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Policy and Technical Aspects of Approach 3, Spatially-Explicit Systems for the Land Sector

System Design, Development and Operation using the FLINT Platform

30 August - 2 September, 2021

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Opening Session

30 August 2021; 08:30 - 9:00

Introductions

UNFCCC

Moja global

Presenters

Process

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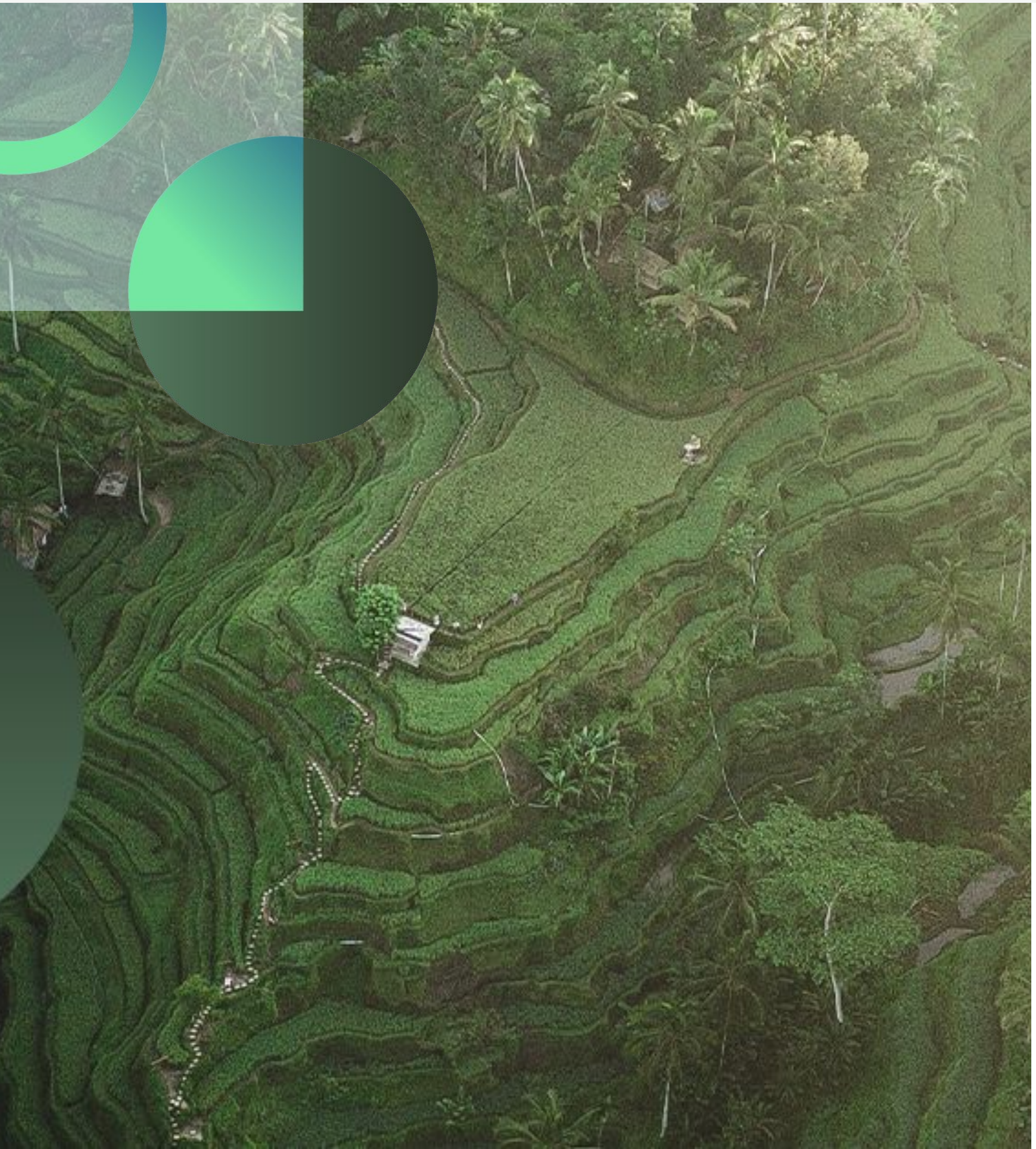
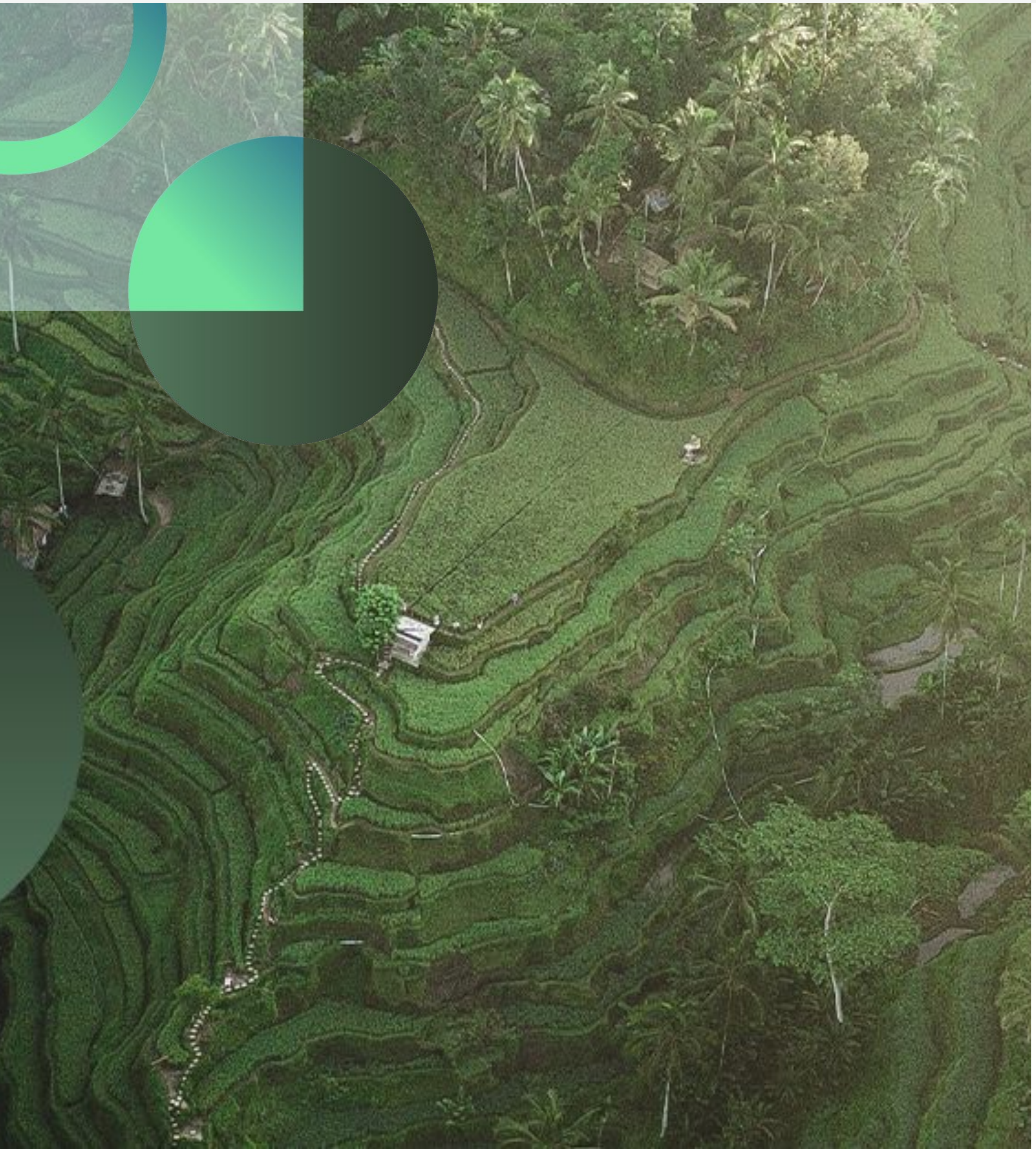


Expected outcomes from this workshop

Increase understanding of:

- Impact of policy drivers on technical system requirements for GHG reporting and projections
- Designing, building and running a system for reporting and projections
- How to engage with open source tools
- Options for using FLINT as a basis for a national GHG land sector reporting system
- Data and model options available to countries



How to make this work!

We have over 700 people from 110 countries registered….

- QUESTIONS: If you have questions during the presentations please put them in the chat at any time
  - We have a team of moja experts who will attempt to answer these
- FLINTpro example: we will do a demonstration of FLINT using FLINTpro
  - Logins will also be available during the course

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The moja team for this workshop

The Presenters

The Support Team

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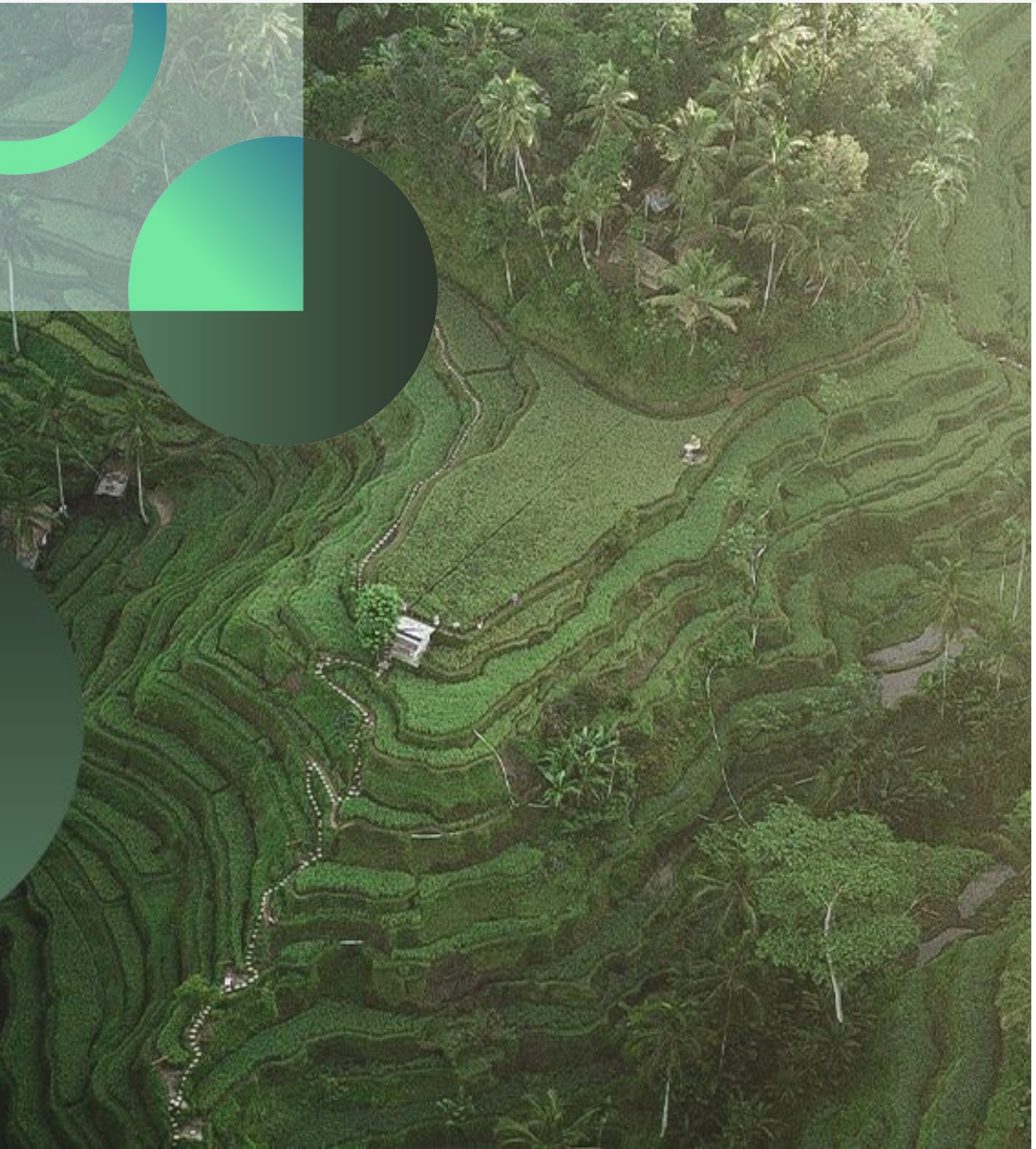
Policy drivers for advanced MRV systems

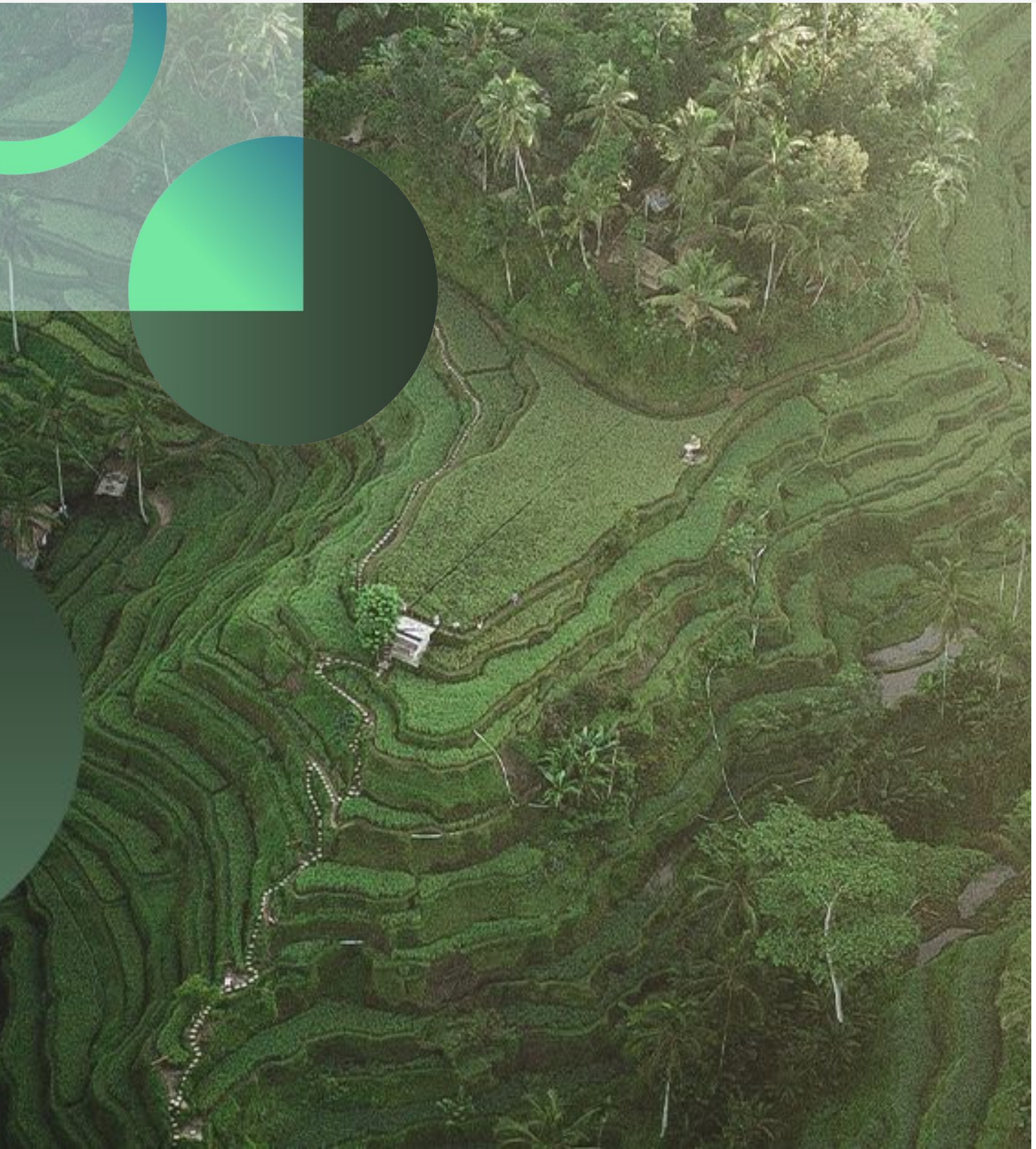
30 August 2021; 9:00 - 10:30



Summary of the session

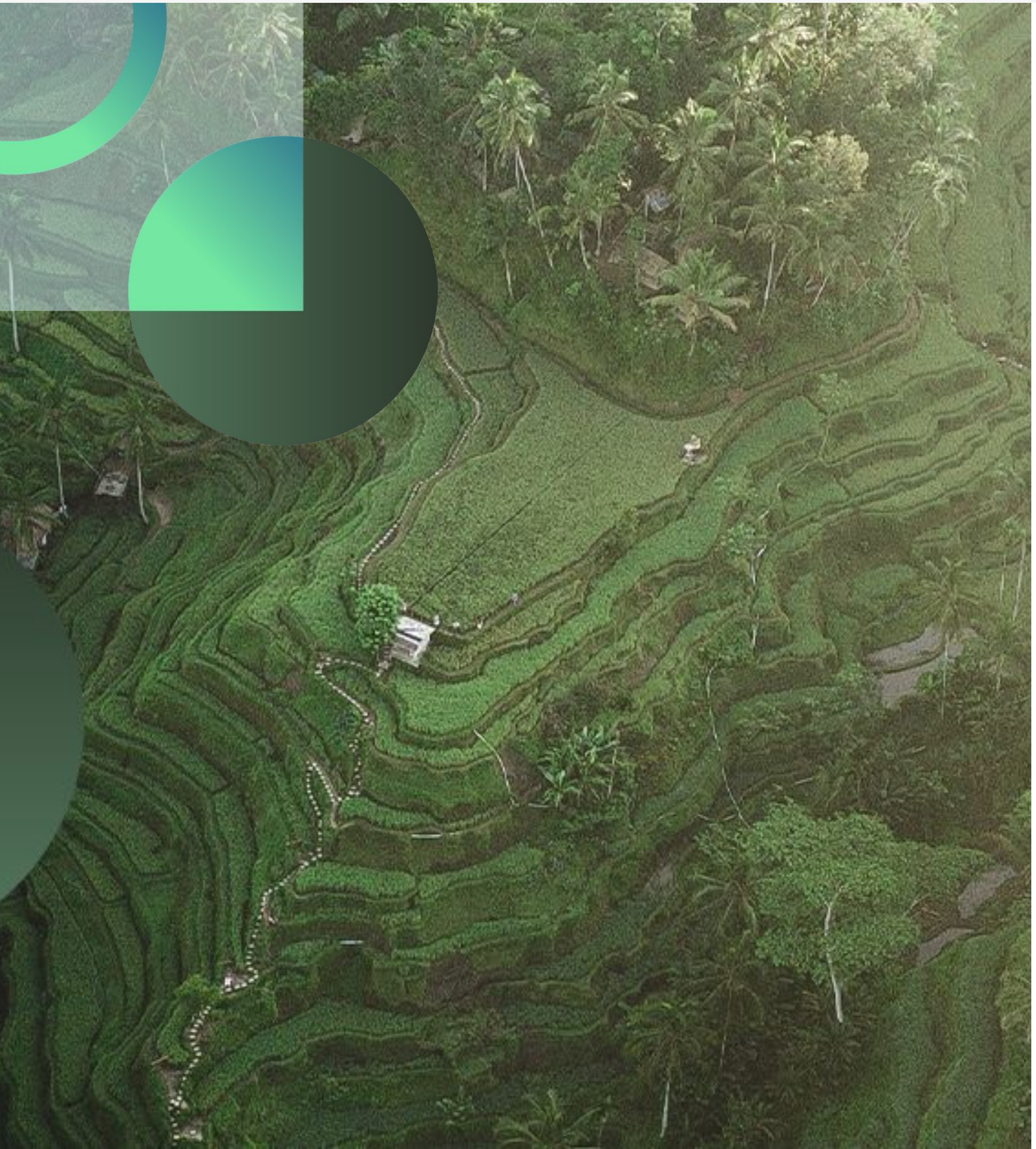
- Technical aspects
    - TACC[C]
    - 2006 [19] GL, tiers and approaches
- Policy and reporting needs
    - Mitigation and adaptation
- System design and operation
    - Processes and lifecycle

Core concepts



TACC [C]

- Transparency
  - Does not mean ‘simple’
- Accuracy:
  - in emissions and removals
- Consistency: time and space
- Completeness: pools, lands
- Comparability: Not in REDD+, but in NDCs



2019 IPCC GLs

- 2019 is an ‘elaboration’: core concepts not changed
- There are a lot of changes
  - Greater explanation
  - Updating of EFs
  - Use of remote sensing
  - Uncertainty analysis
  - ‘Interannual variability’

Tiers

- Tier 1 emissions factors:
  - Global defaults, in reality likely biased for a country
- Tier 2 emissions factors:
  - Country specific: should be unbiased and more accurate
- Tier 3 models or measurements
  - More advanced, accurate and flexible.

Tiers are based on the outputs <u>not</u> inputs

- i.e., just because you have an NFI does not make you Tier 3

Approaches

- Approach 1: total land areas for a period
  - No change information, just estimates for area
- Approach 2: detects net changes over two periods
  - Movements between land uses can be reported
- Approach 3: ‘spatially explicit’, gross changes
  - Also temporally explicit

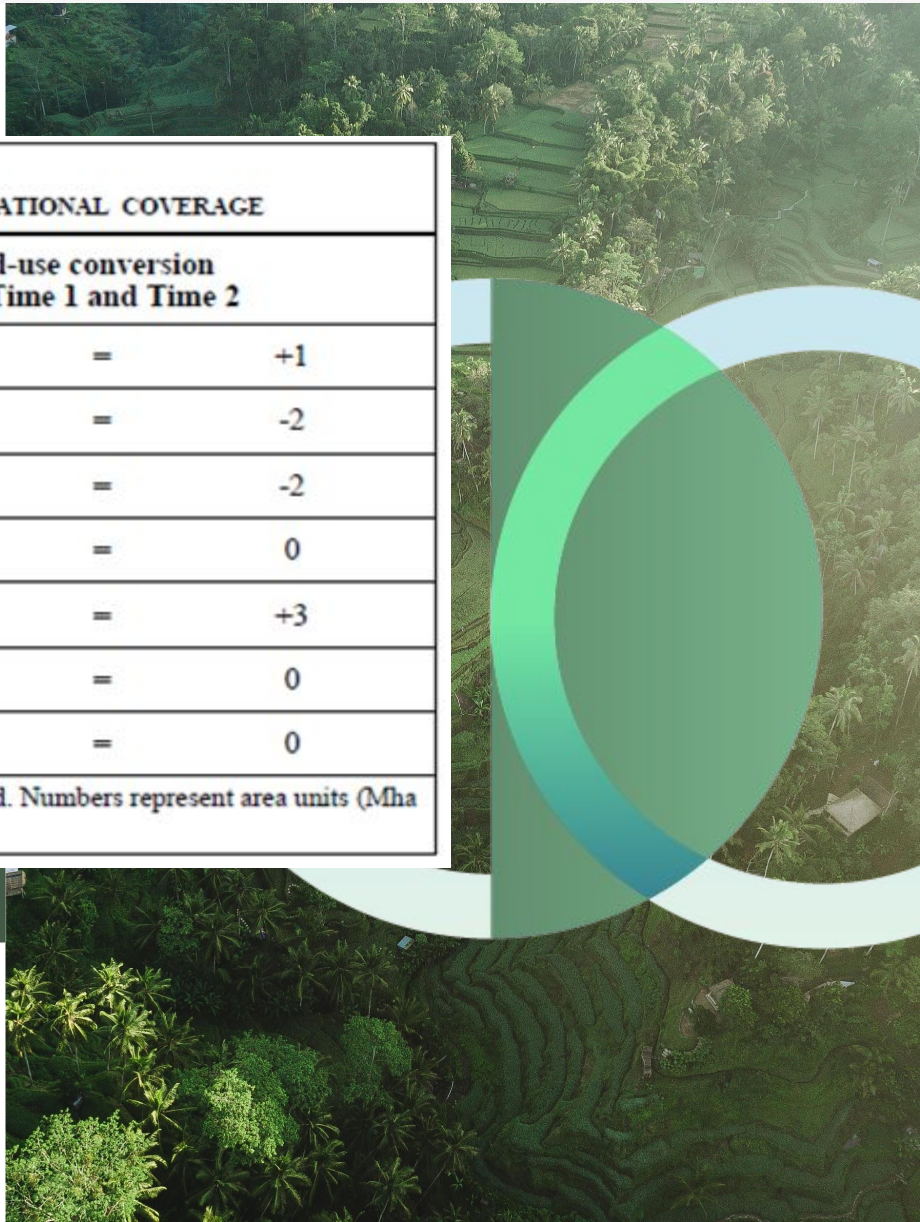
Approaches are based on the outputs <u>not</u> inputs

- i.e., just because you have a map/maps does not make you Approach 3

TABLE 3.2
EXAMPLE OF APPROACH 1: AVAILABLE LAND USE DATA WITH COMPLETE NATIONAL COVERAGE

Time 1			Time 2			Net land-use conversion between Time 1 and Time 2		
F	=	18	F	=	19	Forest Land	=	+1
G	=	84	G	=	82	Grassland	=	-2
C	=	31	C	=	29	Cropland	=	-2
W	=	0	W	=	0	Wetlands	=	0
S	=	5	S	=	8	Settlements	=	+3
O	=	2	O	=	2	Other Land	=	0
Sum	=	140	Sum	=	140	Sum	=	0

Note: F = Forest Land, G = Grassland, C = Cropland, W = Wetlands, S = Settlements, O = Other Land. Numbers represent area units (Mha in this example).



