **Reliable Data Sources:** Stress the importance of using credible, high-quality data

sources. Discuss official reports, peer-reviewed research, government databases, and field data from AI tool deployment. Explain how using poor-quality or biased data can undermine policy recommendations.

Activities

- **Group Activity (15 minutes):** Provide participants with sample datasets (both quantitative and qualitative). Ask them to discuss in groups how they would analyze the data and what insights they would prioritize in their policy brief.
- **Plenary Discussion (5 minutes):** Groups share their analysis approach, emphasizing how they chose between quantitative and qualitative methods for the task at hand.

Topic 3: Evidence Synthesis and Interpretation

Objective

Participants should learn how to combine different types of evidence and draw conclusions that support their policy recommendations.

Facilitator's Instructions

- **Combining Different Types of Evidence:** Discuss how to synthesize quantitative (statistical) and qualitative (narrative) evidence to form a holistic understanding of an issue. For instance, data on AI tool performance should be paired with qualitative insights from end-users (farmers, stakeholders) to craft a comprehensive narrative.
- **Drawing Conclusions:** Teach participants how to use synthesized evidence to support clear conclusions. Highlight the importance of ensuring conclusions are both data-driven and directly linked to the problem addressed in the policy brief.

Activities

- **Case Study Analysis (15 minutes):** Present a case study on the deployment of AI in agriculture (e.g., yield prediction tools). Ask participants to analyze the presented data (quantitative and qualitative), synthesizing both to draw a conclusion for policy action.

Topic 4: Data Presentation and Visualization

Objective
Participants should be able to present data effectively using charts, graphs, and infographics to enhance accessibility and engagement.

Facilitator's Instructions

- **Effective Data Presentation:** Show participants examples of well-designed charts, graphs, and infographics. Emphasize the need for simplicity, clarity, and relevance when choosing data visualizations. Discuss how visuals can make complex data more accessible to non-specialist audiences, such as policymakers.
- **Use of Infographics:** Highlight how infographics can summarize key data points and recommendations in a visually engaging way, making the policy brief more likely to be read and acted upon.

Activities

- Hands-On Exercise (20 minutes): Provide raw data relevant to AI tools for agriculture (e.g., performance metrics, user adoption rates). Participants will choose the best visualization method (e.g., pie charts, bar graphs, or infographics) and create a simple draft visual. This will help them practice data presentation skills for their policy briefs.

Topic 5: Crafting Compelling Recommendations

Objective

Participants should be able to craft clear, evidence-based recommendations and address common challenges in creating policy briefs.

Facilitator's Instructions

- Key Elements of a Recommendation: Teach participants that recommendations should be actionable, specific, and rooted in the data presented in the policy brief.
- For example, rather than stating, "Support AI adoption in agriculture," a well-crafted recommendation might be: "The Ministry of Agriculture should allocate $2 million in funding over three years to pilot AI-driven crop prediction tools in three regions."
- Common Challenges: Discuss the typical challenges in crafting policy recommendations, such as lack of data, balancing ethical considerations, or ensuring recommendations are politically feasible. Discuss how to balance ethical and practical considerations, such as promoting AI while addressing potential biases in AI algorithms or ethical issues like data privacy.

Activities

- Drafting Exercise (20 minutes): Participants will individually draft recommendations based on the case study data from earlier topics. Facilitators should provide feedback on clarity, feasibility, and alignment with evidence.

Topic 6: Group Work: Crafting Policy Recommendations

Objective

Participants will apply what they have learned by collaboratively drafting policy recommendations based on real or hypothetical data.

Facilitator's Instructions

- Group Work Setup: Divide participants into groups and provide a dataset or case study related to AI tools in agriculture. Each group will analyze the data, synthesize evidence, and craft 2–3 policy recommendations.
- Facilitate Collaboration: Monitor group discussions, ensuring each group applies the skills learned in data collection, analysis, synthesis, and visualization. Provide guidance where necessary to ensure that the recommendations are both data-driven and actionable.

Group Work Activity (30 minutes)

- **Deliverable:** Each group will present their policy recommendations to the larger group, followed by peer feedback and facilitator critique. This will serve as a practice exercise for crafting full policy briefs in subsequent sessions.

Wrap-Up and Reflection

At the end of this unit, participants should feel confident in their ability to craft evidence-based policy recommendations and present data effectively in a policy brief.

Facilitator's Instructions

- **Summarize Key Points:** Review the importance of rigorous data collection and analysis, the synthesis of evidence, and the crafting of clear, actionable recommendations.

- **Open the Floor for Questions:** Allow participants to ask any clarifying questions before moving on to the next unit.

Homework Assignment

Participants should start drafting the data section of a policy brief, including data analysis and presentation. This draft will be critiqued in the following session.

UNIT 3: POLICY BRIEFS AS A TOOL FOR EFFECTIVE ADVOCACY AND POLICY INFLUENCE

Content:	This unit will describe: i. Clarity and Conciseness ii. Evidence-Based Arguments iii. Persuasive Language iv. Visual Aids and Infographics v. Dissemination Strategies vi. Case Studies and Examples
Objectives:	At the end of this unit, participants will be able to: i. Understand the importance of clarity and conciseness. ii. Learn to build evidence-based arguments. iii. Use persuasive language and visual aids. iv. Develop dissemination strategies. v. Engage effectively with policymakers and stakeholders
Method of training:	Interactive lectures, short video presentations, brainstorming sessions, case study presentations, reflective discussions and application exercises.
Training material	Flip charts, notebooks and pens, marker pens, white board, whiteboard markers
Duration:	90 mins
Evaluation:	The facilitator to decide the most appropriate evaluation method
Reference materials	Sociology Policy Briefs (n.d.). Writing Policy Briefs. Science Policy Initiative (2021). A Collection of Policy Briefs on Artificial Intelligence. Ashoka University.

Facilitator's Notes:

Topic 1: Clarity and Conciseness

Objective

Participants should learn how to write succinctly while clearly highlighting the key points of their policy brief.

Facilitator's Instructions

- **Importance of Clarity and Brevity:** Emphasize that a policy brief must communicate complex ideas in a clear and concise manner. Policymakers and stakeholders often have limited time, so the brief must get to the point quickly.

- **Writing Techniques:** Teach participants how to write succinctly, removing unnecessary jargon and focusing on the essential information. Key points should be highlighted early in the brief, particularly in the executive summary and recommendations sections.

Activities

- **Editing Exercise (10 minutes):** Provide participants with an overly wordy excerpt from a policy brief and ask them to edit it for clarity and conciseness. Have them share their revised versions with the group for comparisons.

Topic 2: Evidence-Based Arguments

Objective

Participants should be able to build strong, logical arguments backed by data and evidence in support of their policy recommendations.

Facilitator's Instructions

- **Logical Argumentation:** Explain how a strong policy brief is grounded in evidence. Participants should structure their arguments logically, beginning with a clear problem statement, followed by supporting evidence and ending with a justified recommendation.

- **Data Integration:** Show how quantitative and qualitative data should be integrated to support arguments. The data must directly address the issue being discussed, and the connection between data and recommendations must be explicit.

Activities

- **Argument Construction (15 minutes):** Provide a dataset relevant to AI for agriculture. Ask participants to draft a logical argument using the data to support a policy recommendation. Have them present their arguments to the group for feedback.

Topic 3: Persuasive Language

Objective

Participants should learn how to craft compelling narratives that engage the reader and effectively convey the urgency and importance of their recommendations.

Facilitator's Instructions

- **Crafting Narratives:** Teach participants how to use storytelling techniques to frame the issue and their recommendations in a persuasive way. For example, starting with a case study or real-life example can create an emotional connection with the reader.

- **Engaging the Reader:** Discuss the use of persuasive language to keep the reader's attention. Highlight the importance of tone—balancing professional language with an engaging, urgent appeal.

Activities

- **Writing Exercise (10 minutes):** Ask participants to draft a short persuasive paragraph, making the case for the uptake of an AI tool in agriculture. Focus on creating a compelling narrative that would engage a policymaker or stakeholder.

Topic 4: Visual Aids and Infographics

Objective

Participants should be able to enhance the understanding of their policy briefs through the use of visual aids and infographics.

Facilitator's Instructions

- **Importance of Visuals:** Explain that well-designed charts, graphs, and infographics can make complex data more accessible and easier to understand. They help break up large blocks of text and make key points more memorable.

- **Creating Effective Infographics:** Teach participants how to choose the right type of visual (e.g., bar charts for comparisons, pie charts for proportions) and how to design infographics that clearly convey the intended message. Discuss the balance between simplicity and informativeness.