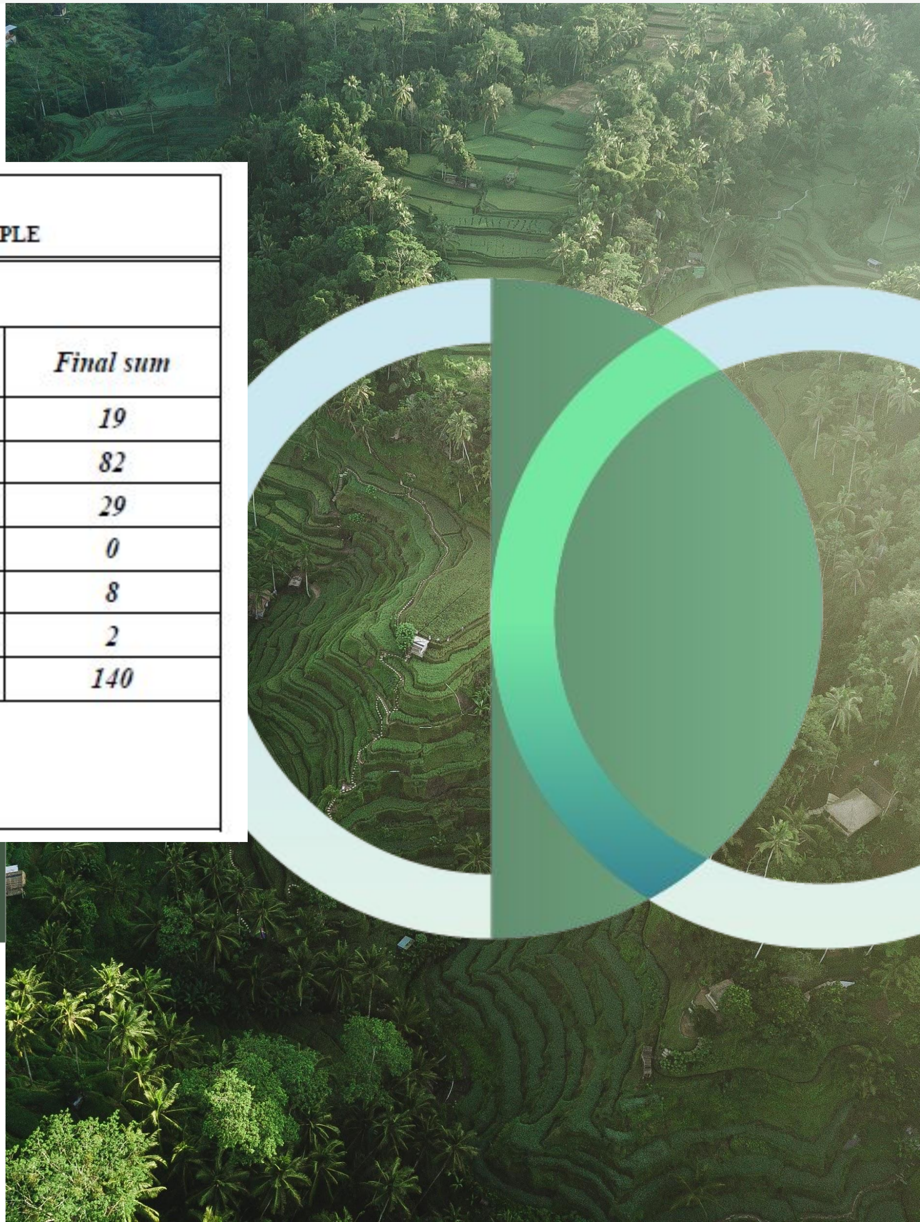
From 2019 IPCC Guidelines

TABLE 3.6
SIMPLIFIED LAND-USE CONVERSION MATRIX FOR APPROACH 2 EXAMPLE

Net land-use conversion matrix

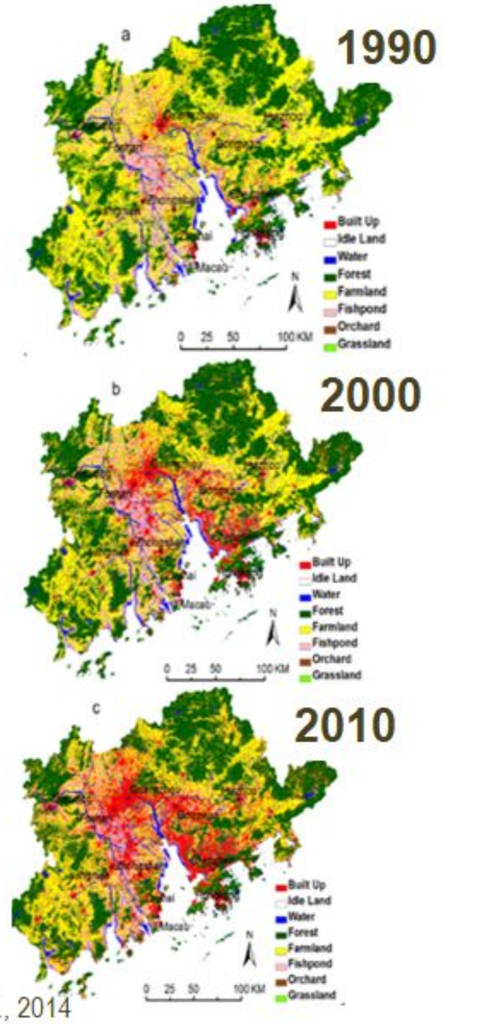
Final \ Initial	F	G	C	W	S	O	*Final sum*
F	15	3	1				*19*
G	2	80					*82*
C			29				*29*
W				0			*0*
S	1	1	1		5		*8*
O						2	*2*
Initial sum	*18*	*84*	*31*	*0*	*5*	*2*	*140*

Note:
F = Forest Land, G = Grassland, C = Cropland, W = Wetlands,
S = Settlements, O = Other Land
Numbers represent area units (Mha in this example).



From 2019 IPCC Guidelines

Approach 3

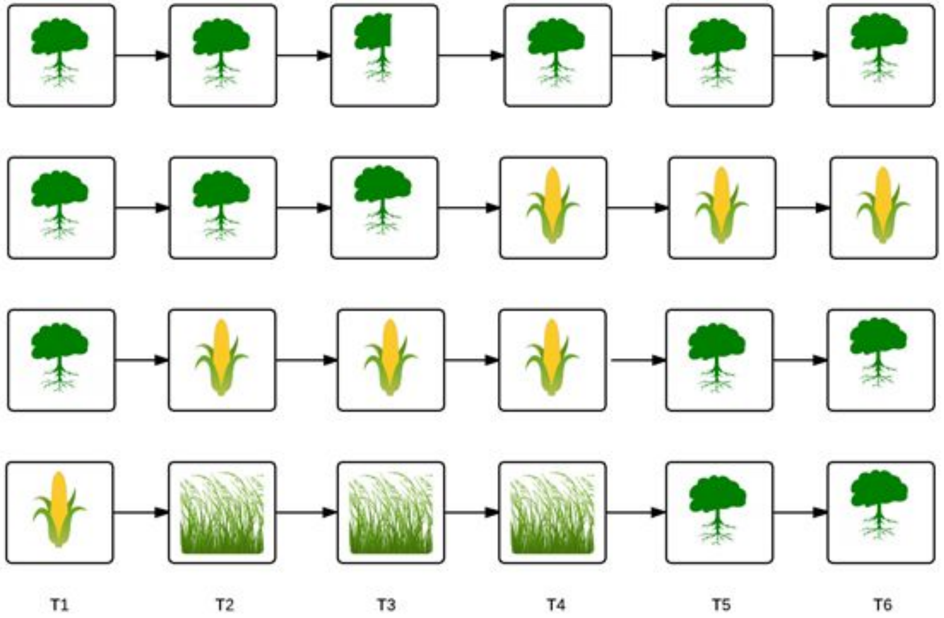


Du et al., 2014

Table 5. Land use conversion during 1990–2000.

1990	2000								Loss
	Built-Up	**Idle Land**	**Water**	**Forest**	**Farmland**	**Fishpond**	**Orchard**	**Grass**	**in 1990s**
Built-up	1,604.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Idle land	265.52	181.57	3.97	9.09	56.80	14.91	49.07	0.23	399.59
Water	54.74	25.42	[illegible]	24.97	[illegible]	26.09	12.61	1.91	226.63
Forest	76.04	46.95	[illegible]	[illegible]	[illegible]	6.60	1,110.26	69.68	**1,821.00**
Farmland	**1,474.72**	461.39	[illegible]	[illegible]	[illegible]	23.04	1,565.80	9.00	**4,708.69**
Fishpond	**324.97**	42.47	3.18	47.49	14.29	4,521.53	20.56	0.19	453.16
Orchard	37.55	25.56	1.08	270.43	339.20	1.85	533.96	9.31	684.99
Grass	0.77	0.78	0.62	194.54	14.97	0.13	44.62	217.56	256.43
Gain in 1990s	2,234.31	602.56	45.20	**1,688.45**	**1,014.08**	72.63	2,802.93	90.33	

Tier 2



The Approaches are not mutually exclusive, and a country can use a mix of Approaches for different regions of the country and/or land uses based on national circumstances.

Three broad methods:

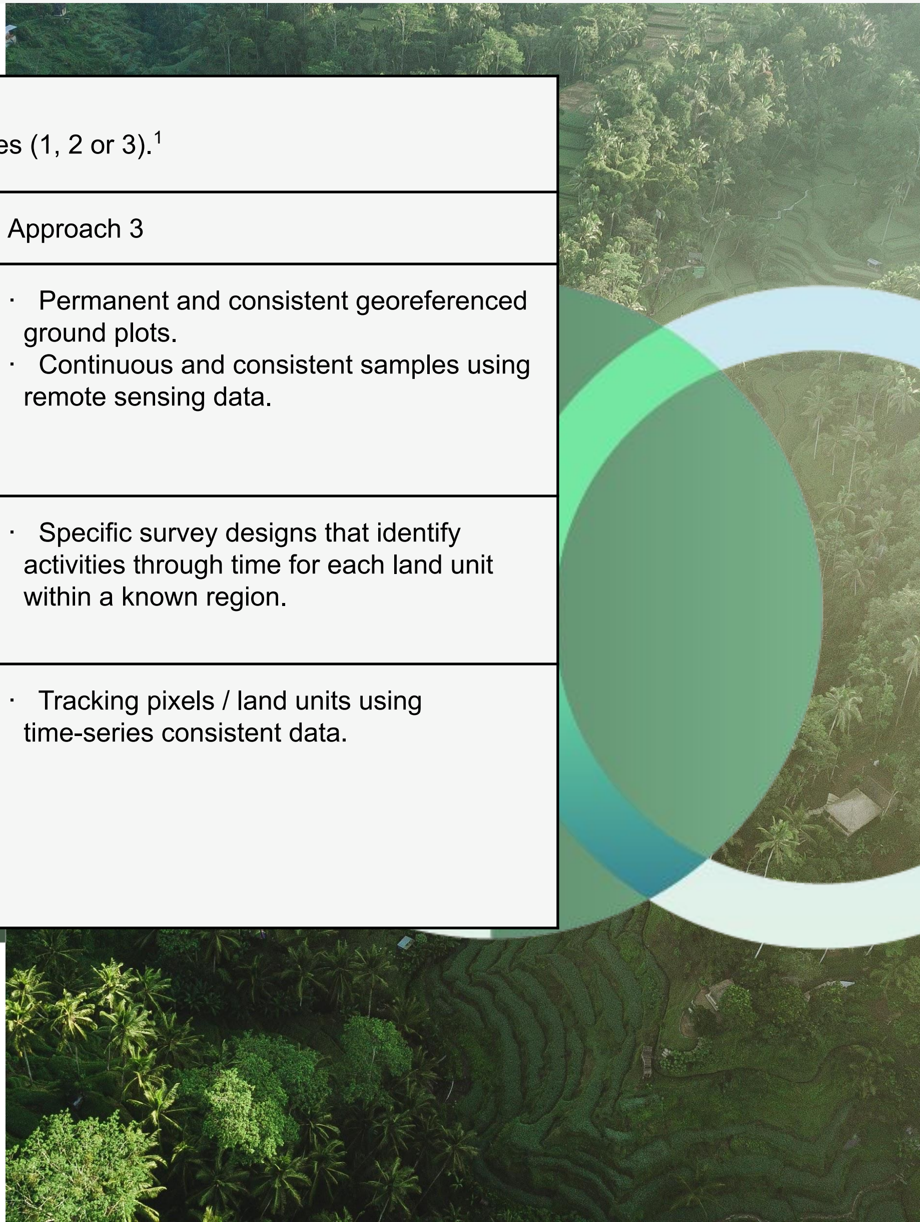
- Sample-based
- Survey-based
- Wall-to-wall methods

FLINT can run at all approaches and use a mix of spatial and aspatial activity and management data

This is the key strength of FLINT: the ability to ingest and run these data. Especially as they become more common.

Table 3.6 a (New)
Examples of different data inputs and methods to derive IPCC land-use classes and the resulting approaches (1, 2 or 3).[1]

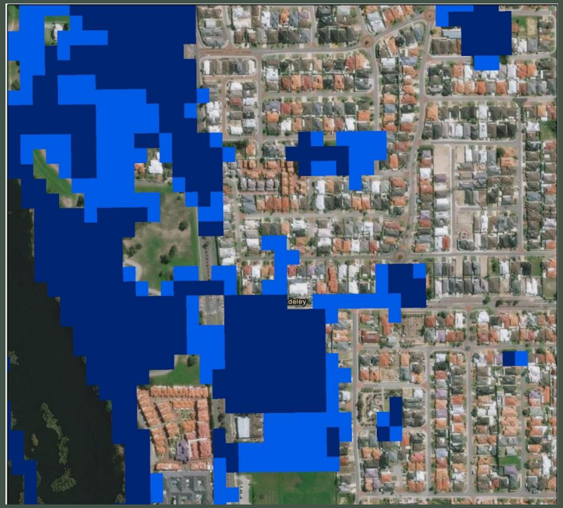
Method	Approach 1	Approach 2	Approach 3
Sample based methods	· Single sample · Temporary sample units	· Non-permanent sample units (e.g., temporary inventory between two points in time). · Samples collected from permanent units but changes only tracked across two consecutive sample periods.	· Permanent and consistent georeferenced ground plots. · Continuous and consistent samples using remote sensing data.
Survey-based methods	· Single census at one point in time. · Repeat census but without reference to previous censuses.	· General surveys between two periods. · National Census data that can refer a past period.	· Specific survey designs that identify activities through time for each land unit within a known region.
Wall-to-Wall methods	· Single map · Inconsistent maps developed at different times.	· Inconsistent maps through time combined with Approach 2-type samples (e.g. using maps as stratifications). · Maps developed using consistent methods changes tracked across two consecutive maps only not tracked through a time-series of maps.	· Tracking pixels / land units using time-series consistent data.

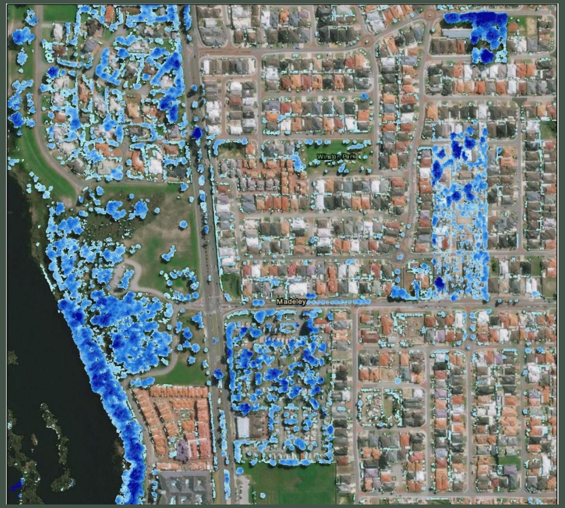


From 2019 IPCC Guidelines

To keep in mind

- Tiers and Approaches <u>as a result of decisions</u>
    - <u>not a decision in themselves</u>
- Design systems to meet multiple needs
    - Not just GHG reporting...
- IPCC GLs are the foundation, not the building
- There is a lot more than Tiers and Approaches
    - Think about how the system will operate





Example over Perth
*example mapping courtesy of CSIRO

System design and policy/reporting needs

We have a series of new challenges

Policy and reporting needs

- Paris Agreement (mitigation planning, reporting, NDCs, transparency)
- Analyses of land-sector contributions to net zero emission goals
- Analyses of natural-climate solutions
- Multiple standards and guidelines
- Support financial and market access (legislative and commitments)
- Cover all land uses, activities and metrics (carbon, biodiversity, water etc)
- Stand or project to national assessments
- Supply chain analysis
- Determine legacy effects and drivers
- Reporting, planning and scenarios

Operational needs

- Lifetime cost of operation
- Managed access to data and results
- Data archiving and management
- 24/7 access to results
- Auditing and reliable QA/QC
- Version control and updating
- System documentation
- Transparency

PCAF Partnership for Carbon Accounting Financials

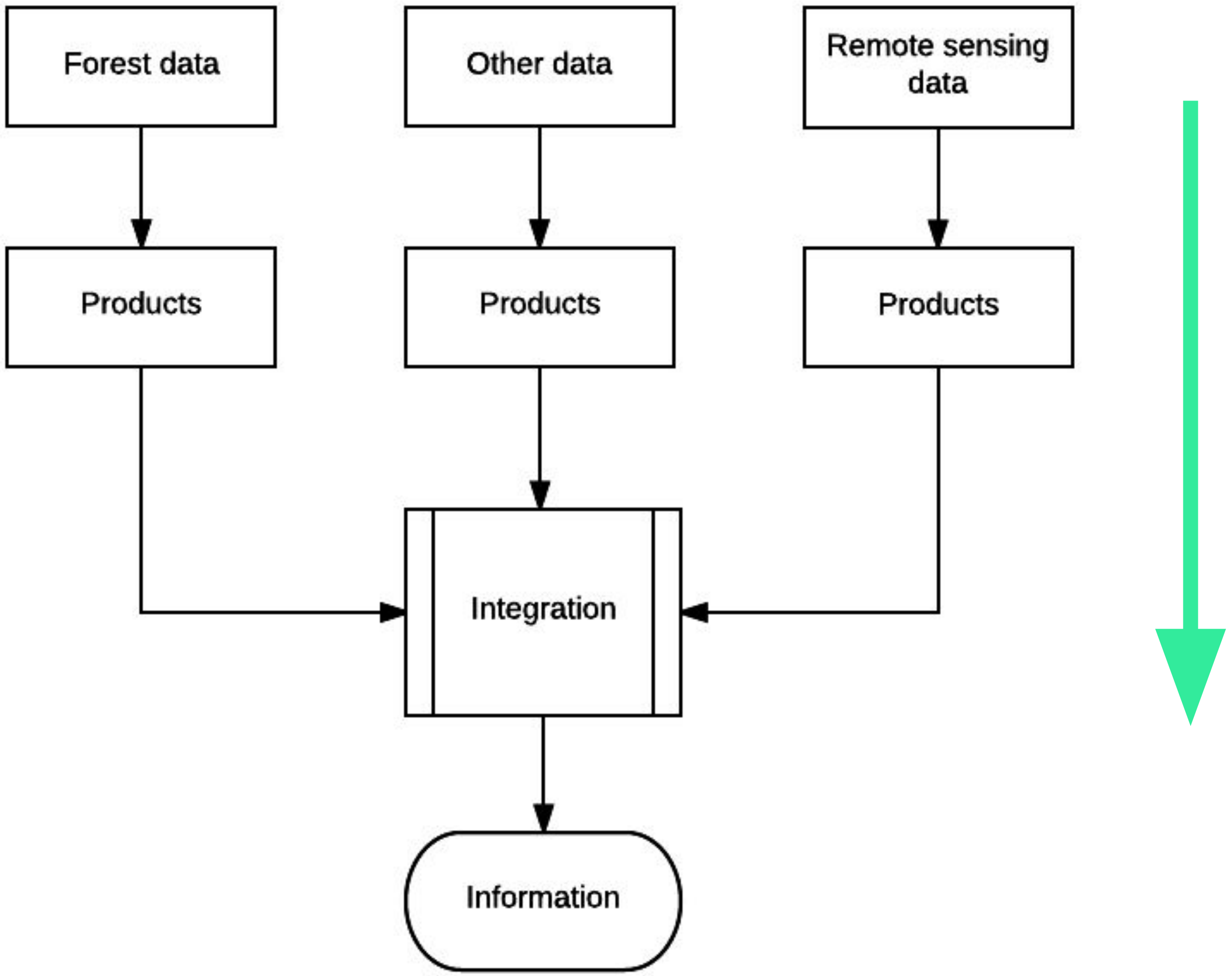
TCFD TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