Activities

- **Visual Design Workshop (15 minutes):** Provide participants with raw data related to AI tools and ask them to create a simple infographic. Use software tools (e.g., Canva, PowerPoint) if possible, or ask them to sketch on paper. Afterward, discuss the effectiveness of the visuals in conveying the message.

Topic 5: Dissemination Strategies

Objective

Participants should learn how to develop effective dissemination strategies for their policy briefs to ensure they reach and influence the target audience.

Facilitator's Instructions

- **Identifying Target Audience:** Discuss the importance of understanding who the policy brief is for (e.g., government officials, NGOs, private sector actors). Tailoring the message to the audience's needs and interests is key to effective advocacy.
- **Channels of Distribution:** Highlight the different channels for distributing policy briefs, including online platforms (email campaigns, social media, websites) and print formats. The chosen method should align with the preferences of the target audience.
- **Timing and Relevance:** Discuss the importance of releasing policy briefs at the right time, such as when policy discussions are ongoing or when new legislation is being considered. This ensures the brief is relevant and timely.
- **Engaging with Policymakers and Stakeholders:** Provide tips on how to actively engage with policymakers after distributing the brief, such as through follow-up meetings, presentations, or roundtable discussions.

Activities

- Strategic Planning Exercise (20 minutes): Have participants develop a dissemination strategy for their policy brief, identifying the target audience, distribution channels, and follow-up actions. They should also consider the best timing for maximum impact.

Topic 6: Case Studies and Examples

Objective

Participants should gain insight into successful policy briefs and the lessons learned from real-world examples of policy influence.

Facilitator's Instructions

- **Real-World Success Stories:** Present examples of successful policy briefs that led to tangible policy changes or stakeholder engagement. Analyze what made these briefs effective, such as the clarity of their recommendations, use of data, or the timing of their release.
- **Lessons Learned:** Discuss the lessons that can be applied from these cases to the participants' own policy briefs. Key aspects such as audience engagement, strategic dissemination, and persuasive communication should be emphasized.

Activities

- **Case Study Review (20 minutes):** Provide participants with a case study of a successful policy brief. Ask them to analyze the components that contributed to its success and discuss how they would apply similar techniques to their own briefs.

Wrap-Up and Reflection

Objective

At the end of this unit, participants should feel confident in their ability to use policy briefs as tools for effective advocacy and policy influence, employing clarity, persuasive language, data-backed arguments, and strategic dissemination.

Facilitator's Instructions

- **Summarize Key Takeaways:** Review the importance of clarity, conciseness, evidence-based arguments, persuasive language, and strategic dissemination in crafting an impactful policy brief.

- **Open the Floor for Questions:** Allow participants to ask questions and clarify any concepts covered in the unit.

Homework Assignment

Participants should begin drafting their policy brief, focusing on clarity, use of evidence, and persuasive language. They will refine their drafts based on feedback in the next session.

UNIT 4: OVERVIEW OF POLICYMAKING PROCESSES

Content:	This unit will describe: i. Definition and Importance of Policymaking ii. Key Actors in the Policymaking Process iii. Stages of Policymaking iv. Models of Policymaking v. Role of Evidence in Policymaking
Objectives:	At the end of this unit, participants will be able to: i. Learn the definition and importance of policymaking. ii. Identify key actors in the policymaking process. iii. Understand the stages and models of policymaking. iv. Recognize the role of evidence in policymaking.
Method of training:	Interactive lecture, short video presentations, brainstorming sessions, case study presentations, reflective discussions and application exercises.
Training material	Flip charts, notebooks and pens, marker pens, whiteboard, whiteboard markers
Duration:	90 mins
Evaluation:	The facilitator to decide the most appropriate evaluation method
Reference materials	Court, J., Mendizabal, E., Osborne, D., & Young, J. (2006). Policy Engagement: How Civil Society Can Be More Effective. Overseas Development Institute.

FACILITATOR'S NOTES:

Topic 1: Definition and Importance of Policymaking

Objective

Participants should be able to define policymaking and articulate its importance in governance and societal development.

Facilitator's Instructions

- **Definition of Policymaking:** Introduce policymaking as the process by which governments and organizations create rules, regulations, or guidelines that shape society and address public issues. It involves the actions and decisions taken by public authorities to address societal challenges and objectives.

- **Importance of Policymaking:** Discuss how policymaking influences every aspect of society, including economic development, environmental sustainability, public health, and social welfare. Highlight its role in establishing priorities, allocating resources, and creating frameworks for action.

Activities

- **Group Discussion (10 minutes):** Ask participants to reflect on specific policies that have impacted their work or lives and discuss the importance of those policies. What were the key drivers behind their development?

Topic 2: Key Actors in the Policymaking Process

Objective

Participants should be able to identify and explain the roles of the various actors involved in the policymaking process.

Facilitator's Instructions

- **Policymakers:** Define policymakers as elected officials (e.g., legislators, government executives) and appointed bureaucrats who are responsible for making and implementing decisions.
- **Stakeholders:** Explain that stakeholders include anyone affected by a policy, such as the general public, civil society, businesses, and advocacy groups.
- **Interest Groups:** Discuss how interest groups, such as non-governmental organizations (NGOs), lobbyists, and trade associations, influence policymaking by advocating for specific outcomes based on their interests.

Activities

- **Mapping Exercise (15 minutes):** Ask participants to map out the key actors involved in the policymaking process within their countries or sectors, identifying how these actors influence the process. This can be done using flip charts or sticky notes to create a visual map.

Topic 3: Stages of Policymaking

Objective

Participants should understand the different stages of the policymaking process and the sequence of actions involved.

Facilitator's Instructions

- **Agenda Setting:** Explain how issues gain attention from policymakers and enter the public agenda. Discuss the role of media, advocacy, and public opinion in shaping this stage.
- **Policy Formulation:** Describe how policies are developed, including drafting proposals, consulting stakeholders, and considering evidence.
- **Policy Adoption:** Discuss how policies are formally approved, whether through legislation, executive orders, or regulatory actions.
- **Implementation:** Explain the process of putting a policy into action, including the role of government agencies and other actors responsible for execution.
- **Evaluation:** Highlight the importance of monitoring and evaluating the policy's impact to determine if it achieves its intended outcomes and to inform future decisions.

Activities

- **Case Study Analysis (20 minutes):** Provide participants with a case study of a policy that went through all the stages of policymaking. Ask them to identify how each stage was handled and what challenges emerged. Discuss the importance of each stage for the overall success of the policy.

Topic 4: Models of Policymaking

Objective

Participants should be able to distinguish between different models of policymaking and understand their applications.

Facilitator's Instructions

- **Rational Model:** Introduce the rational model of policymaking, which is based on a logical, step-by-step approach to decision-making. In this model, policymakers define the problem, evaluate all alternatives, and choose the best course of action based on available evidence.
- **Incremental Model:** Discuss the incremental model, which suggests that policymaking is often a slow, evolutionary process where small, gradual changes are made rather than major shifts. This is often due to political, financial, or practical constraints.
- **Other Models:** Briefly touch on other models such as the garbage can model, which views policymaking as a less structured and more chaotic process where decisions result from the random intersection of problems, solutions, and actors.

Activities

- **Model Comparison Exercise (15 minutes):** Ask participants to compare the rational and incremental models in small groups. Provide them with a policy issue and ask them to consider how each model would address the issue. Have them present their findings to the group.

Topic 5: Role of Evidence in Policymaking

Objective

Participants should understand the importance of evidence in policymaking and learn how to effectively integrate research and data into the policy process.

Facilitator's Instructions

- **Evidence-Based Policy:** Emphasize the growing trend toward evidence-based policymaking, where decisions are informed by data, research, and empirical evidence rather than solely by ideology or political considerations.
- **Sources of Policy Evidence:** Discuss various sources of evidence, including academic research, government data, international organizations, and expert analysis. Highlight the importance of using credible and reliable sources.
- **Integrating Research:** Show participants how to synthesize and present evidence in a way that is accessible and convincing for policymakers. Explain that evidence must be relevant to the issue, timely, and presented in a format that aligns with the needs of decision-makers.

Activities

- **Evidence Review Exercise (20 minutes):** Provide participants with a dataset or research paper relevant to AI tools in agriculture. Ask them to identify key pieces of evidence that would support a policy recommendation. Discuss how they would present this evidence in a policy brief or advocacy setting.

Wrap-Up and Reflection

Objective

At the end of this unit, participants should have a comprehensive understanding of the policymaking process, key actors, and the importance of evidence-based decision-making.

Facilitator's Instructions

- **Summarize Key Concepts:** Review the stages of policymaking, the roles of key actors, the different models of policymaking, and the critical role that evidence plays in policy decisions.
- **Q&A Session:** Allow participants to ask questions and clarify any points that were discussed in the unit.