CDP DISCLOSURE INSIGHT ACTION

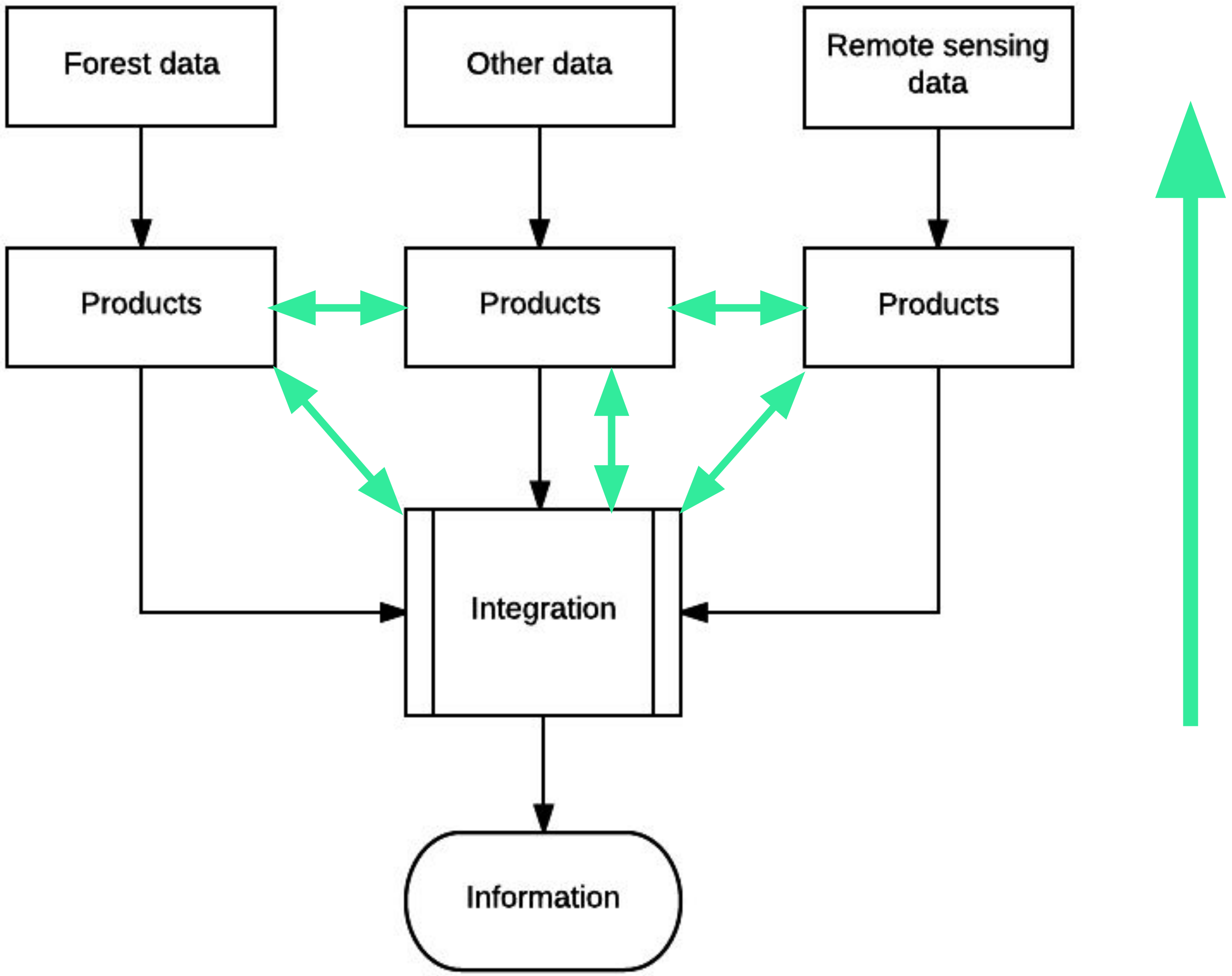
SCIENCE BASED TARGETS DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

SUSTAINABLE DEVELOPMENT GOALS

These are driving the need from tools to systems

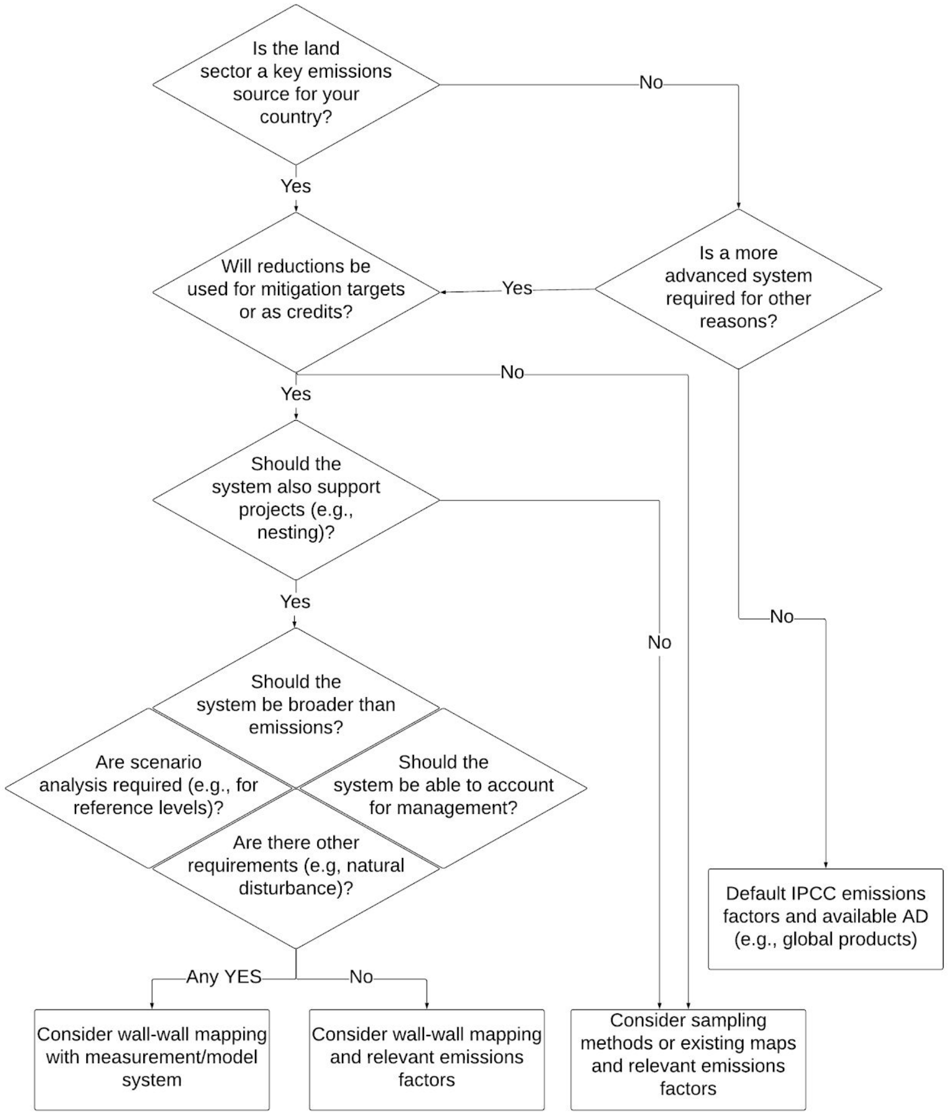


Data are used to create products, which are combined to produce information



Start with information needs, work back

Understand the process and other products



Questions that inform solutions

- What information has to be reported?
- What land uses need to be reported?
- What activities need to be reported?
- At what frequency do the results have to be reported?
- When do the observations start?
- Are scenarios or projections needed?
- What subnational reporting is needed?
- What will the results of the reports be used for?

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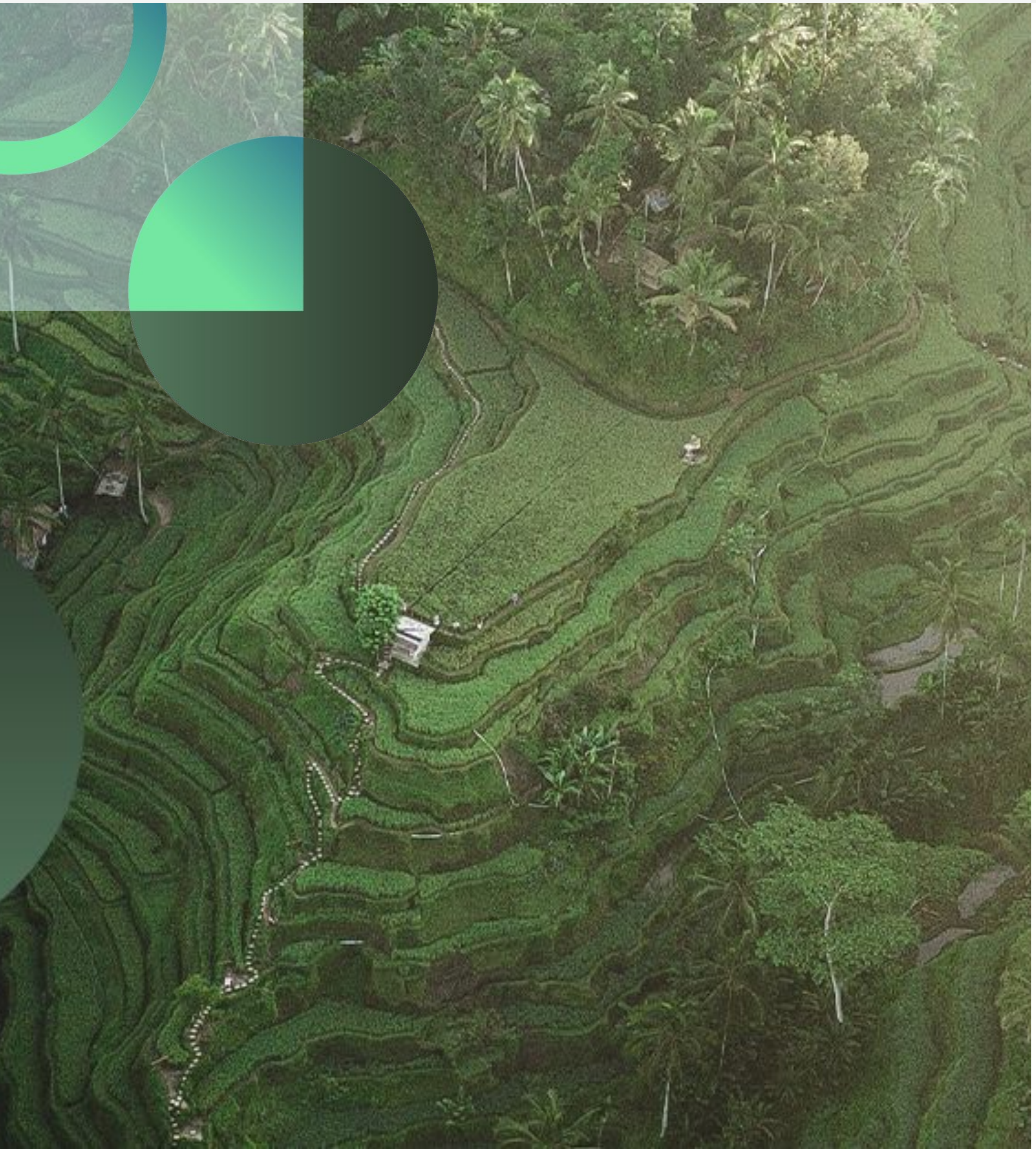
What makes a system operational?

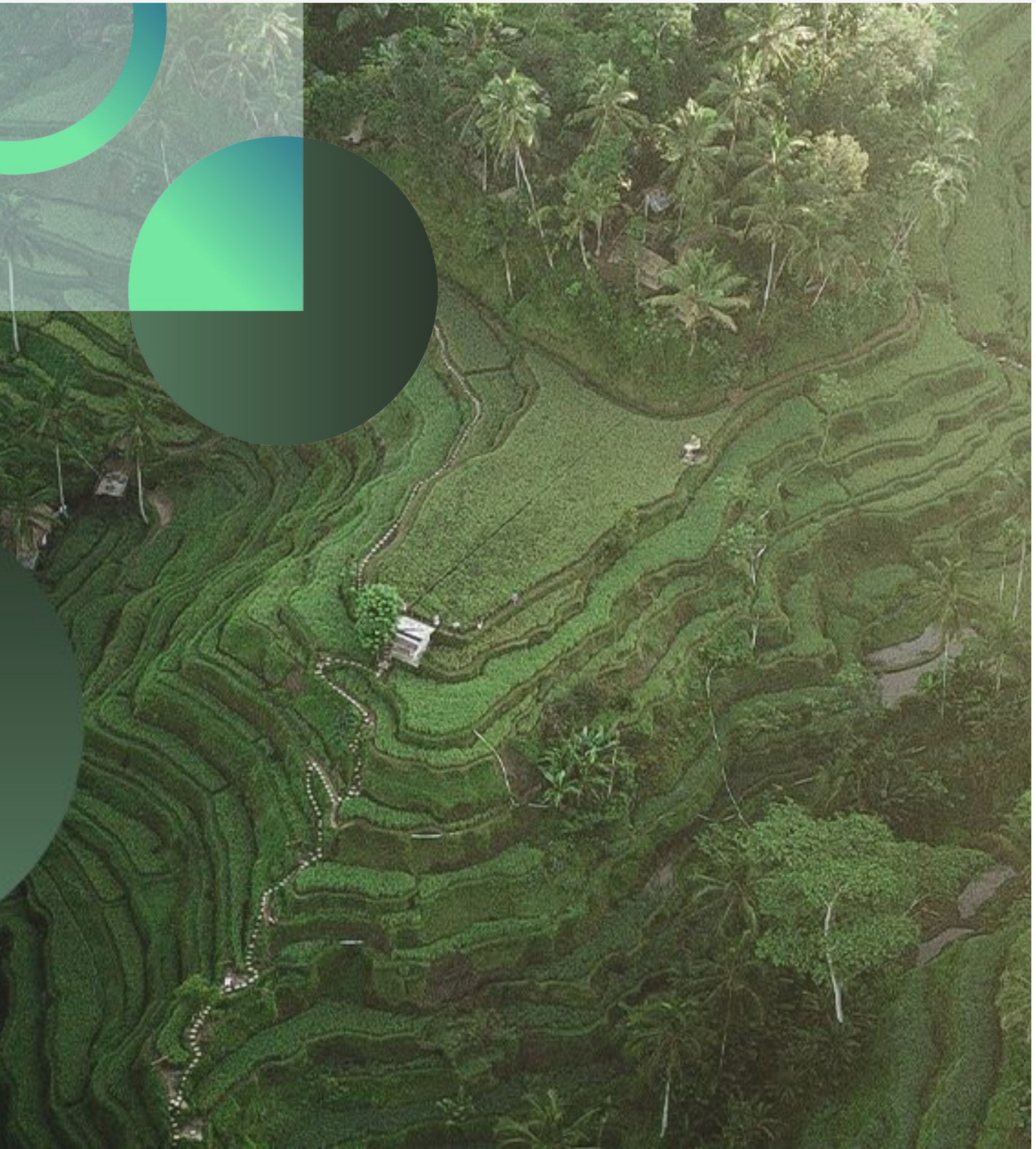


Define operational...

'Provides necessary information to those that need it, when it is needed and to the standard that's needed.'

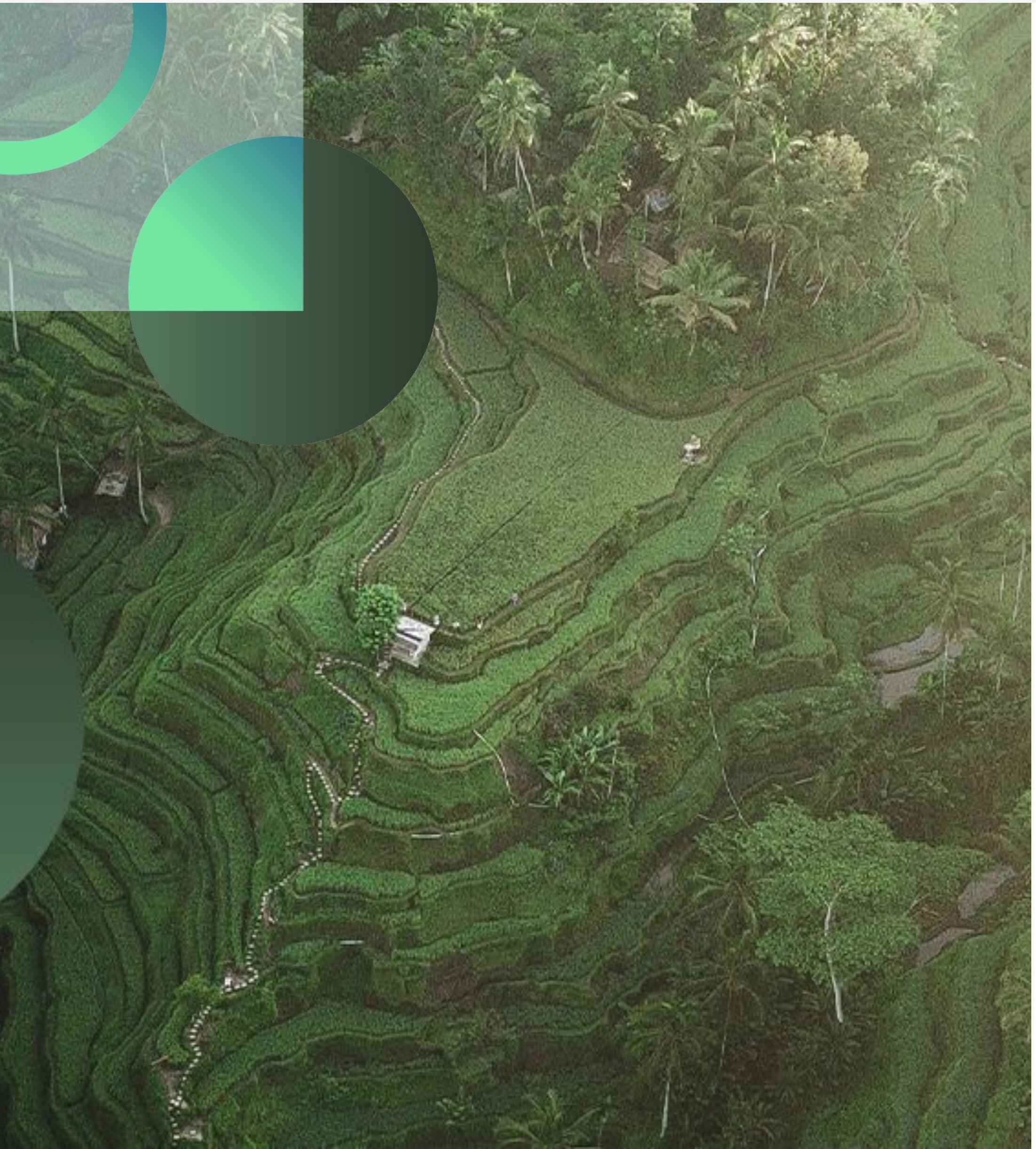
Information: UNFCCC reporting etc

- Who needs it: Government, land holders, private sector
- When they need it: annual reports, ad hoc, on demand
- Standards needed: IPCC, markets, government requirements



What is needed to be 'operational'?

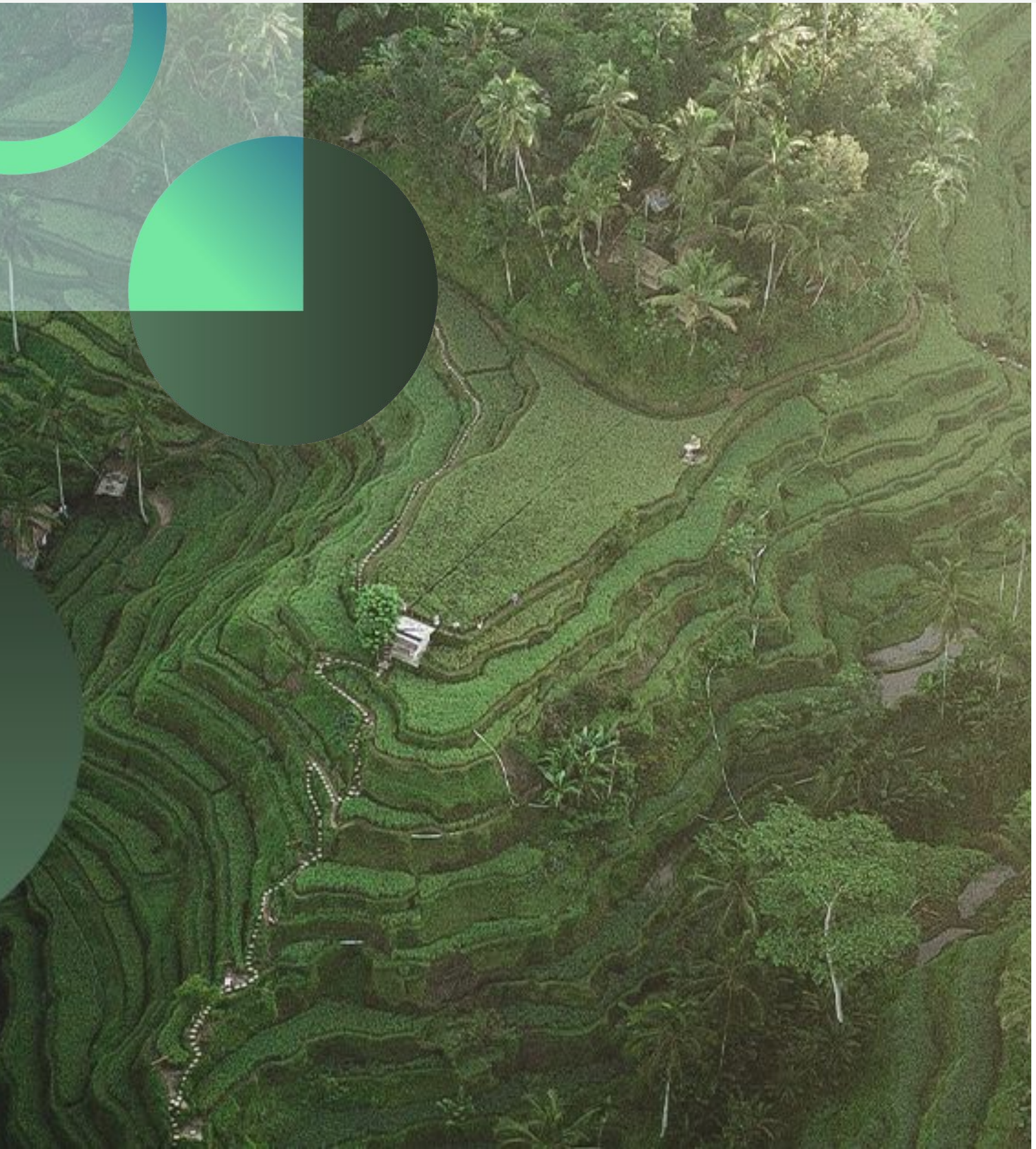
- Meet all IPCC/UNFCCC reporting requirements
  - Annual Reporting of National GHG Inventory
  - BUR, REDD+
- FCPF, ISFL BioCF
  - Meet all IPCC guidance for inventories
    - Transparent
    - Documented
    - Consistent over time,
    - Complete (i.e. pools, gases and lands)
    - Comparable
    - Assessed for uncertainty
    - Subject to Quality Assurance and Quality Control (QA/QC)



What is needed to be ‘operational’?