Homework Assignment

Participants should research a current policy issue in their field and identify where the issue is in the policymaking process. They should also outline how they would present evidence to influence that policy.

UNIT 5: IDENTIFYING AND ENGAGING WITH THE TARGET AUDIENCE

Content:	This unit will describe: i. Audience Segmentation and Analysis ii. Building Stakeholder Profiles iii. Strategies for Effective Engagement iv. Case Studies and Role-Play Scenarios
Objectives:	At the end of this unit, participants will be able to: i. Learn audience segmentation and analysis. ii. Build stakeholder profiles. iii. Develop strategies for effective engagement.
Method of training:	Interactive lecture, short videos presentations, brainstorming sessions, case study presentations, reflective discussions and application exercises.
Training material	Flip charts, notebooks and pens, marker pens, white board, whiteboard markers
Duration:	90 mins
Evaluation:	The facilitator to decide the most appropriate evaluation method
Reference materials	NIHR Policy Research Unit in Behavioural Science (2021). A Practical Guide to Writing Policy Briefs.

Facilitator's Notes:

Topic 1: Audience Segmentation and Analysis

Objective

Participants should understand how to categorize audiences and assess their needs to tailor policy briefs effectively.

Facilitator's Instructions

- **Identifying Different Audience Segments:** Introduce the concept of audience segmentation, which involves dividing the policy brief's audience into distinct groups based on their roles, influence, and interests. Segments could include policymakers, civil society groups, private sector actors, academia, and local communities.

- **Categorizing Audiences:** Guide participants in grouping audiences by the nature of their involvement in the policy process, such as decision-makers, influencers, or beneficiaries.

- **Understanding Audience Needs:** Explain that different audience segments have varying preferences for receiving information. Discuss how some may require technical data (e.g., policymakers or academic experts), while others may respond better to clear, concise summaries and practical implications (e.g., community groups or local government officials).

Activities

- **Audience Mapping Exercise (15 minutes):** Have participants select a policy brief they are working on and categorize their key audience segments. Ask them to identify what kind of information each segment needs and the most effective way to present it.

Topic 2: Building Stakeholder Profiles

Objective

Participants should be able to map and analyze stakeholders based on their level of influence, interest, and relevance to the policy issue.

Facilitator's Instructions

- **Mapping Stakeholders:** Explain that stakeholder mapping involves identifying the individuals and groups who are most affected by or have the most influence over the policy issue. Stakeholders may include policymakers, local governments, interest groups, industry representatives, and citizens.

- **Analyzing Influence and Interest:** Introduce participants to the "influence-interest matrix" and demonstrate how to categorize stakeholders based on their level of influence and interest in the policy issue. Discuss the importance of prioritizing high-influence, high-interest stakeholders in the engagement process.

- **Influence-Interest Matrix:** Help participants categorize stakeholders into quadrants, showing which stakeholders need close management, monitoring, or minimal attention.

Activities

- **Stakeholder Mapping Exercise (20 minutes):** In small groups, participants will choose a policy issue and develop a stakeholder map using the influence-interest matrix. Each group should analyze the stakeholders' potential impact and determine engagement strategies.

Topic 3: Strategies for Effective Engagement

Objective

Participants should learn techniques for tailoring policy briefs and establishing effective stakeholder engagement channels.

Facilitator's Instructions

- **Tailoring Policy Briefs:** Discuss the importance of customizing policy brief content to resonate with different audience segments. Highlight that the tone, format, and complexity of information should vary based on the target audience's role and understanding of the issue. For example, technical reports may be appropriate for academic stakeholders, while high-level summaries and key recommendations may be more suitable for policymakers.

- **Feedback Mechanisms and Iterative Engagement:** Explain that engagement does not stop after the policy brief is shared. Participants should create opportunities for feedback from stakeholders. This may include follow-up meetings, surveys, or workshops where stakeholders can provide input, leading to revisions and improvements in future communications.

- **Iterative Engagement:** Stress that engagement is a continuous process. Successful advocacy often involves revisiting stakeholders multiple times to refine the message and align it with their evolving needs and priorities.

Activities

- **Feedback Mechanism Planning (15 minutes):** Ask participants to design a simple feedback mechanism for a specific audience they are targeting. They should think about how they will gather feedback, what questions to ask, and how they will use that information to refine future policy briefs.

Topic 4: Case Studies and Role-Play Scenarios

Objective

Participants should apply their audience engagement strategies in practical exercises to simulate real-world scenarios.