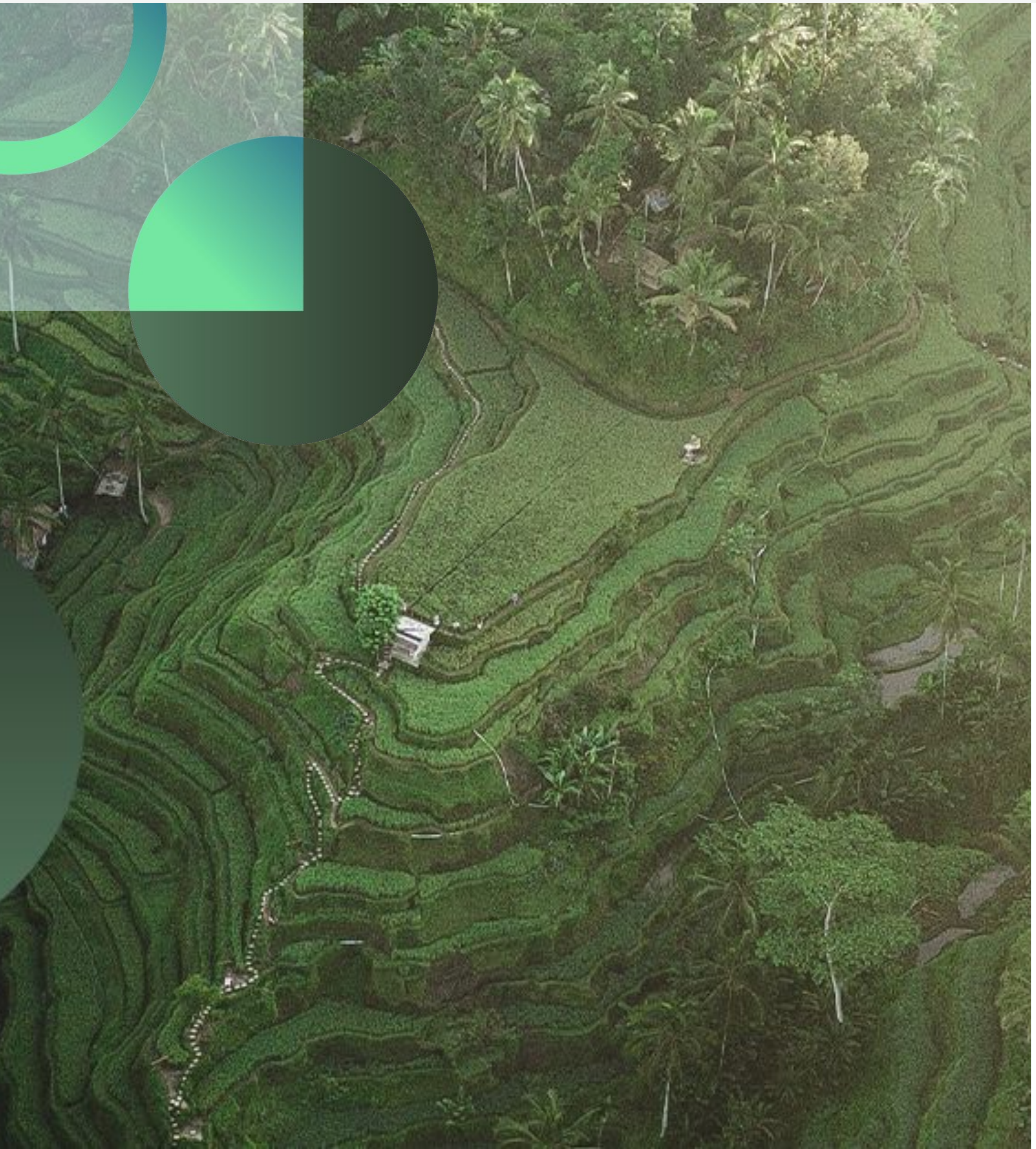
- Meet all policy requirements, e.g. support not only for reporting but also analyses of policy options such as REDD+ strategies, mitigation and adaptation options.
- Governance and institutional arrangements
  - Needs to be sustainable and consistent
  - Requires domestic institutional capacity
- By addressing needs beyond GHG estimation and reporting, likely to be more sustainable.

Moving from science to operation is the challenge!



Cyclical system perspective

- In the rush to meet policy and reporting tasks MRV has been viewed as a series of deliverables
  - NDC, FREL/FRL, NGGI
- Limits the development of operational systems
- Compromises capacity



It's all about the people!

A technical program is still a program

A team is required to deliver this: not just technical experts.

The team should include:

- Program manager
- Administrative officer
- IT experts
- Data managers/data analysts
- Policy-technical experts
- MRV experts...

http://mulliongroup.com.au/a-technical-program-is-still-a-program-the-forgotten-role-of-program-management-in-mrv/

Developing an operational MRV

An operational MRV system has three main components

- POLICY: **Sets** the needs, timing, responsibilities
- GOVERNANCE: **Manages** the process and system, provides adequate, sustained resources
- TECHNICAL: **Produces** the required outputs

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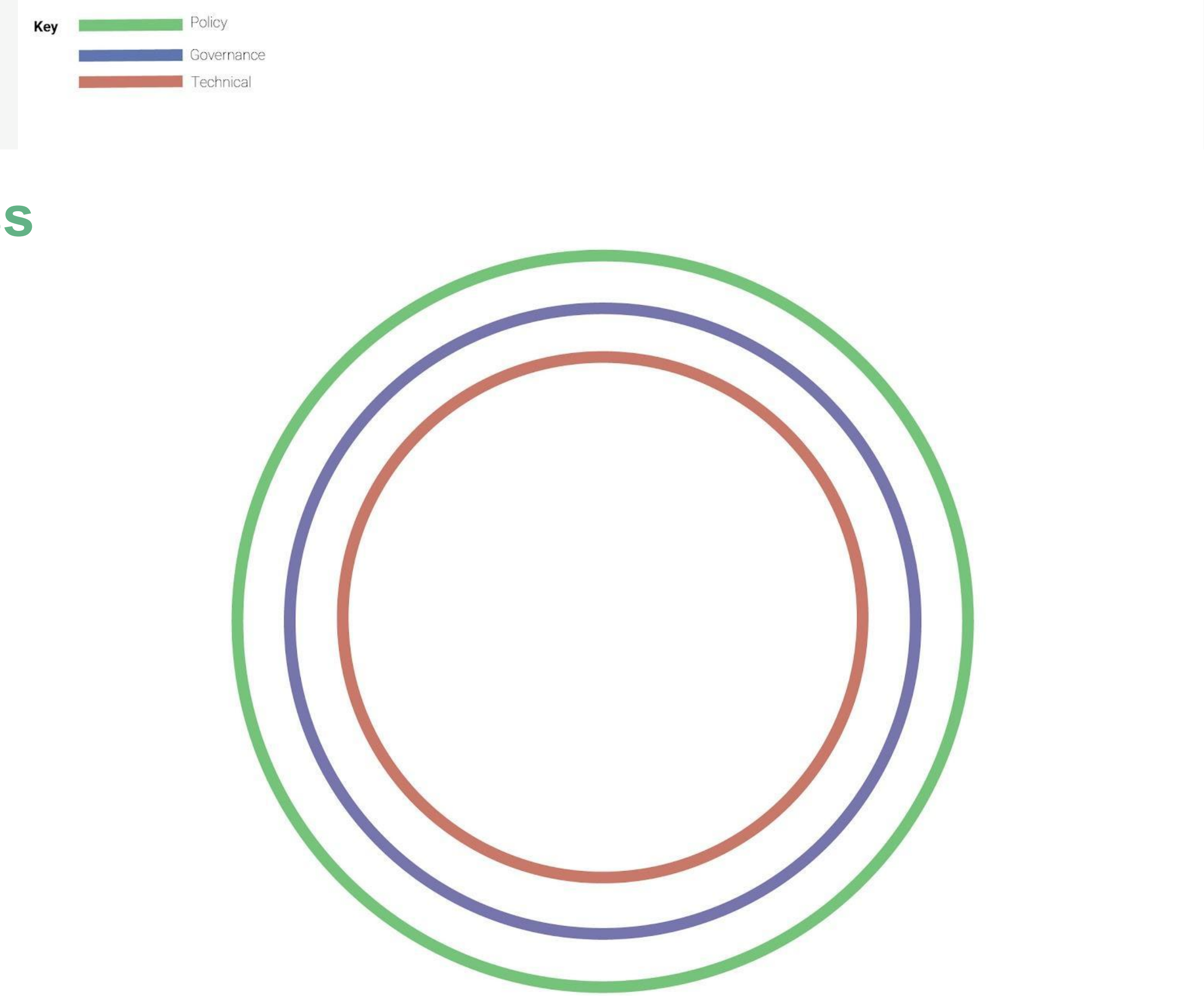
Continuous improvement process

- MRV systems development must be considered as cyclical
- Look beyond the near-term outputs, with a focus on the longer term processes and requirements



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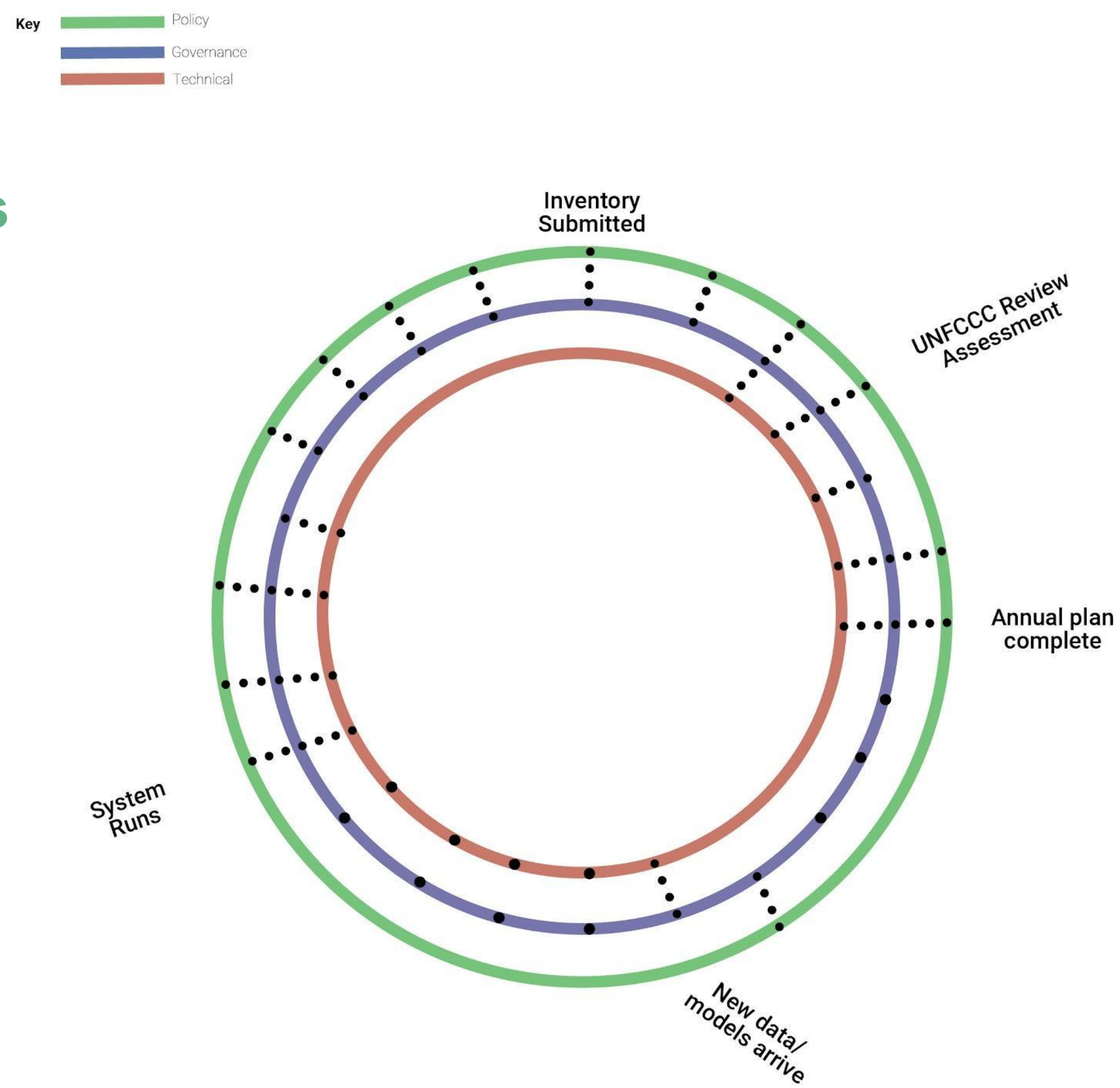
Continuous improvement process

- There are five ‘Key Milestones’ for an operational MRV system
  - Complete the annual Plan
  - Compile new data
  - Calculate the emissions and removals (Run)
  - Submit the Inventory Report
  - Complete the independent UNFCCC assessment
- Repeat!



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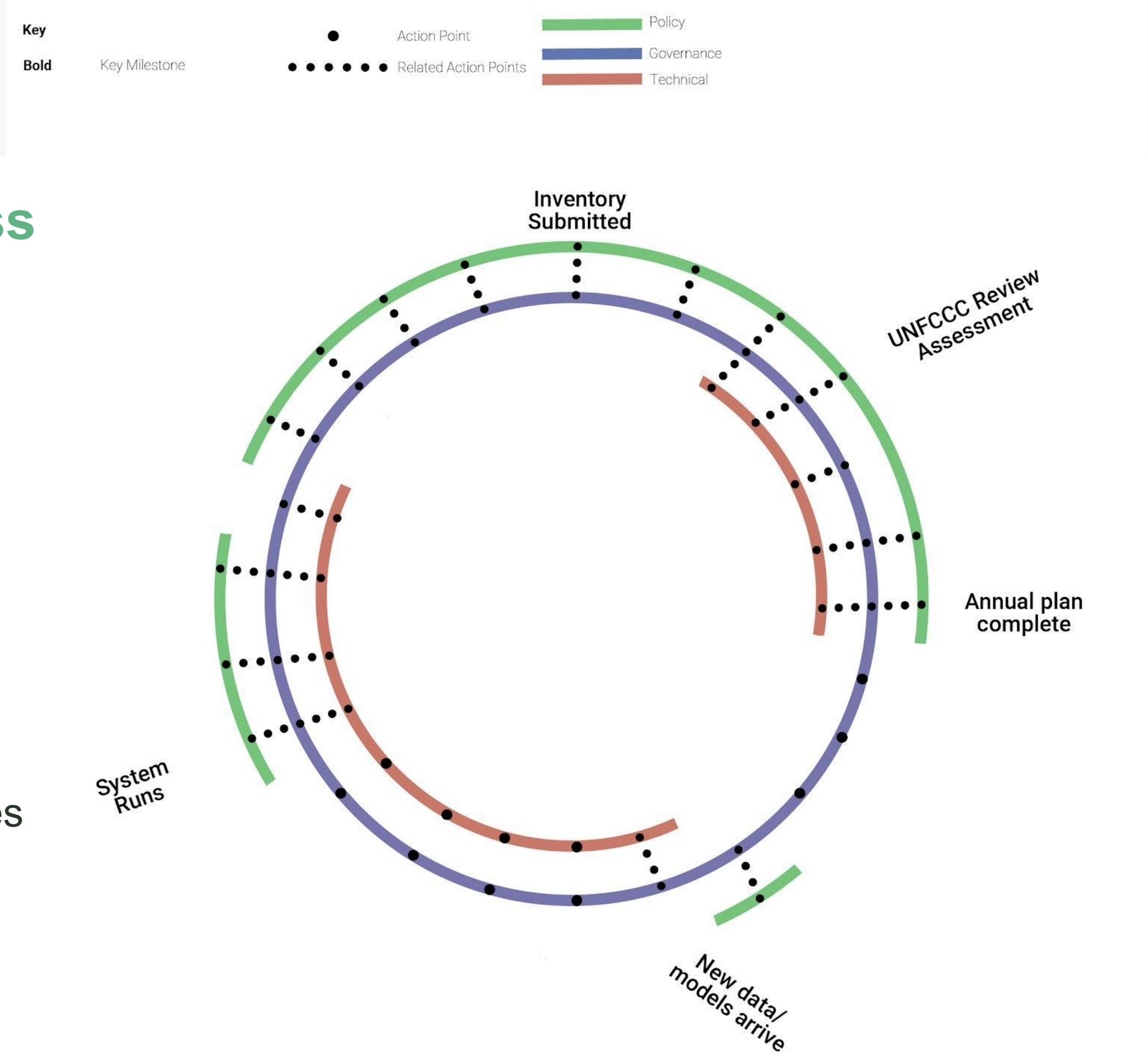
Continuous improvement process

- MRV Systems require Policy, Governance and Technical input throughout the cycle
  - Governance is fundamental for the whole process
- Good Governance includes:
  - Clear objectives
  - Documented roles & responsibilities
  - Clear pathways of engaging between parties



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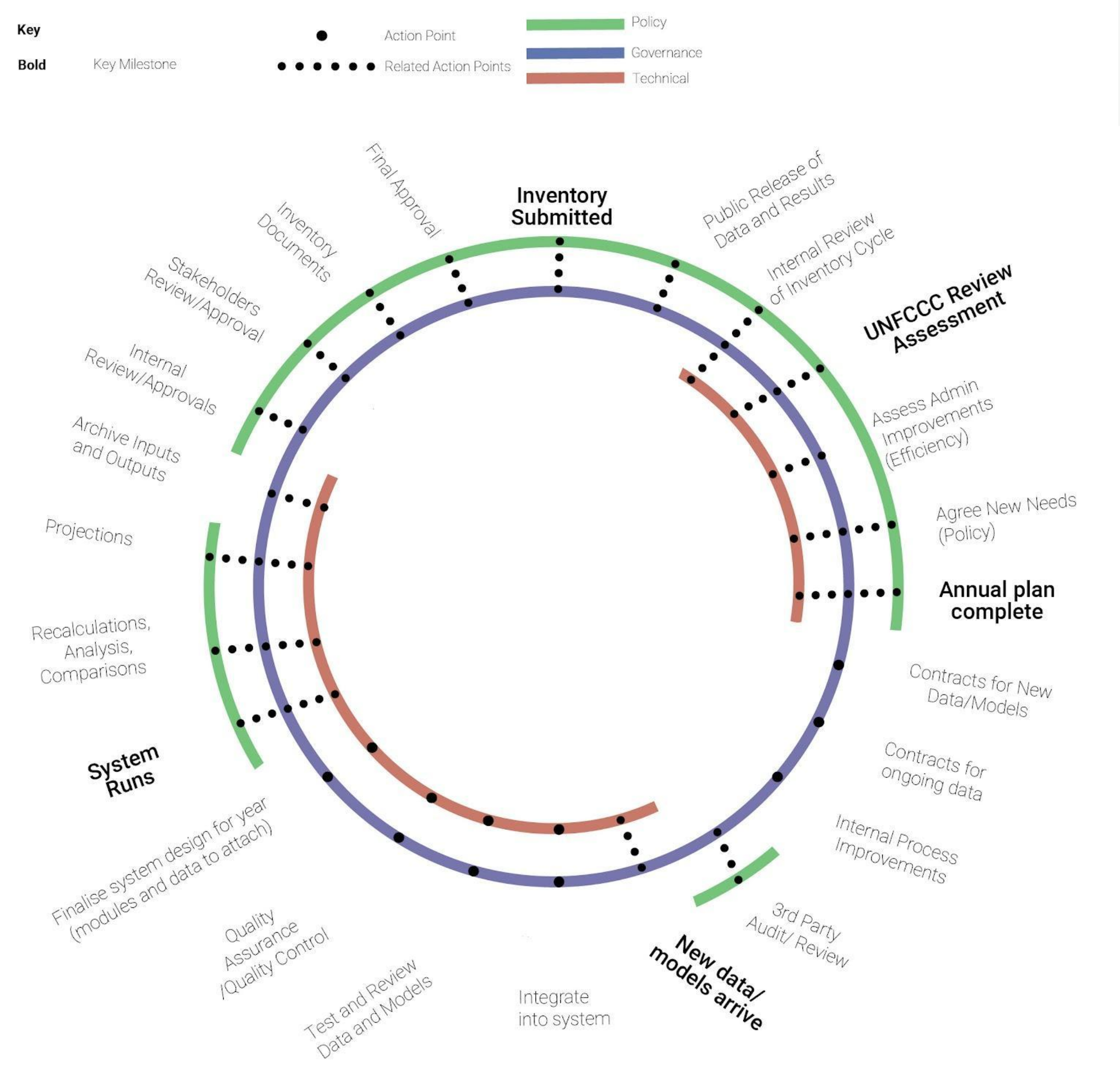
Continuous improvement process

In achieving each of these Key Milestones multiple decisions are made, needing Policy, Governance, and Technical input



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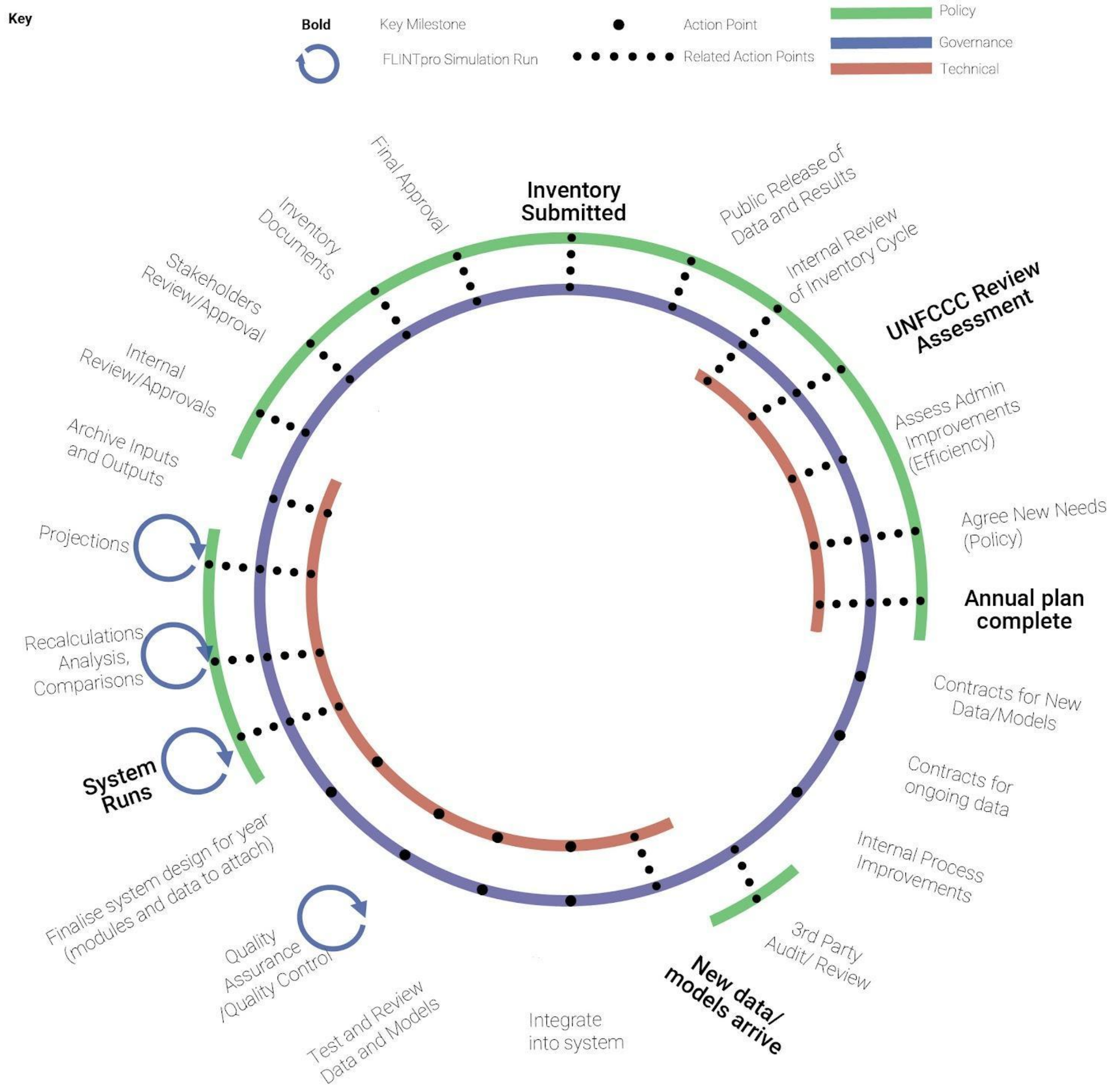
Continuous improvement process

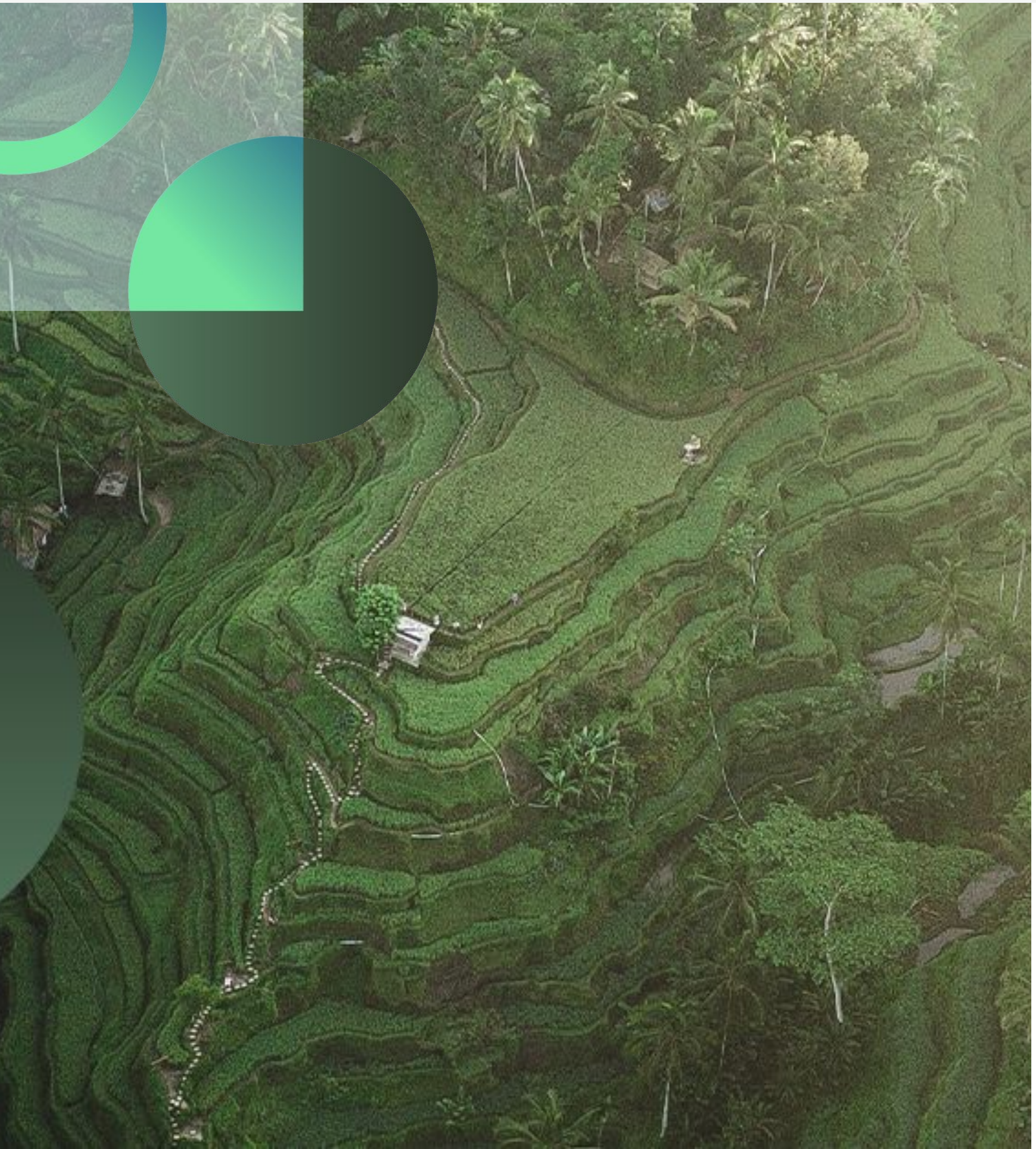
An operational MRV system must be able to:

- Test new data
- Complete QA/QC
- Provide reliable results
- Assess uncertainty and support continuous improvement
- Have capacity to quickly assess change
- Be run every year, and likely much more frequently in the future



Eat, Sleep, Run, Repeat...

- Take a breath, relax
- With a systematic approach, you now have a baseline for improvement
- Like running another marathon, the next cycle may not be easier, but you have a base to build on and will run faster and better!

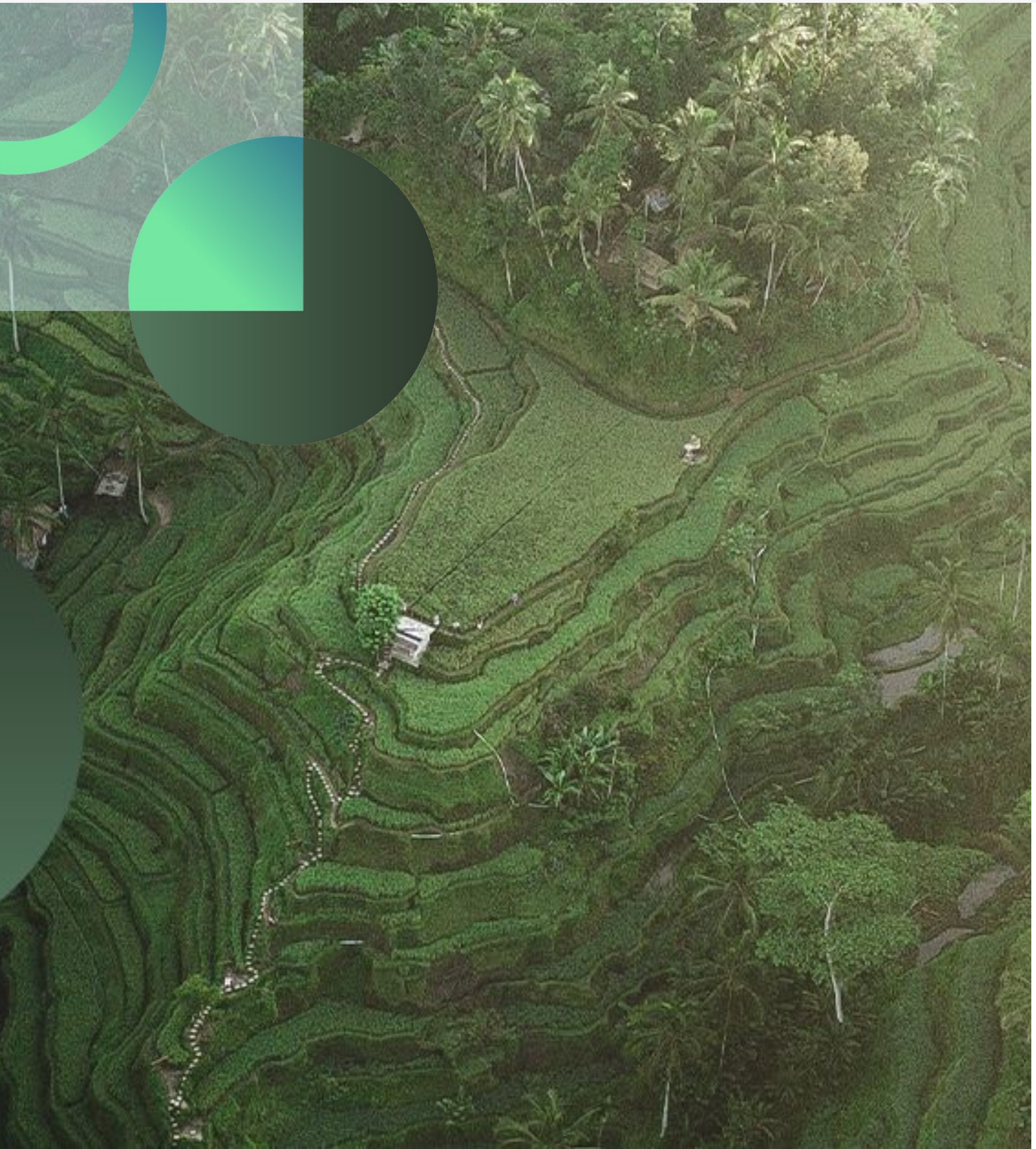


You don't have to do it all yourself...

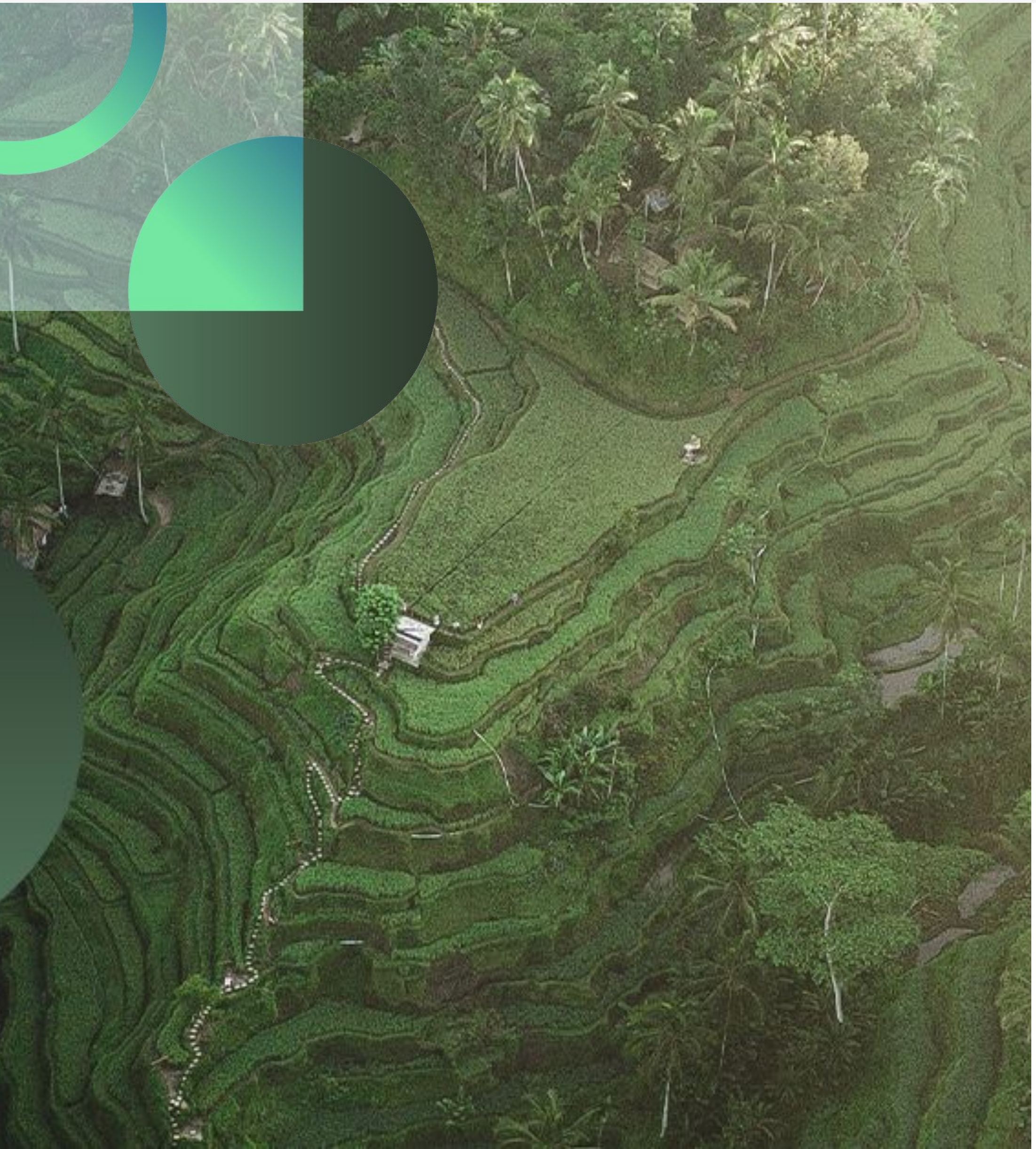
Use the resources available in the best way

- Use the private sector, researcher, other agencies
    - Australia's NCAS was 6 people, but hundred of contracts
    - Huge cost reductions, faster, better...
- Don't use scientists to do repetitive work
    - 'Find the best, train the rest'
- Build relationships
    - these will be long-term relationships: and it is nice!
- Fit all of these resources into the system design
    - and use them
- Externals can help improve processes

The role of moja.global is to provide software, tools and know-how to facilitate the building of MRV systems by providing open-source, reusable and configurable tools that can be assembled to meet national MRV needs.



QUESTIONS AND THOUGHTS



DAY 2

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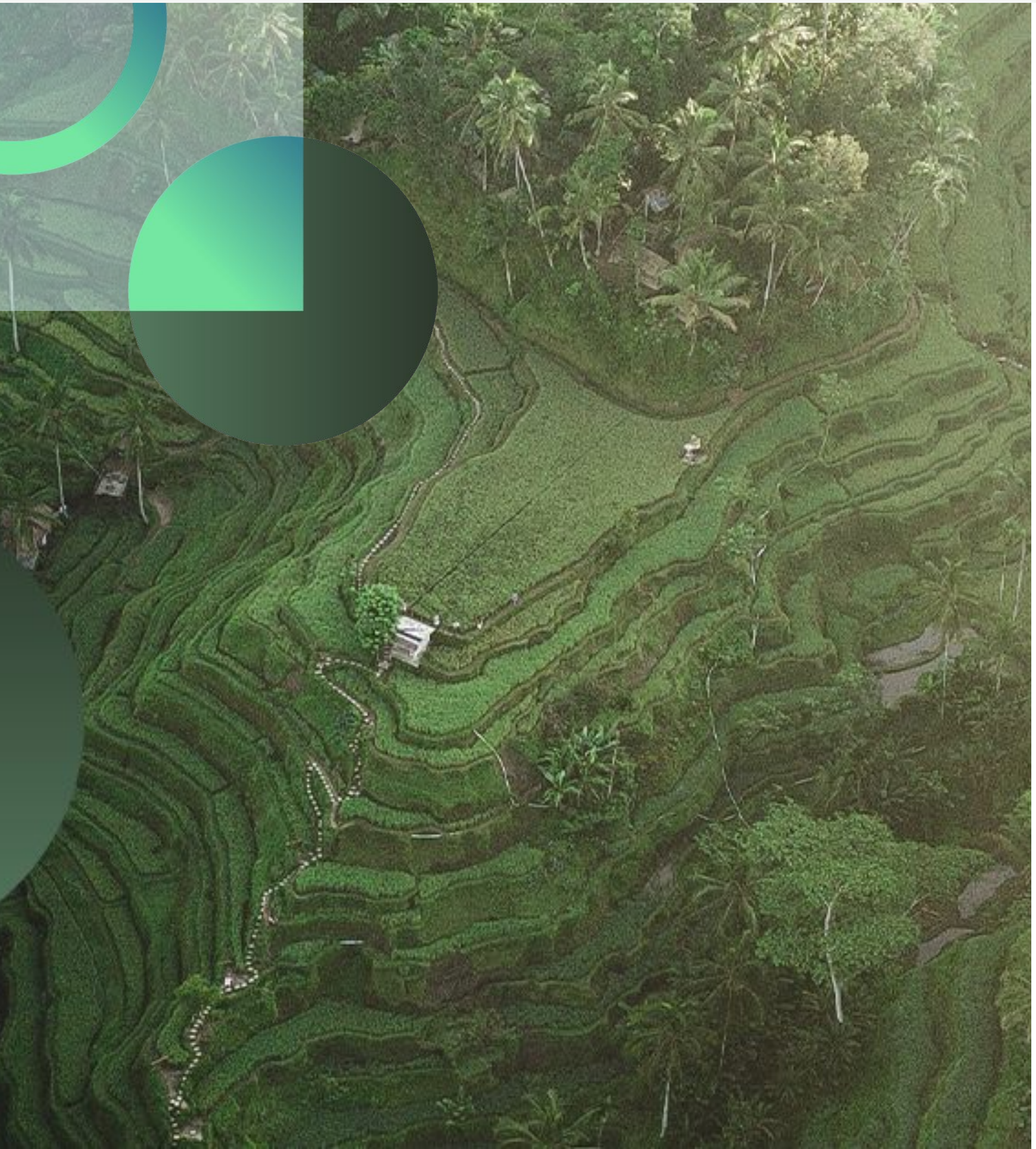
Background to the FLINT and moja global

31 August 2021; 08:30 - 10:30



This session will cover the background to the development of the FLINT software and the moja global organization.

This will give participants a clear understanding of how and why the FLINT was developed and why the modular open-source structure was chosen and is supported by moja global.

- Description of first-generation integration tools, and why a new system was needed
- The core design principles for the FLINT
- Decision process for creating moja global under the Linux Foundation to manage the open source components of FLINT

What is the difference between moja.global and FLINT?

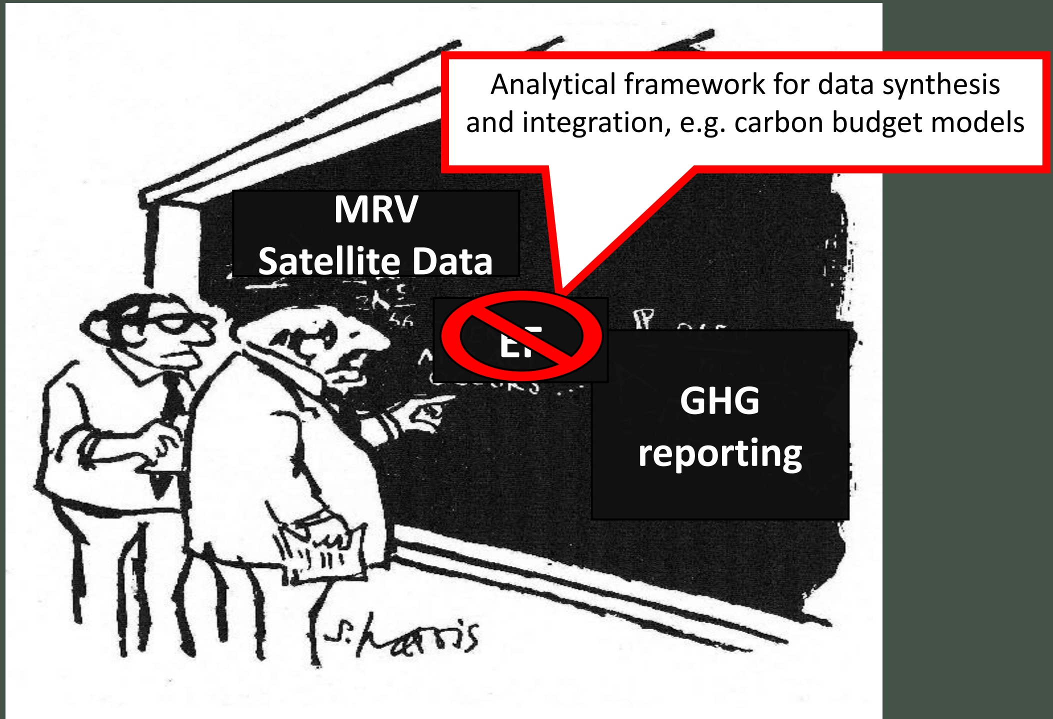
Moja global: An open source project tasked with managing software tools and related documentation for land sector GHG emissions estimation

FLINT (Full Lands Integration Tool): Core software package managed under the moja global project.

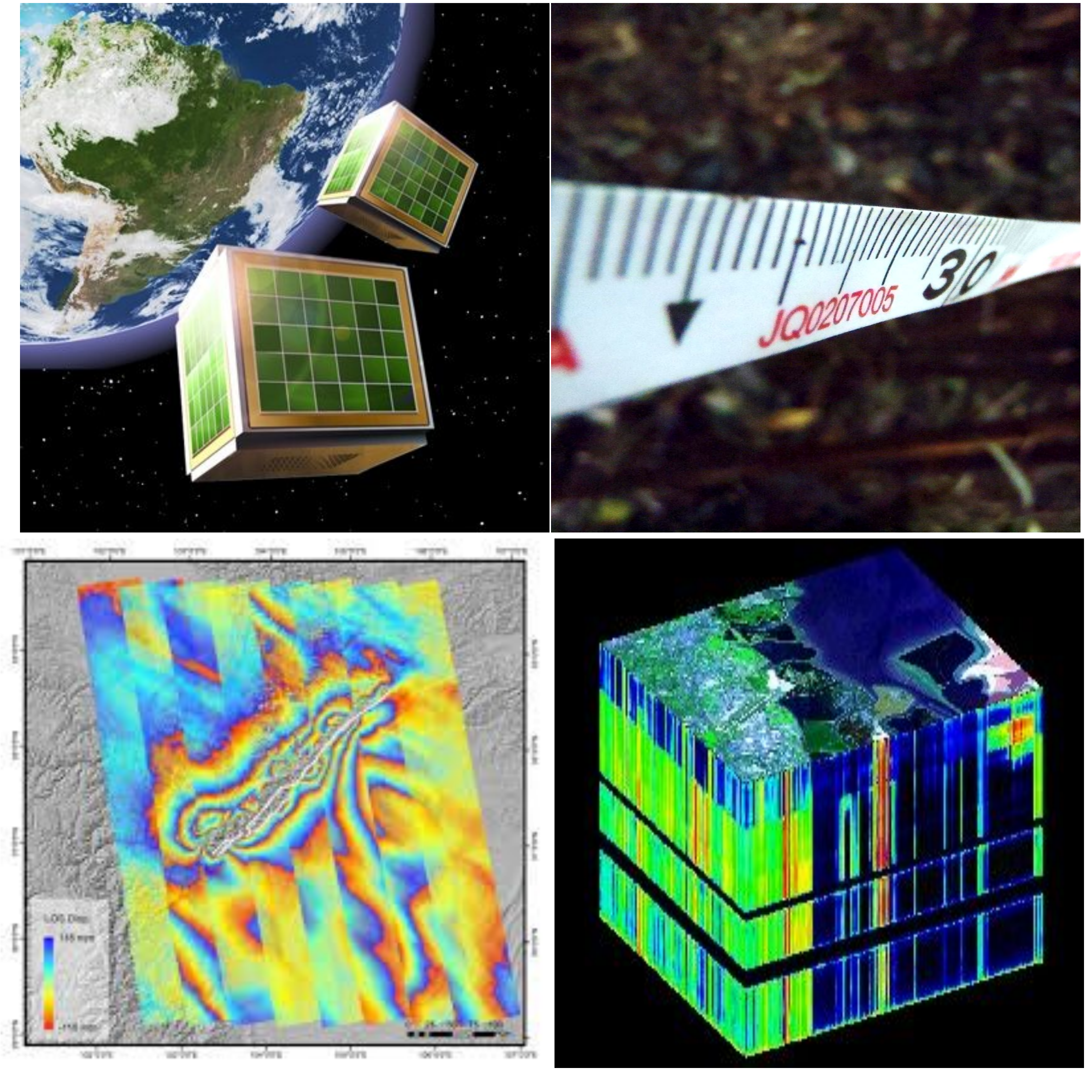
The problem:

Ground measurements and remote sensing products are developed to aid GHG emissions and removals reporting and REDD+

but …



"I think you should be more specific here in step 2"



What is integration?