Facilitator's Instructions

- Case Studies: Provide examples of successful and unsuccessful audience **engagement e**fforts in policy advocacy. Discuss why certain strategies worked well and where others fell short, focusing on elements like tailoring the message, timing, and audience needs.
- **Role-Playing:** Introduce role-playing as a method to simulate interactions between advocates and stakeholders. Each participant will take on a role, such as a policymaker, community leader, or advocate, and engage in a mock meeting to discuss a policy brief. This exercise helps participants practice tailoring their messages and adjusting their approach based on stakeholder reactions.

Activities

- **Role-Play Exercise (30 minutes):** Divide participants into groups and assign roles (e.g., policymaker, stakeholder, policy advocate). Each group will simulate a stakeholder engagement meeting in which they present a policy brief and adjust their strategy based on the stakeholder's feedback and concerns. After the role-play, the group will analyze what worked and what could be improved.

- **Discussion and Reflection (10 minutes):** Facilitate a group discussion where participants reflect on the effectiveness of their engagement strategies during the role-play. Encourage them to share insights on how they tailored their messages and how they responded to feedback from the stakeholders.

Wrap-Up and Reflection

Participants should be able to consolidate their understanding of audience engagement strategies and recognize the importance of tailoring and feedback in policy advocacy.

Facilitator's Instructions

- **Summarize Key Learnings:** Review the key points of audience segmentation, stakeholder mapping, and tailoring messages to different audiences. Reiterate the importance of feedback mechanisms in refining policy briefs for effective engagement.

- **Reflection Questions:** Ask participants to reflect on the following:
  - How will they apply audience segmentation to their policy briefs?
  - What feedback mechanisms will they incorporate into their engagement strategy?

Homework Assignment

Participants will develop a stakeholder engagement plan for their ongoing policy briefs, outlining audience segments, key messages, and planned feedback mechanisms.

UNIT 6: DISSEMINATING POLICY BRIEFS AND ADVOCATING FOR CHANGES IN POLICY AND PRACTICE

Content:	This unit will describe: i. Dissemination Strategies ii. Engaging with Traditional and New Media iii. Building Alliances and Coalitions iv. Strategies for Effective Advocacy Campaigns v. Case Studies and Simulation: Developing Advocacy Plans
Objectives:	At the end of this unit, participants will be able to: i. Develop dissemination strategies for policy briefs. ii. Use social media and online platforms effectively. iii. Engage with traditional and new media.
Method of training:	Interactive lecture, short video presentations, brainstorming sessions, case study presentations, reflective discussions and application exercises.
Training material	Flip charts, notebooks and pens, marker pens, white board, whiteboard markers
Duration:	90 mins
Evaluation:	The facilitator to decide the most appropriate evaluation method
Reference materials	Science Policy Initiative (2021). A Collection of Policy Briefs on Artificial Intelligence. Ashoka University. Sociology Policy Briefs (n.d.). Writing Policy Briefs. Young, E. & Quinn, L. (2017). An Essential Guide to Writing Policy Briefs. International Centre for Policy Advocacy.

Facilitator's Notes:

Topic 1: Dissemination Strategies

Objective

Participants will understand how to choose and implement dissemination channels for their policy briefs, ensuring maximum reach and impact.

Facilitator's Instructions

- **Online and Print Dissemination:** Introduce participants to the various methods of distributing policy briefs, including digital platforms, websites, social media, email newsletters, and printed materials. Discuss the importance of choosing a dissemination method that suits the target audience's preferences and access.
  - Online Platforms: Emphasize the growing role of online platforms such as LinkedIn, Twitter, and institutional websites in reaching a wide, diverse audience.
  - Print Dissemination: While digital dissemination is prevalent, printed briefs may be more impactful for certain traditional sectors or regions with limited internet access.

- **Workshops and Conferences:** Explain how in-person dissemination methods, such as presenting policy briefs at workshops, conferences, or stakeholder meetings, can provide opportunities for direct engagement with key decision-makers.

- **Social Media Strategies:** Highlight how social media platforms can be used to increase the visibility of policy briefs and foster public engagement. Discuss the importance of using targeted hashtags, infographics, and short videos to summarize key points.

Activities

- Dissemination Plan Development (15 minutes): Ask participants to create a brief dissemination plan for their policy brief, specifying the channels they will use (e.g., online, print, social media) and how they will engage their target audiences.