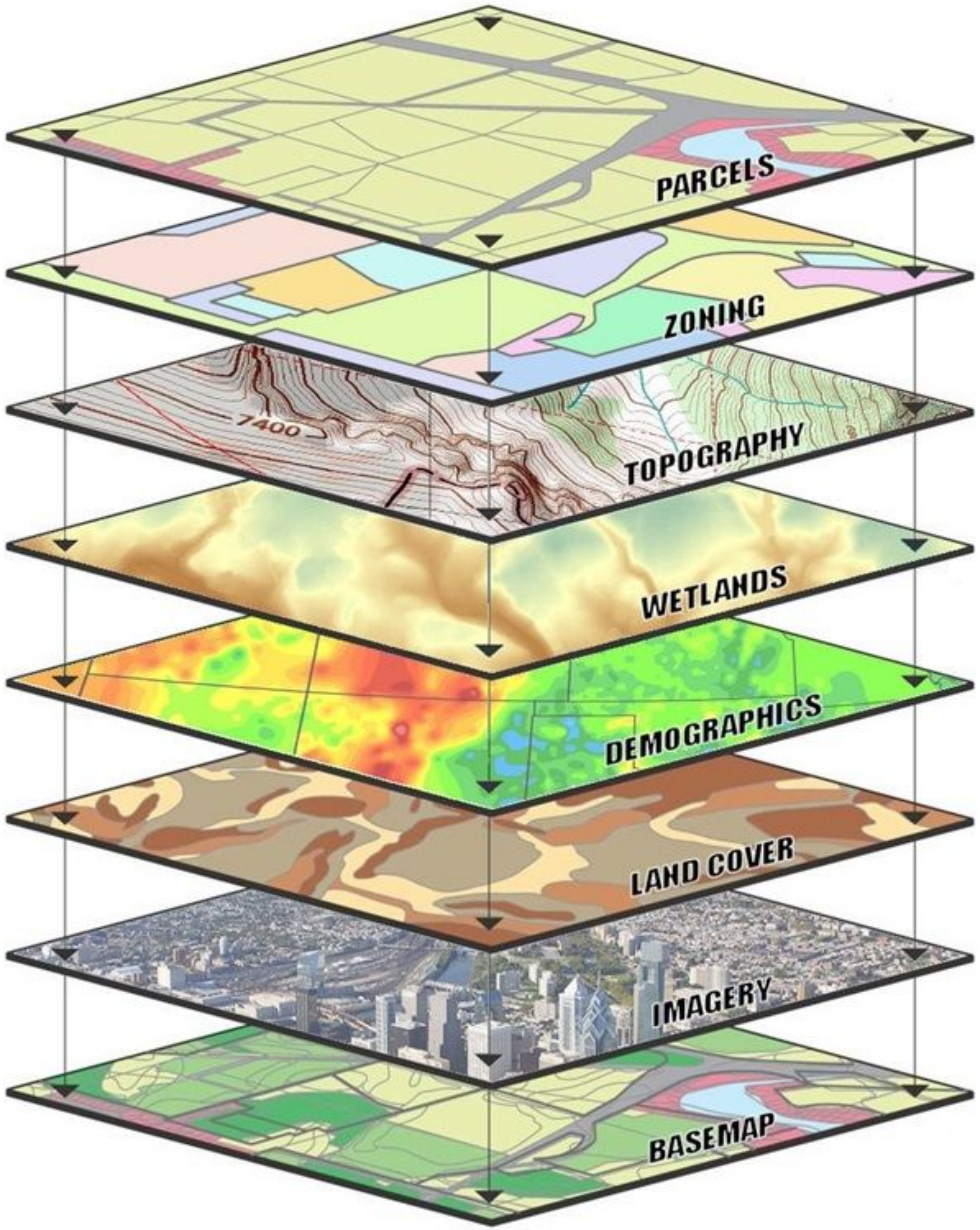
The systematic combination of multiple data types, methods and processes, without degrading data

In MRV this involves a software platform for bringing together remote sensing, models, spatial and ground data

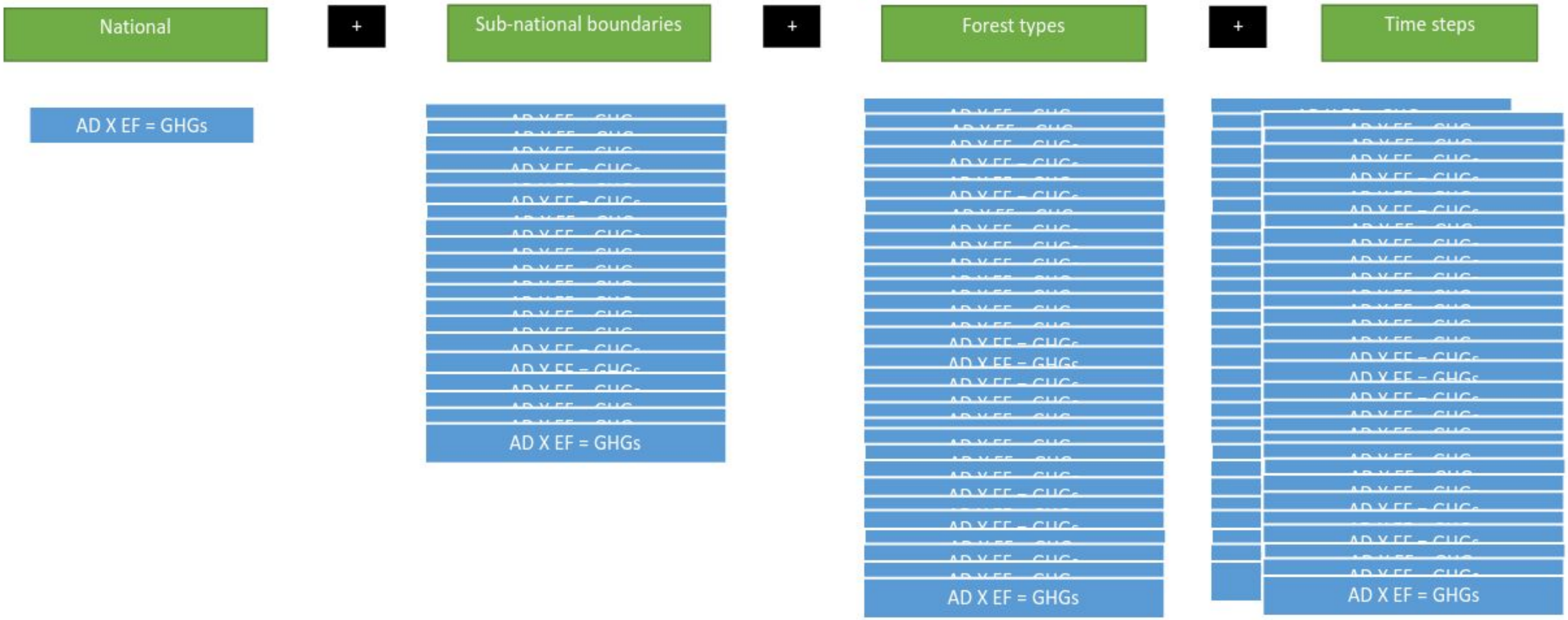
Through integration we increase the value of each individual component to generate policy-relevant information

The FLINT concept

- Carbon stock and fluxes are driven by spatial and temporal variation.
  - Different variables affect the carbon stock and fluxes (soil, climate etc.)
  - These variables also change across the landscape
- Reflecting this can be complex
  - Reflecting this in tabular data is very complex and can't reflect all the variation
- Through moving to a spatial modelling system, this complexity can be reduced on the users end



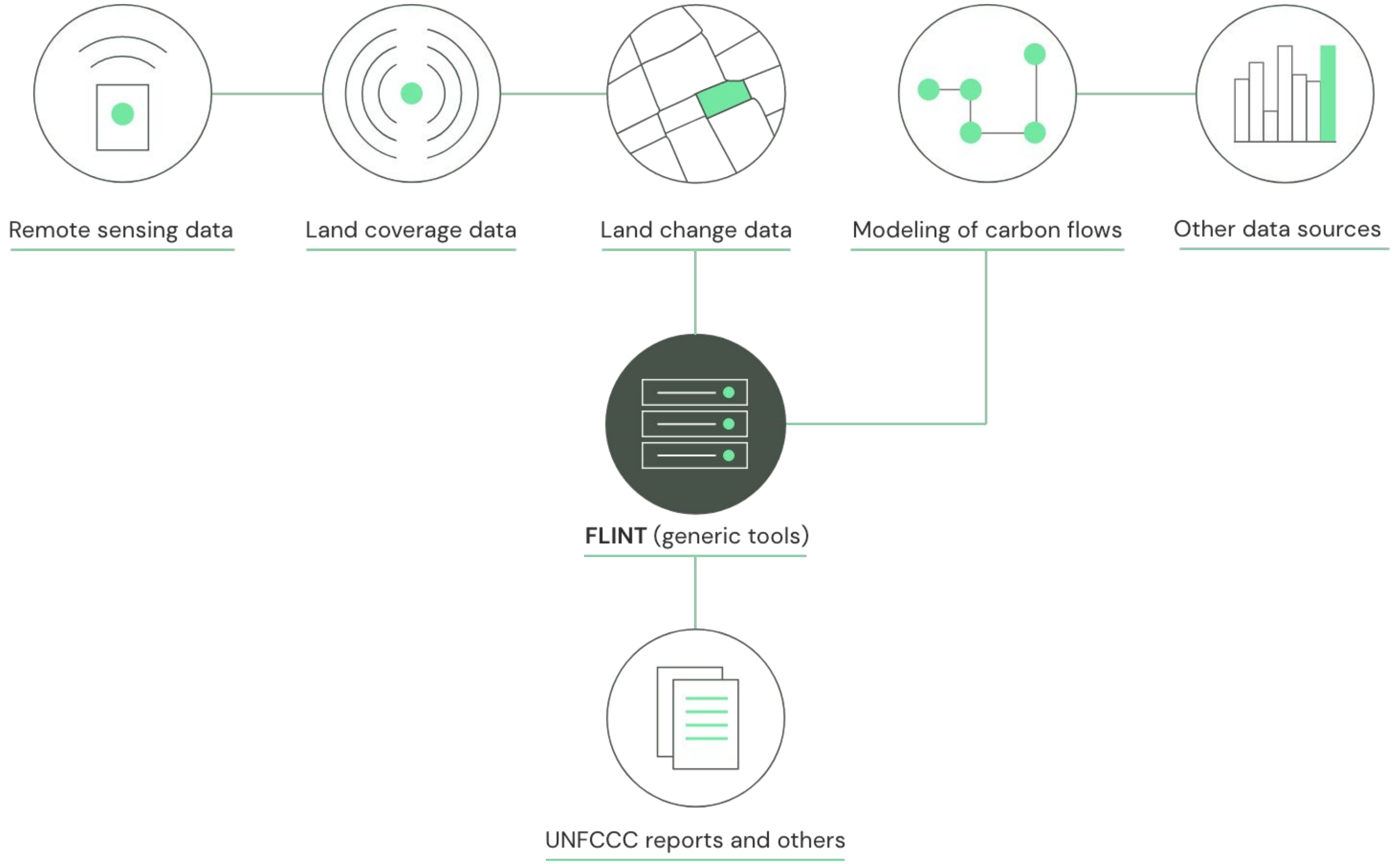
Even basic methods can create complex systems



No one method or technology can address all of the policy, reporting and management needs that organisations are identifying

FLINT facilitates the integration of these data to meet a variety of needs

Measure / Method	Remote Sensing	Models	GIS	FLINT
	Value When Used in Isolation			Integrated
Land cover/use change	High	No	Low	High
Biomass and GHGs	Low	High	Low	High
Carbon and GHG	Low	High	Medium	High
Multiple Measures	Low	High	Low	High
Projections / Scenarios	No	High	Medium	High
Other Land Uses	Medium	High	Medium	High
Products, Bioenergy	Low	High	Medium	High

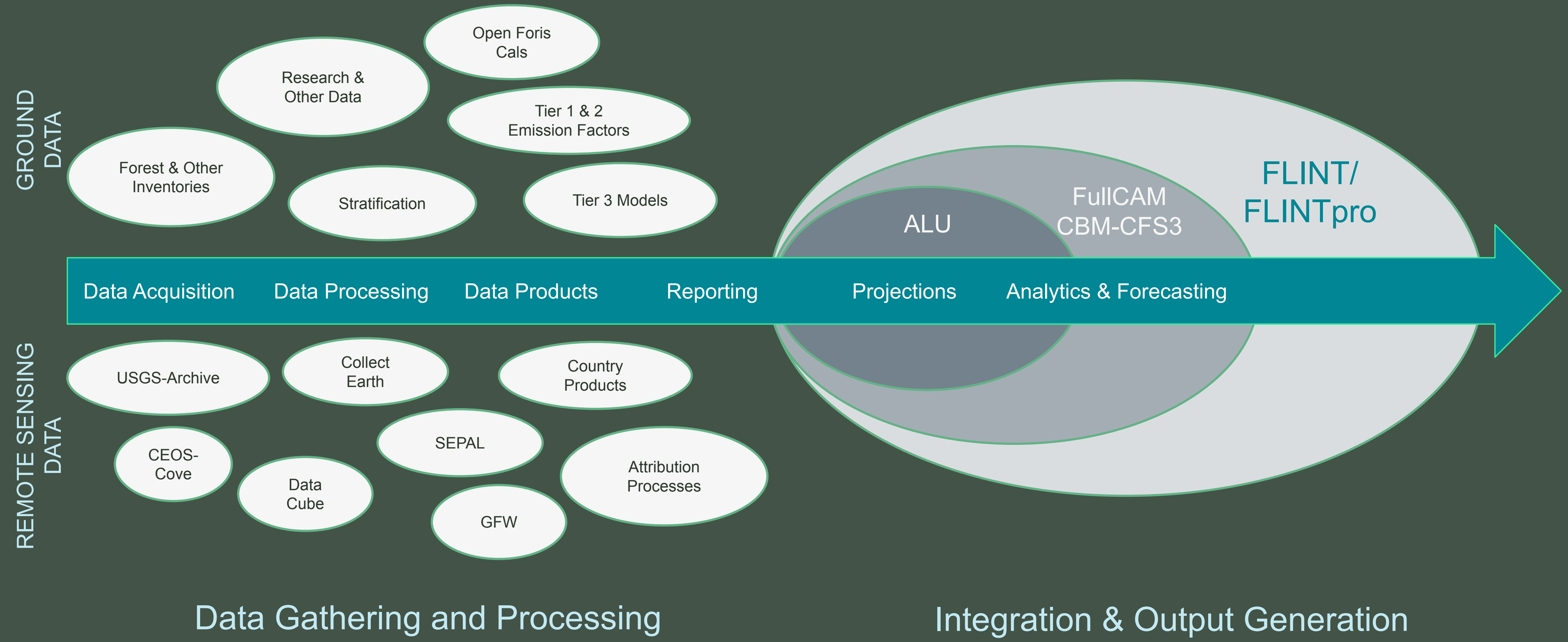


General components of a moja global MRV system

The role of integration

- Estimating land sector greenhouse gas emissions and removals requires data from many different sources.
- No one technology or approach can provide all required information:
- Remote sensing, forest inventories, research sites, soils maps, climate information and other data sources each provide valuable data.
- Integration is a way to bring these together in a systematic way

Adding value to existing data products and processes



Why integrate?

- Reduce process inefficiencies
  - use software systems to automate repetitive tasks
- Reduce errors
  - Minimise errors by removing manual handling
- Reduce issues of spatial gaps and double counting
- Better responsiveness
  - questions can be answered without having to rework many different spreadsheets
- User driven improvement - better ability to improve the system

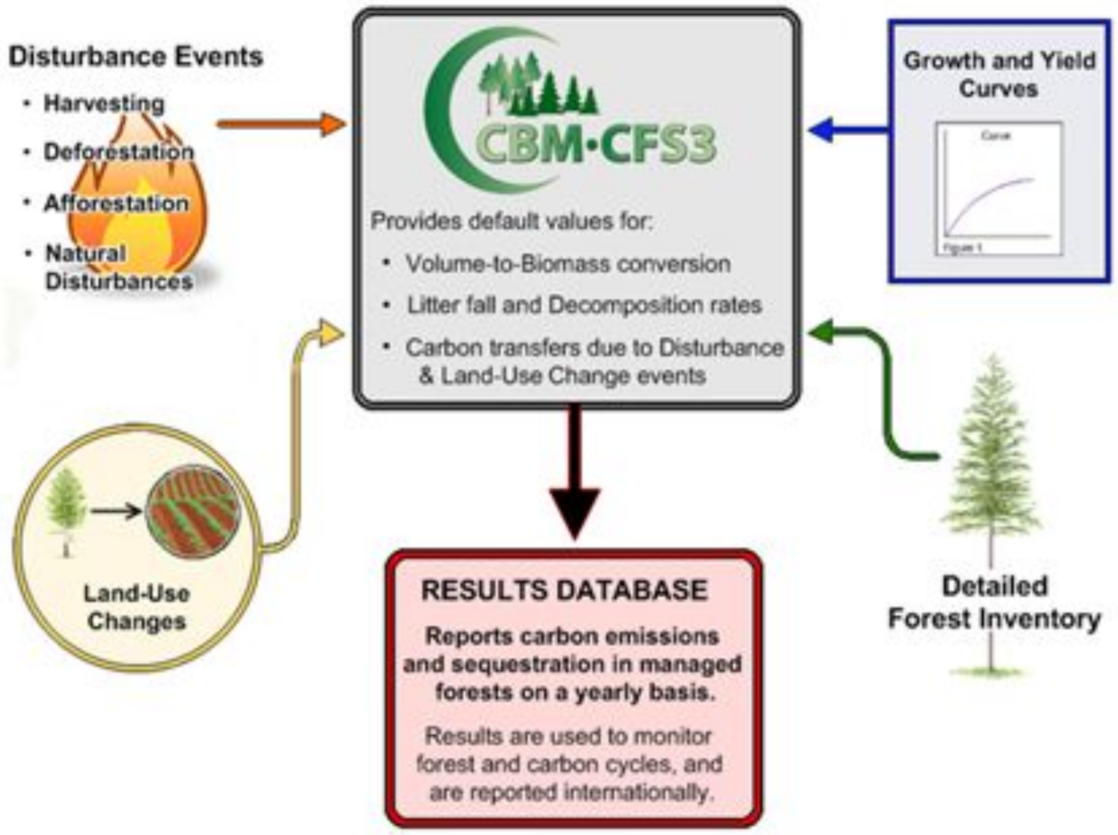
Brief history of land-use data integration tools

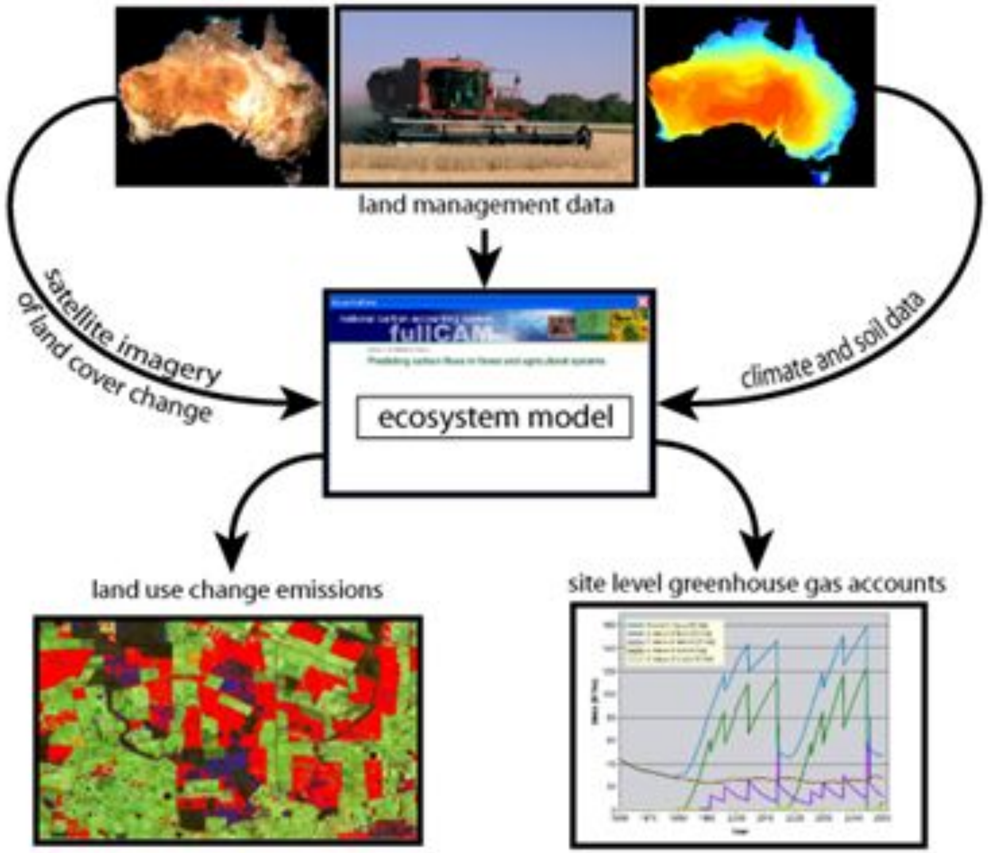
First generation tools (1990's-present)

- Built around country-specific policy goals
  - Kyoto Protocol-national inventories
  - Policy development
  - Carbon markets

Second generation work (FLINT) (2015+)

- First generation tools unable to deal with:
  - New data (esp remote sensing)
  - New policy (sector expansion)
  - Evolving market needs
- Globally applicable, generic framework
- Ability to work with new data providers





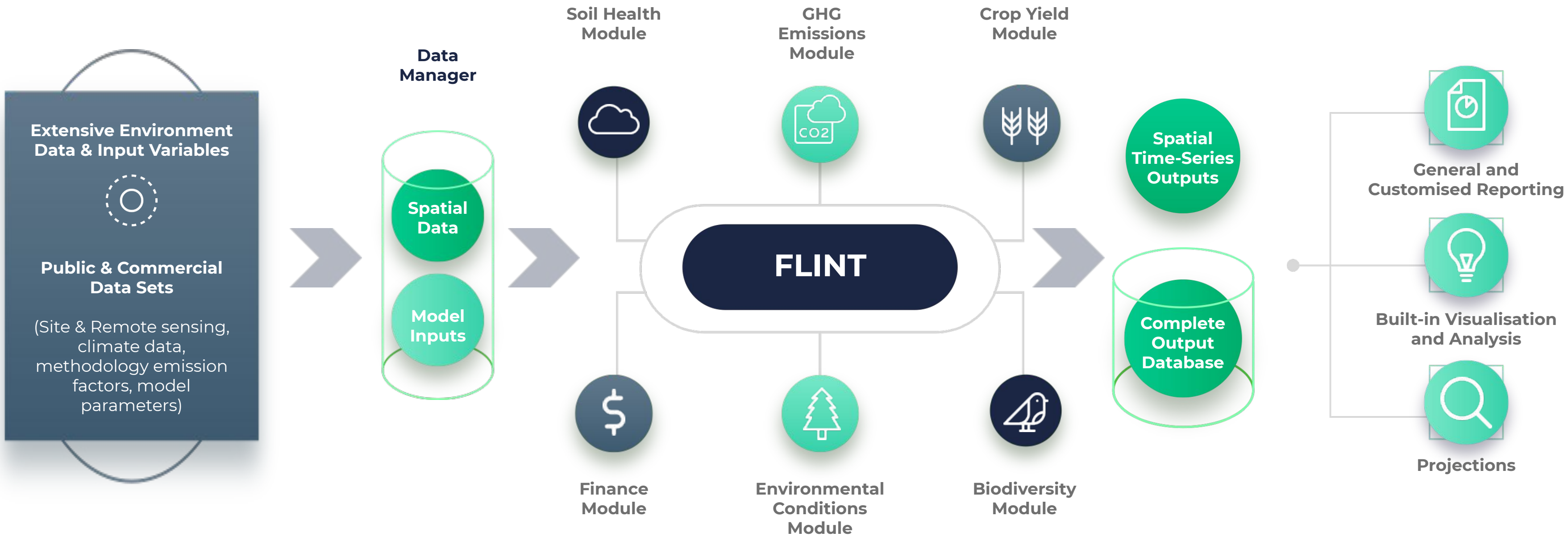
Examples of current operational integration systems in Canada and Australia

The Full Lands Integration Tool (FLINT)

- Software that integrates data and models in a coherent but flexible manner
  - Provides a framework for managing and analysing data
  - Integrates spatial and aspatial data without losing information
- A ‘second generation’ integration tool
- Open source software available through moja global

Core principles

- Flexible
  - Users can modify the system to suit their needs
- Scalable and supports nesting
  - Project > National level > Global
- Data agnostic
  - Not restricted to any data type or format
- Ensures comparability of indices
  - Consistency in data inputs
- Operational and scientific
  - Maintains mass balance of all stocks and flows
  - ‘Commercial grade’ software development processes
- Takes advantage of new compute technology
  - Distributed computing, links to other systems


Extensive Environment Data & Input Variables
Public & Commercial Data Sets
(Site & Remote sensing, climate data, methodology emission factors, model parameters)
Data Manager
Spatial Data
Model Inputs
Soil Health Module
GHG Emissions Module
Crop Yield Module
CO2
FLINT
Finance Module
Environmental Conditions Module
Biodiversity Module
Spatial Time-Series Outputs
Complete Output Database
General and Customised Reporting
Built-in Visualisation and Analysis
Projections

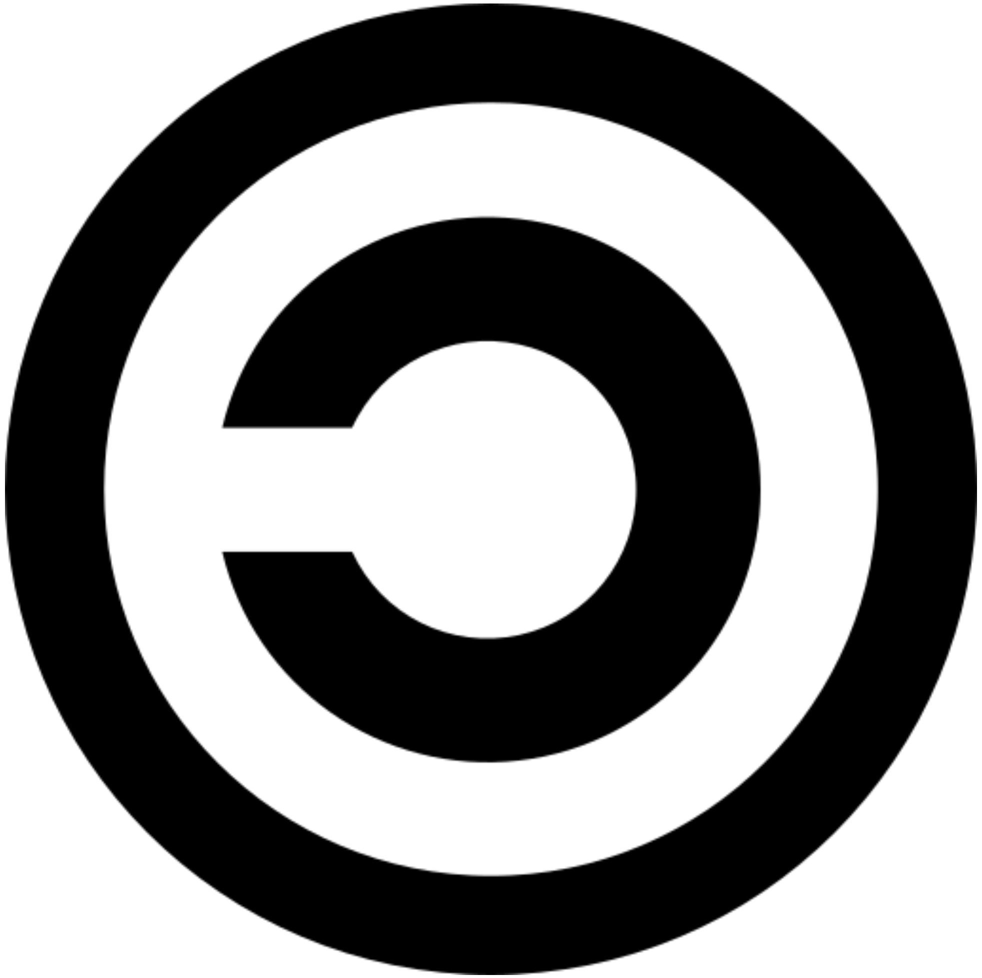
moja global

Introduction to moja global

31 August 2021; 08:30 - 10:30

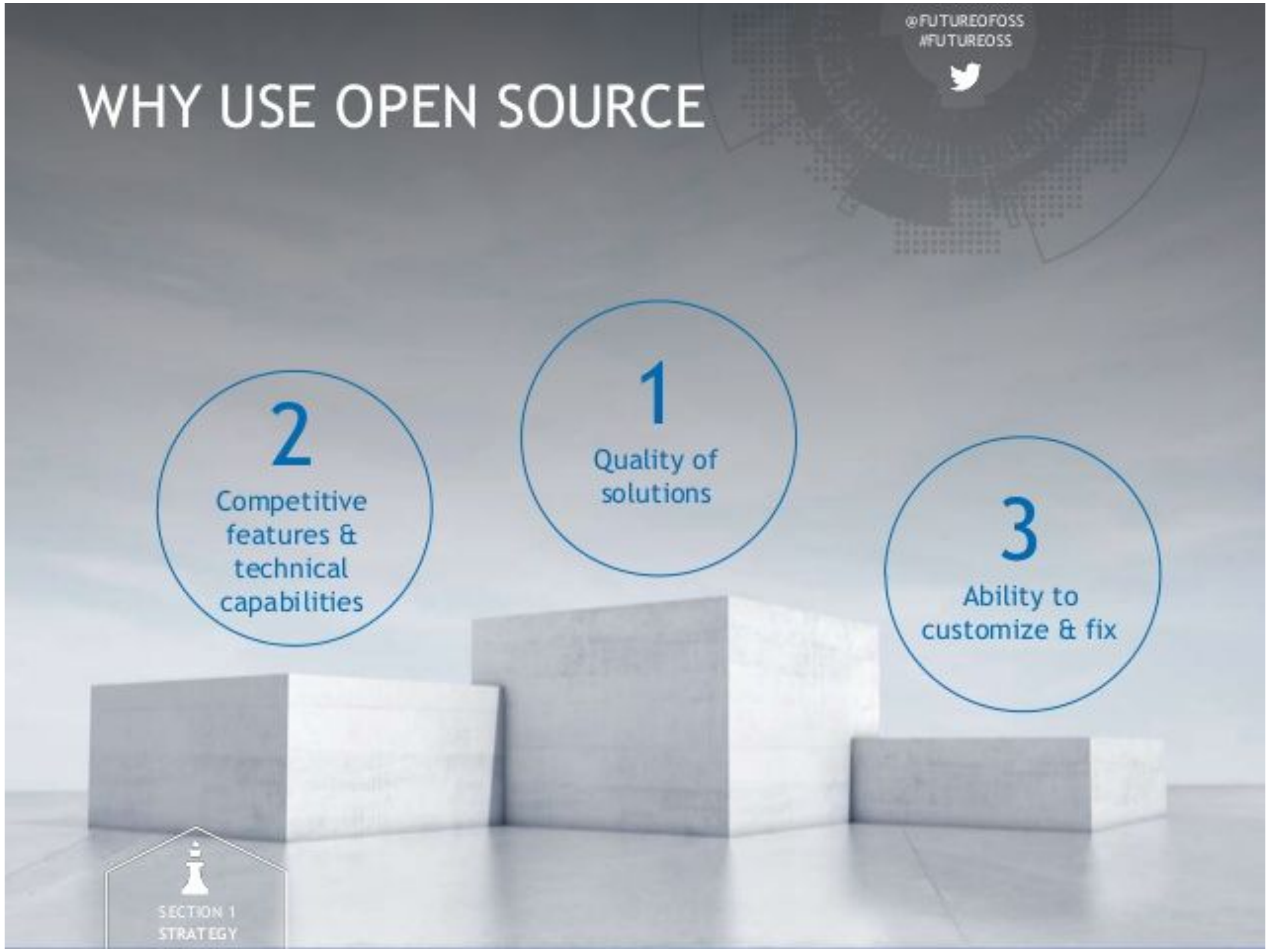
Definition of Open Source

- Source “code” is available: anybody can inspect, use, modify, and distribute the software and derived products
- Stimulate collaboration
- Licence: I share with you, you share with me
- Copy Right vs Copy Left
- Open “anything”



Why use Open Source?

- Quality
- Features (Innovation)
- Customizable
- No Vendor Lock-in
- Easy to deploy
- Cost benefit
- Mobilize global capacity
- Less donor dependency
- Reduces duplication



Open Source is Everywhere!

Visible

Invisible

98% of all software is built on open source components

Key Performance Indicators for Open Source

- ~~Couch by the roadside~~
- 1 licence agreed by all
- 1 code base open to all
- 1 vision supported by all
- Buzzing ecosystem
- Support for ecosystem
- Professional DevOps
- Professional legal umbrella

Once open source, always open source

- Hard to reverse open source
- Contributors remain owners of their contribution
- Contribution is licensed to all other persons

Why Open Governance?

- Users are owners who jointly determine strategic direction of tools
- Users are in control
- Ownership is key to contributions

moja global and The Linux Foundation

moja global

- Facilitate Collaboration (physical and organisational infrastructure)
- Non-profit
- No commercial interest

The Linux Foundation

- Legal Entity
- Lessons learned
- Accounting, HR, Marketing, etc.

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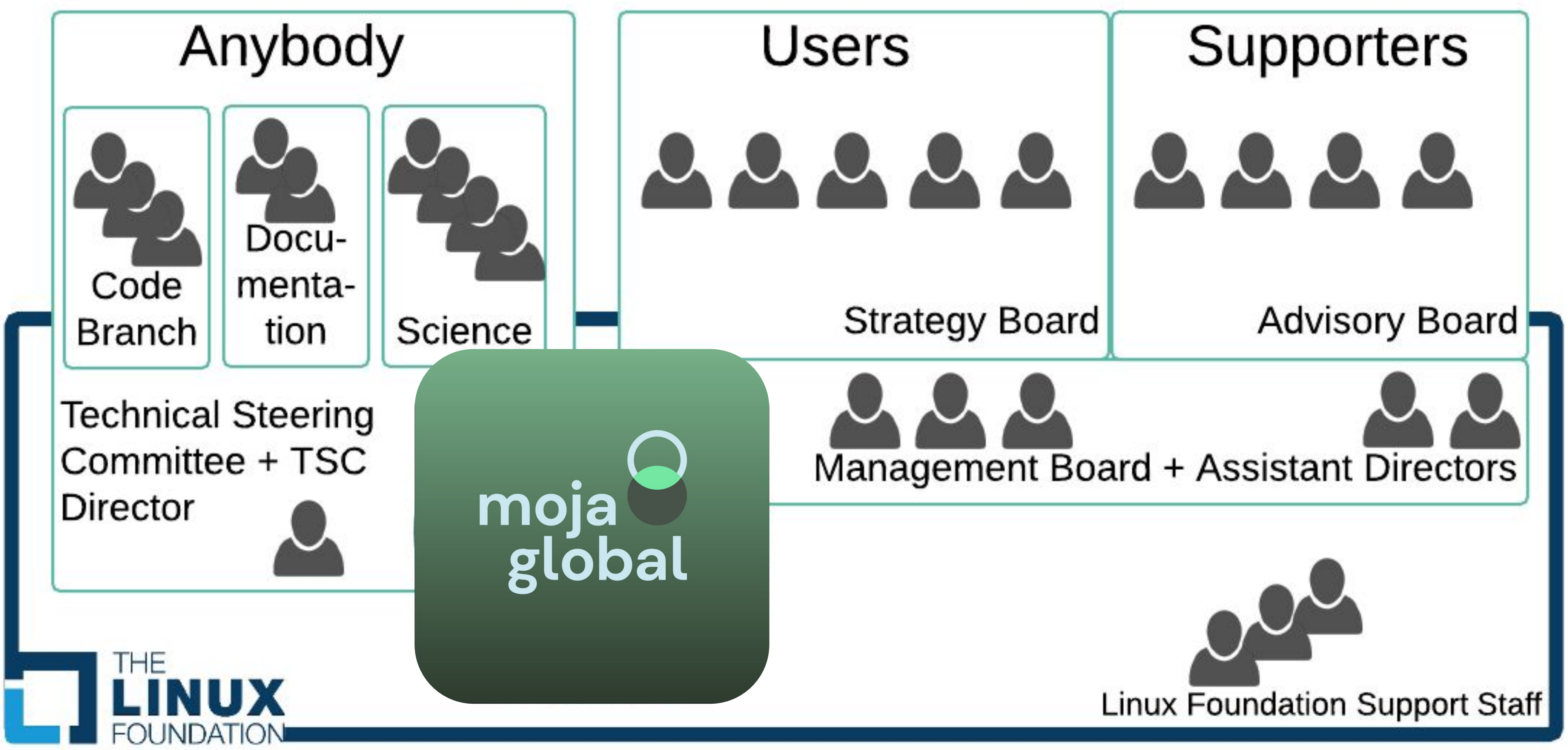
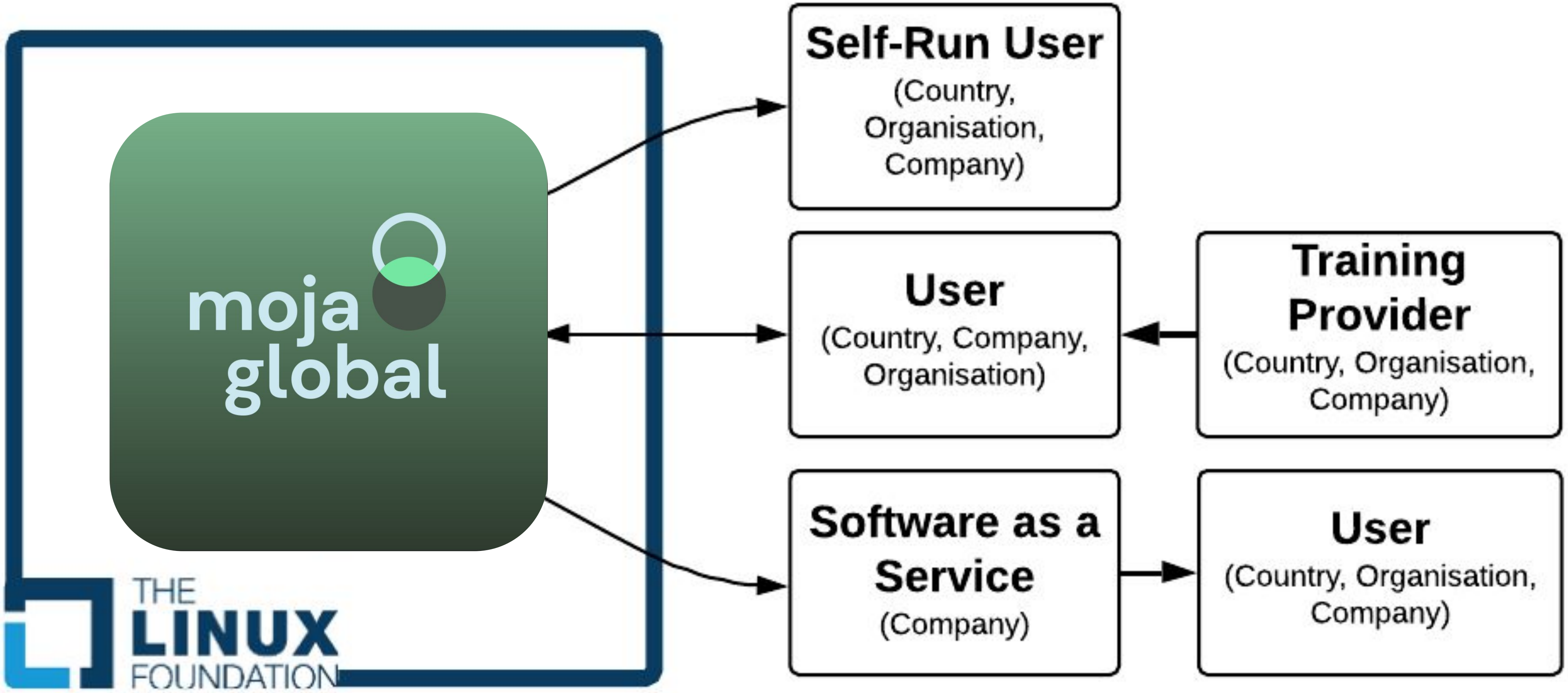


Anybody
Code Branch
Docu-menta-tion
Science
Technical Steering Committee + TSC Director
Users
Strategy Board
Supporters
Advisory Board
Management Board + Assistant Directors
moja global
THE LINUX FOUNDATION
Linux Foundation Support Staff


moja global
THE LINUX FOUNDATION
Self-Run User
(Country, Organisation, Company)
User
(Country, Company, Organisation)
Training Provider
(Country, Organisation, Company)
Software as a Service
(Company)
User
(Country, Organisation, Company)

Case Studies

KENYA

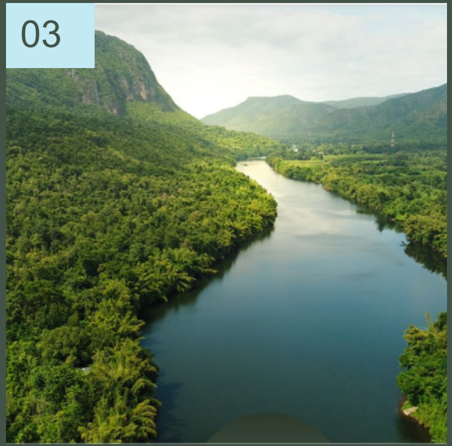
System for Land-based Emissions Estimation

The FLINT was developed in Kenya as part of the program called System for Land-based Emissions Estimation in \Kenya (SLEEK). SLEEK was a Government wide program. The system has been improved in several cycles, including the development of a tool that can generate results in internationally agreed reporting formats and the development of an enteric fermentation model.

CHILE

Chile’s National Forestry Corporation collaboration

Chile’s National Forestry Corporation (CONAF), in collaboration with the Canadian Forest Service and the Mullion Group, is running a pilot project using a FLINT-based system in the Los Rios Region in southern Chile. CONAF is interested to test how available spatially explicit data can be integrated in a transparent and consistent manner.



CANADA

Generic Carbon Budget Model

The Canadian Forest Service is one of the most active contributors to moja global. The Generic Carbon Budget Model (GCBM) uses Canadian Forest Service (CFS) science modules on top of the FLINT platform. GCBM has been applied in various projects and at various scales by National and Provincial governments in Canada and in the rest of the world.The Generic Carbon Budget Model (GCBM) , Canadian Carbon Budget Model science modules on top of the FLINT platform) has been applied in various projects and at various scales by National and Provincial governments. There is also a keen interest of various companies to start using GCBM.

INDONESIA

Indonesian National Carbon Accounting System

Conclusions

To meet complex needs, moving beyond spreadsheets,

Developing estimates of land-sector GHG emissions and removals requires data from many sources

Integrating tools can assist in converting such data into policy-relevant information

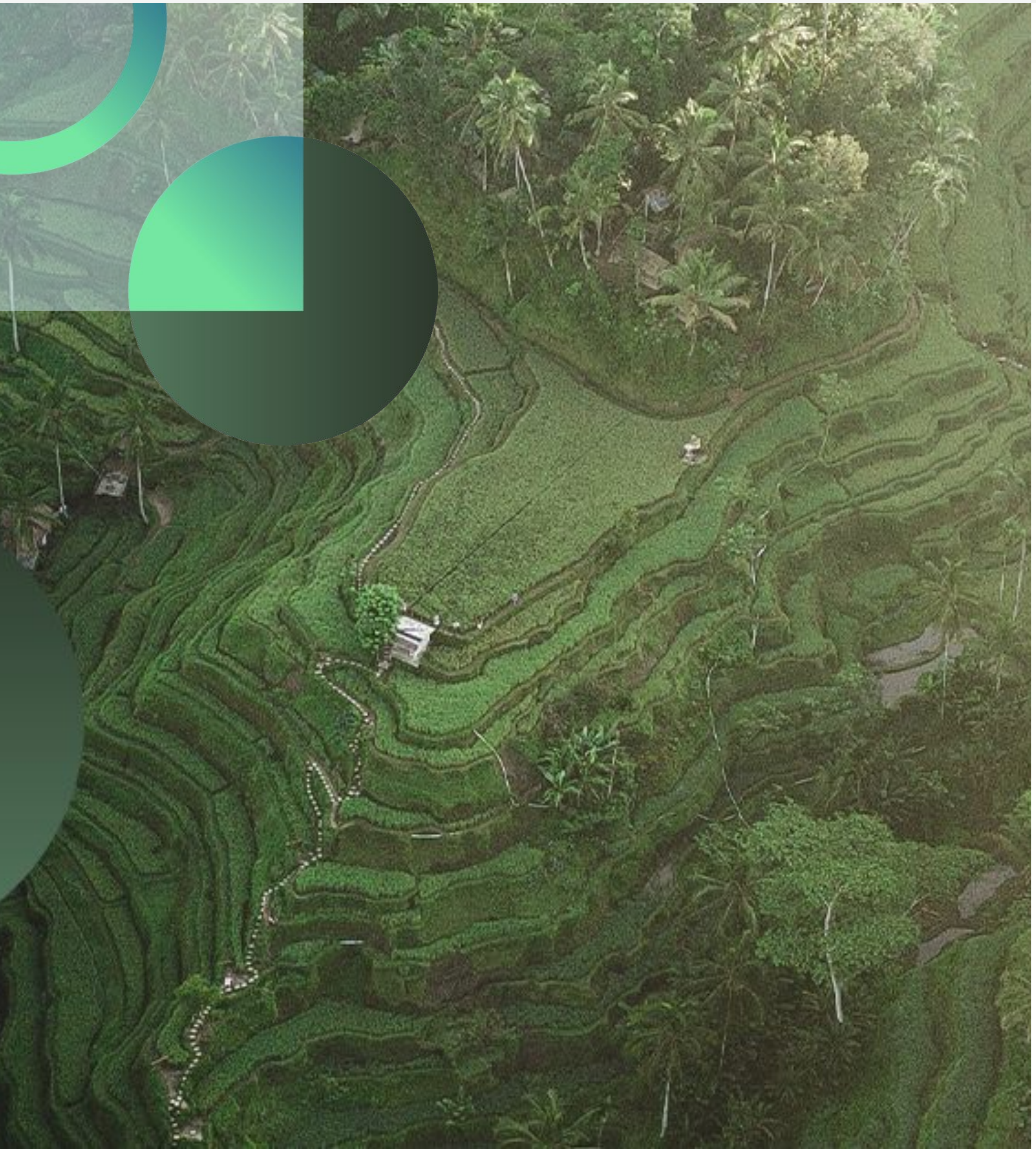
Existing integration tools such as FullCAM and CBM-CFS3 have successfully supported reporting, policy development and science.