Topic 2: Engaging with Traditional and New Media

Objective

Participants should learn how to collaborate with media professionals to increase the reach and impact of their policy advocacy.

Facilitator's Instructions

- **Building Media Relationships:** Explain the role of traditional media (e.g., newspapers, radio, TV) in policy advocacy and how developing relationships with journalists and media outlets can help amplify messages. Encourage participants to build a media contact list and establish relationships with reporters covering relevant topics.

- **Leveraging New Media:** Discuss the importance of utilizing new media channels, including blogs, podcasts, and social media influencers, to spread policy messages. Show examples of how advocacy groups have successfully used new media to build momentum around specific policy issues.

Activities

- **Media Engagement Exercise (15 minutes):** Have participants draft a media engagement plan, identifying key journalists, bloggers, and media outlets to approach for coverage of their policy brief. Encourage them to practice crafting a press release or a media pitch.

Topic 3: Building Alliances and Coalitions

Objective

Participants should learn how to collaborate with organizations and stakeholders to strengthen their advocacy efforts.

Facilitator's Instructions

- **Partnering with Like-Minded Organizations:** Explain how forming alliances with other organizations working on similar issues can increase the reach and credibility of policy advocacy efforts. Discuss examples of coalitions that have successfully influenced policy changes.

- **Coordinating Advocacy Efforts:** Highlight the importance of coordinating advocacy actions with coalition partners to avoid duplication and to amplify impact. Discuss strategies for aligning messaging and coordinating campaigns.

Activities

- **Alliance Mapping Exercise (20 minutes):** In small groups, participants will create a stakeholder map identifying potential partners for their advocacy efforts. They should consider NGOs, government bodies, academic institutions, and private sector organizations that align with their policy goals.

Topic 4: Strategies for Effective Advocacy Campaigns

Objective

Participants should learn the process of planning and executing advocacy campaigns that support the adoption of their policy recommendations.

Facilitator's Instructions

- **Planning Campaigns:** Introduce the key components of an advocacy campaign, including goal setting, message development, audience identification, timing, and resource allocation. Emphasize the importance of clear, measurable objectives and realistic timelines.

- **Executing Campaigns:** Discuss the steps involved in executing an advocacy campaign, such as launching the campaign, engaging with stakeholders, monitoring progress, and making adjustments as necessary.

- **Monitoring and Evaluation:** Explain the role of monitoring and evaluation (M&E) in advocacy campaigns. Participants should learn how to track the effectiveness of their efforts, measure outcomes, and refine strategies for future advocacy.

Activities

- **Campaign Strategy Exercise (30 minutes):** Ask participants to work in small groups to design an advocacy campaign around a policy brief they've developed. Each group should present their campaign strategy, including key messages, target audiences, dissemination tactics, and how they will measure success.

Topic 5: Case Studies and Simulation: Developing Advocacy Plans

Objective

Participants will apply what they've learned by engaging in practical exercises to develop and simulate advocacy plans.

Facilitator's Instructions

- **Case Studies:** Present case studies of successful advocacy campaigns driven by policy briefs. Analyze the strategies used in these campaigns, focusing on how policy briefs were disseminated, how media engagement was managed, and how alliances were built.

- **Simulation Exercise:** Facilitate a simulation where participants create an advocacy plan based on a hypothetical policy issue. The simulation should involve selecting dissemination strategies, planning media engagement, and identifying key stakeholders for alliance building.

Activities

- **Advocacy Plan Development (30 minutes):** In groups, participants will develop a comprehensive advocacy plan for a given policy issue. They should consider all the components covered in the unit, including dissemination strategies, media engagement, building alliances, and campaign planning. Each group will present their plan and receive feedback from peers and facilitators.

Wrap-Up and Reflection

Objective

Participants should consolidate their knowledge on policy brief dissemination and advocacy and reflect on how they will apply these strategies in their work.

Facilitator's Instructions

- **Review Key Points:** Summarize the importance of selecting appropriate dissemination methods, engaging with media, building alliances, and designing effective advocacy campaigns.
- **Reflection Questions:** Ask participants to reflect on the following:
  - What dissemination strategy will they use for their policy brief?
  - How can they leverage media and build alliances to support their advocacy efforts?

Homework Assignment

Participants should develop a draft advocacy plan for their ongoing policy briefs, including dissemination channels, media outreach, and potential alliances.

Notes

Notes

ISBN: 978-9966-124-46-3

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