FLINT is being developed as a next generation tool that can be implemented and tailored to country circumstances

moja global

FLINT: SLEEK reporting tool

31 August 2021; 08:30 - 10:30

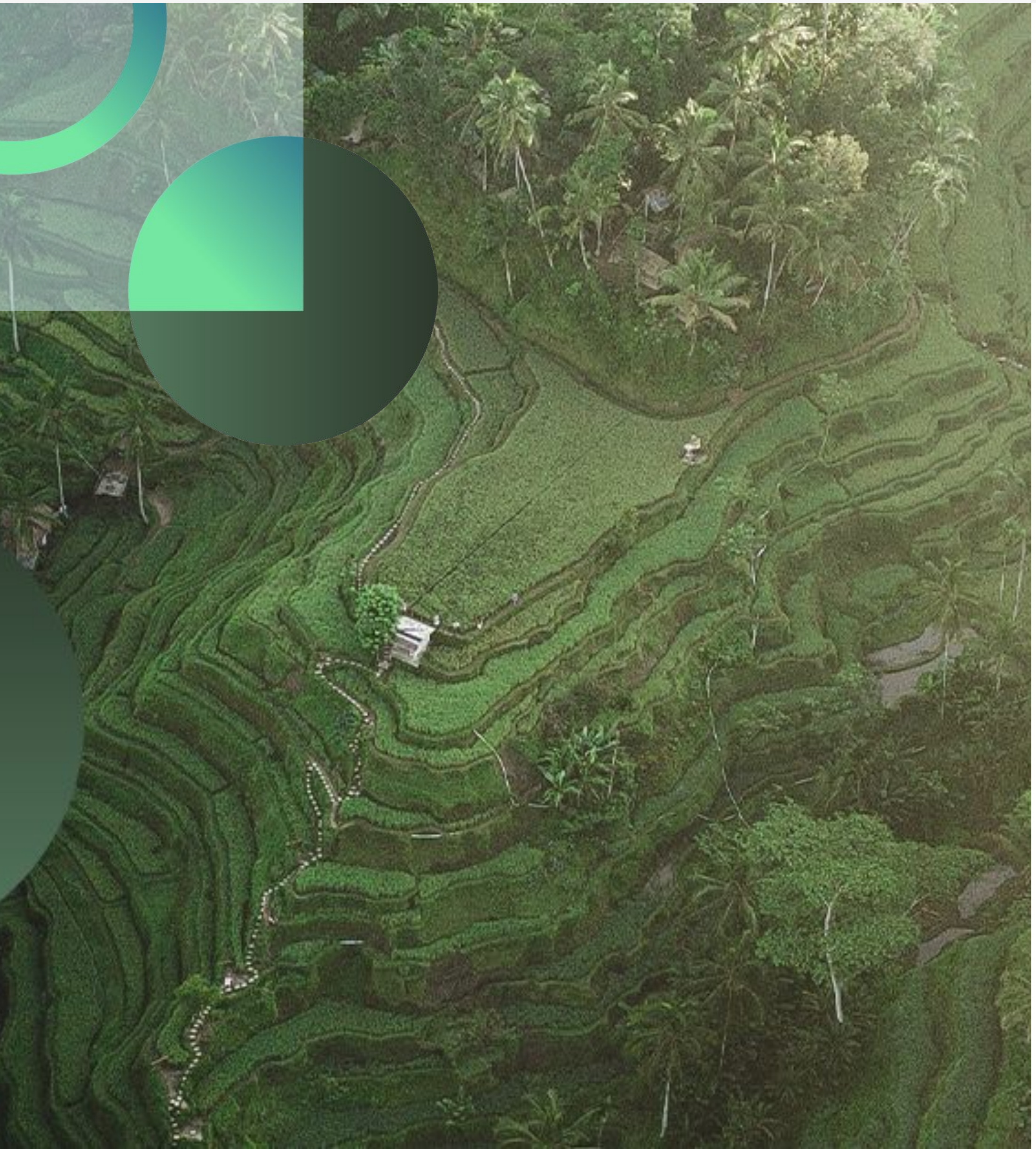


DAY 3

moja global

Implementing a FLINT-based system

1 September 2021; 08:30 - 10:30



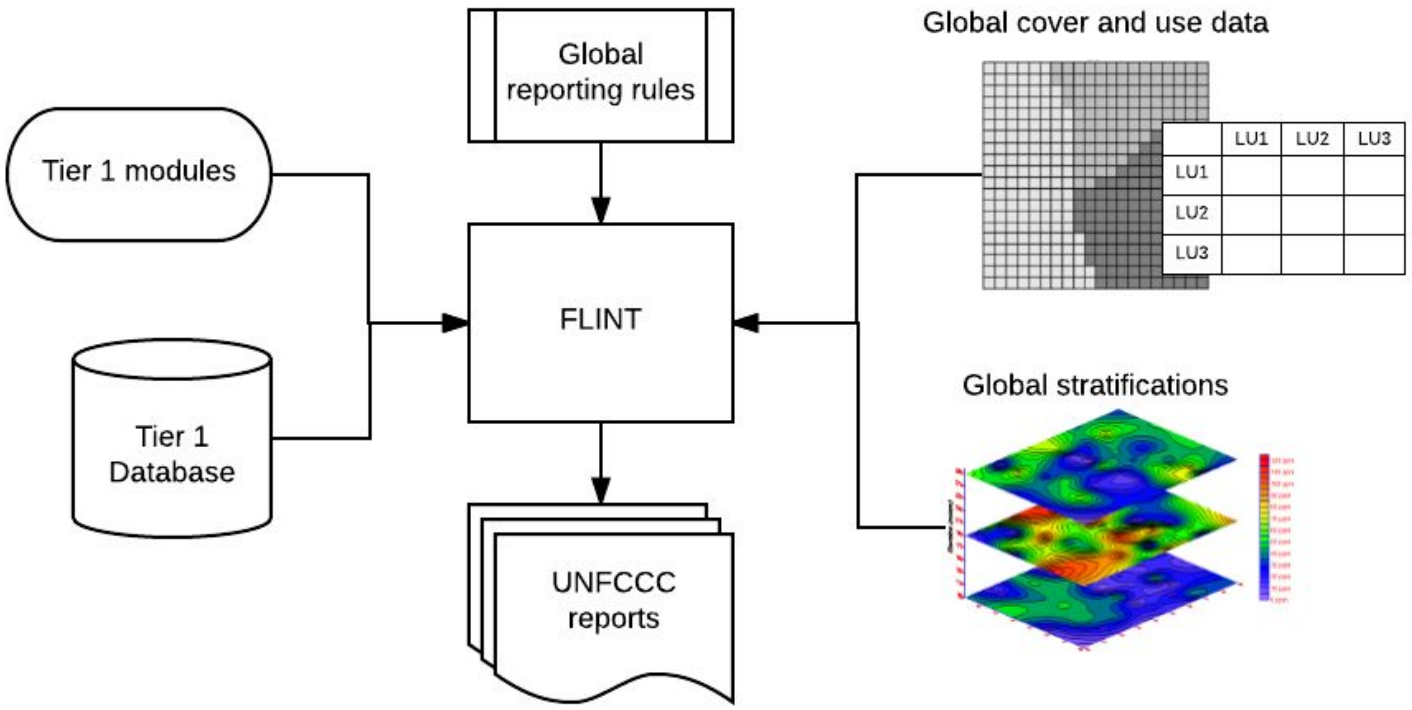
This session will cover how to use the FLINT and will provide some examples using FLINTpro

How to use the FLINT
- What you can start with
- Types of data you are going to need
- How to add new data and models over time

Examples:
- Example trading platform
- FLINTpro
  - Building a model
  - Example runs using different data
  - Types of outputs

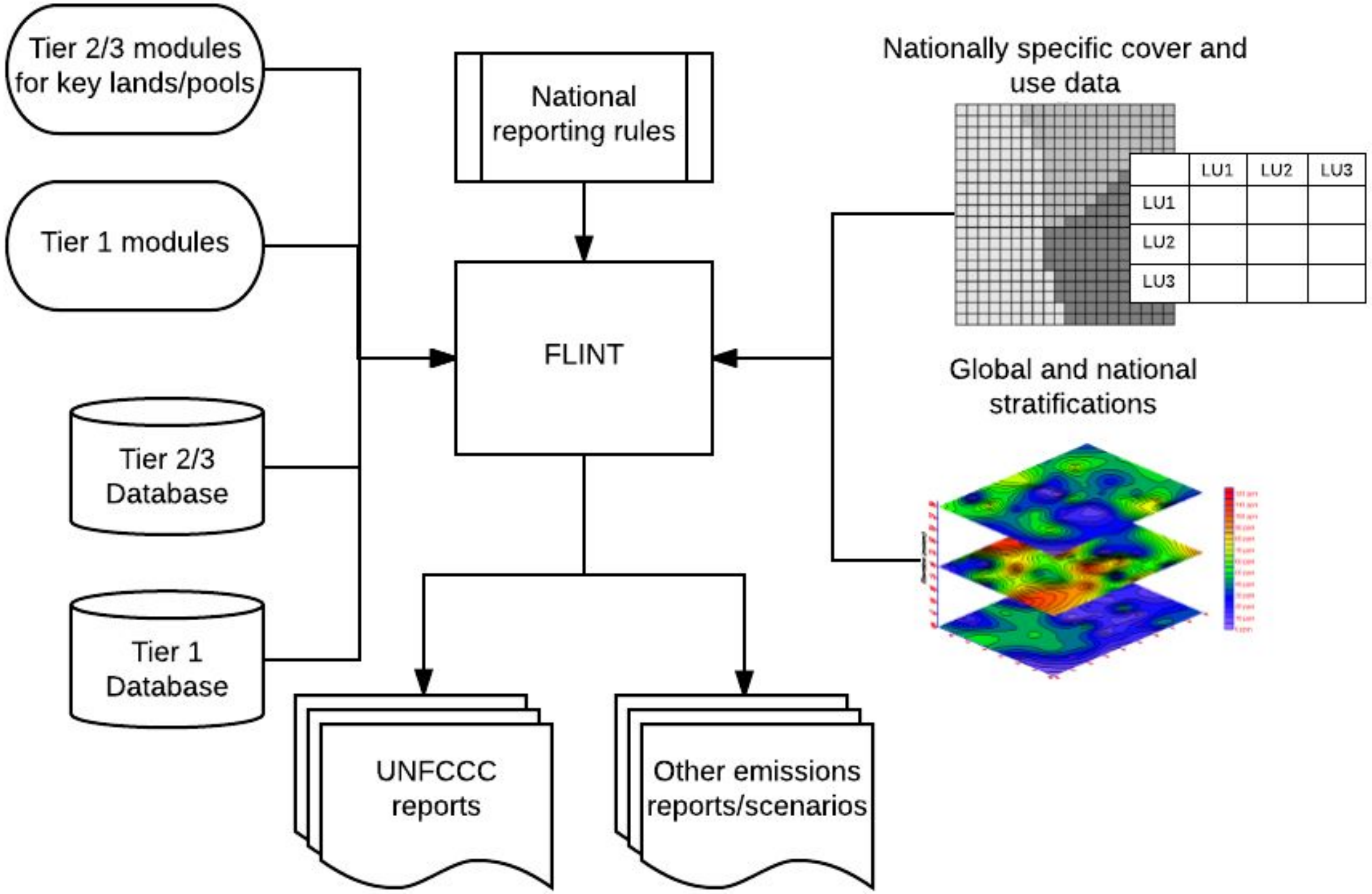
Start with what you can get

- Start very simple
- Can be pre-packaged, including IPCC and UNFCCC reporting rules
- Framework in place, ready for improvement



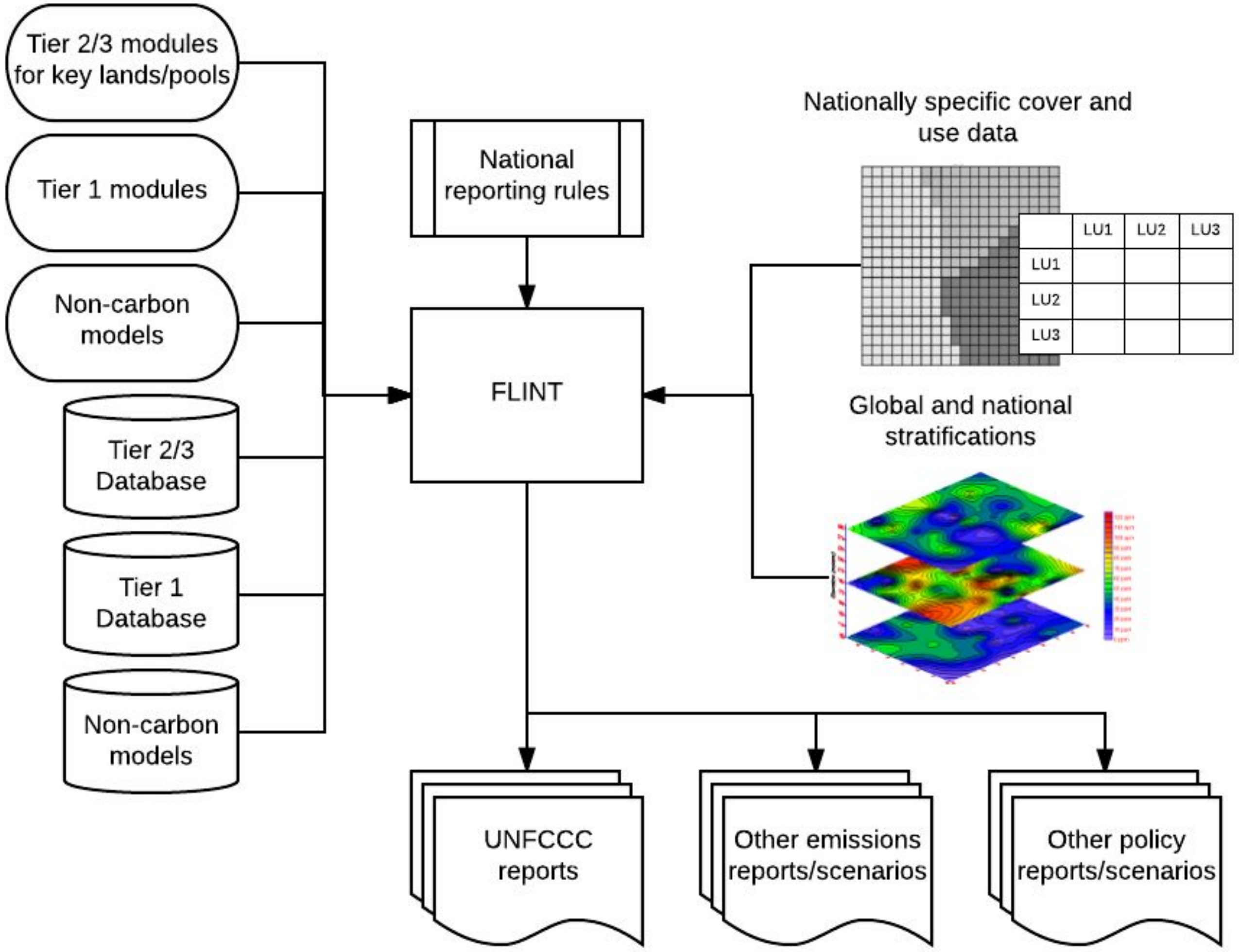
Add more as you go

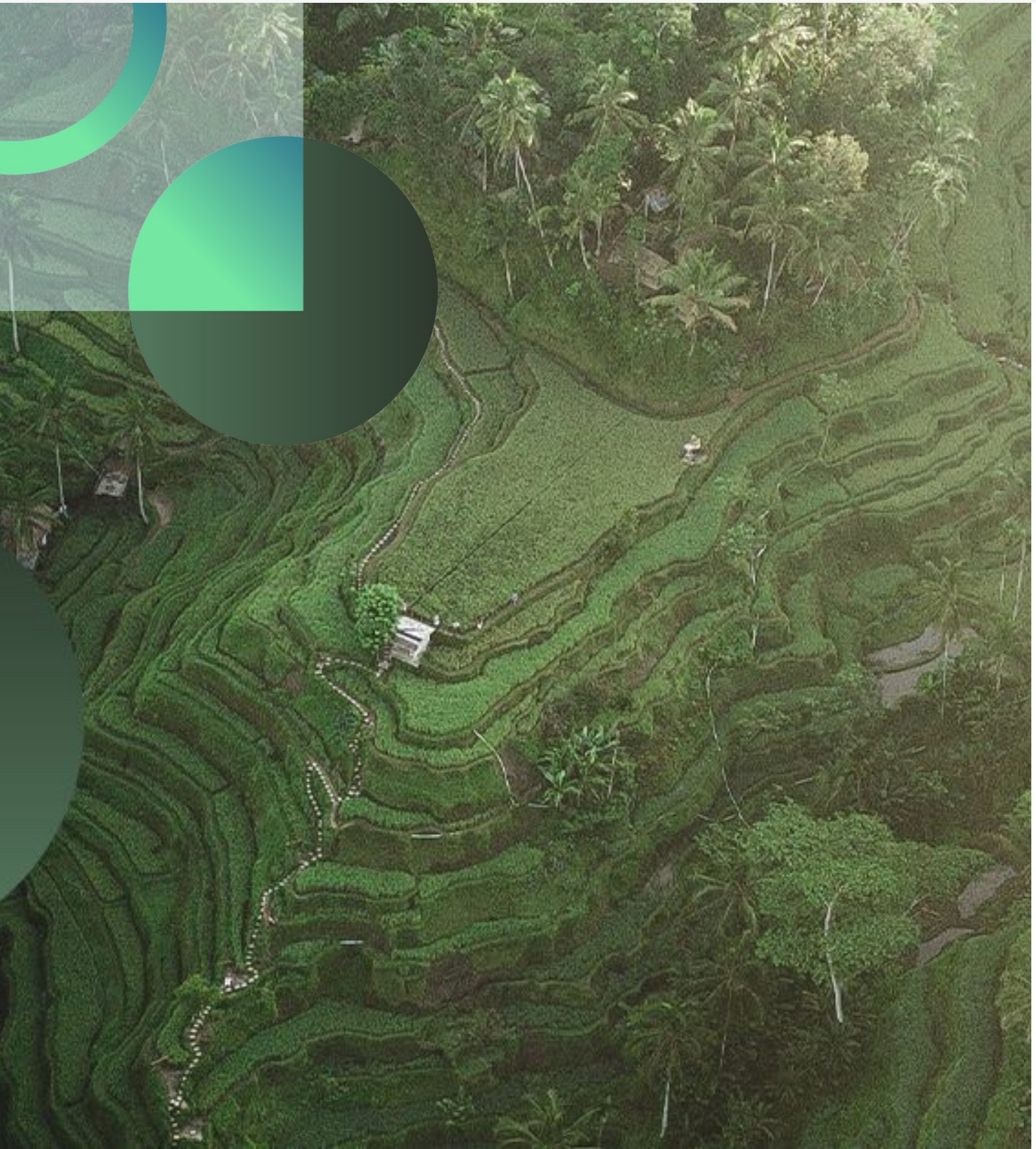
- Start to move some pools/lands from Tier 1 to 2/3
- Easy to replace data
- Replace global data with national data
- Reporting rules can be set by countries
- Able to do more advanced reporting



And then add more

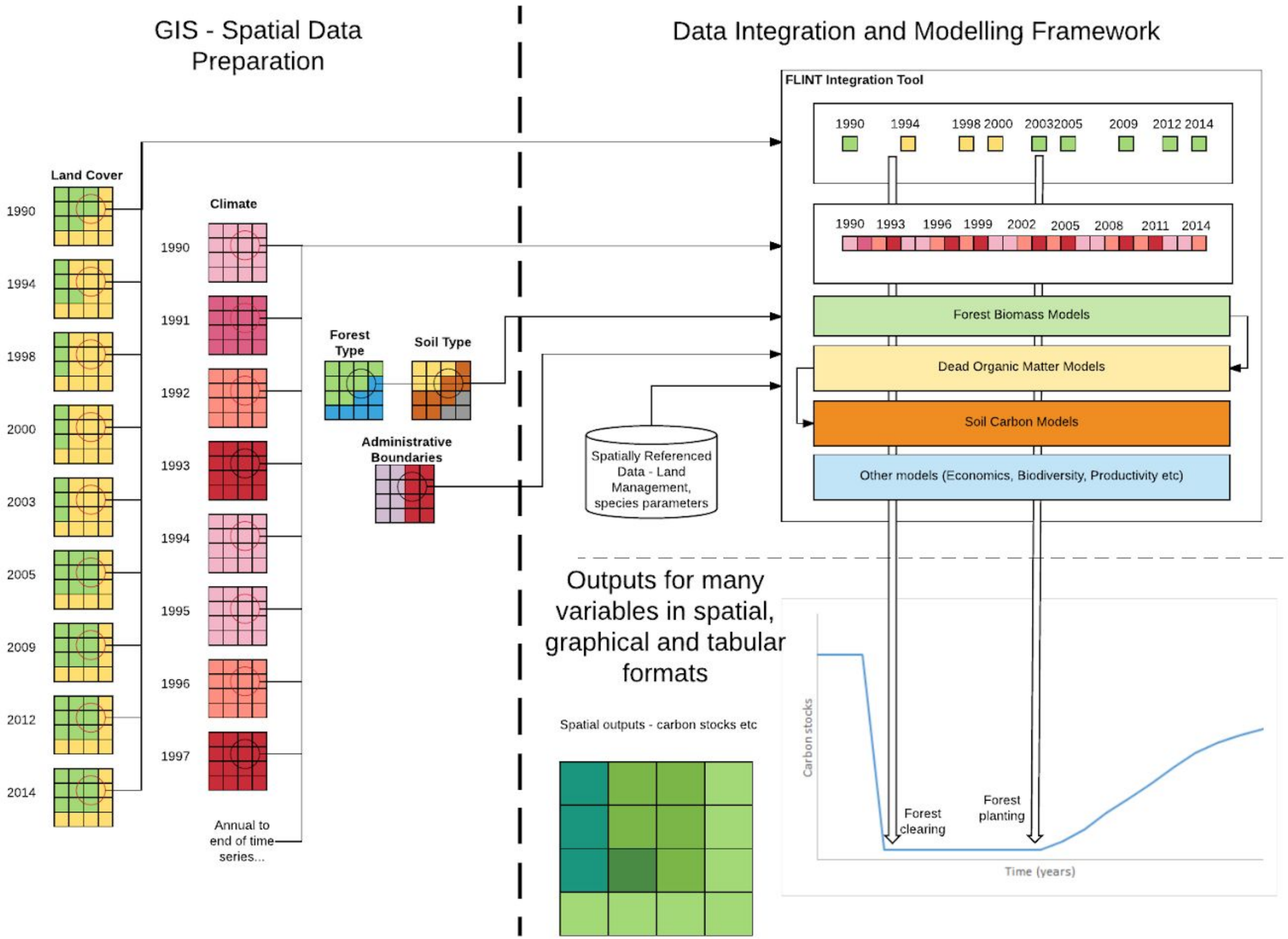
- Continue to improve data for existing modules
- Move more modules to Tier 2/3
- Add non-carbon modules to assess co-benefits





Simulation types

- Can run spatially-referenced or spatially-explicit
  - Inventory based stand lists
  - Sample-based methods
  - Wall to wall time series of cover change
- Activities/disturbances triggered through multiple mechanisms
  - Spatial layers
  - Statistical rules
  - Management regimes
- Examples
  - CBM-CFS3 modules on FLINT platform in Yucatan Peninsula using NASA Landsat land cover data and growth data from Mexican NFI



Year	Total Carbon Stock (t C)
1990	100
1991	100
1992	100
1993	5
1994	5
1995	5
1996	5
1997	5
1998	5
1999	5
2000	5
2001	9
2002	15
2003	23
2004	30
2005	37
2006	45
2007	52
2008	57
2009	61
2010	64
2011	67
2012	69
2013	72
2014	74

EVENTS	Initial C-Value			Fire		Harvest Wood					Plant Maize			Harvest		Plant Maize			Harvest	
CARBON POOLS / TIME STEP	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
Atmosphere		−	−	+	−	+	+	+	+	+	+	+	−	+	+	+	+	−	+	+
Crop Stems	0											+	+	−			+	+	−	
Crop Leaves	0											+	+	−			+	+	−	
Crop Roots	0										+	+	+	−		+	+	+	−	
Crop Debris	0											+	+	+	−	+	+	+	+	−
Crop Residue	0											+	+	+	−		+	+	+	−
Crop Fruit	0											+	+	−			+	+	−	
Tree Stems	7	+	+	−	+	−														
Tree Foliage	9	+	+	−	+	−														
Tree Branches	2	+	+	−	+	−														
Tree Roots	4	+	+	−	+	−														
Tree Debris	4	+	+	−	+	+	−	−	−	−	−	−	−							
Tree Residue	5	+	+	−	+	+	−	−	−	−	−	−	−							
Dead Roots	6	+	+	−	+	−	−	−	−	−	−	−	−	−						
Standing Dead Wood	4	+	+	−	+	−														
Fallen Dead Wood	2	+	+	−	+	−														
Resistant Plant Material	5	+	+	+	+	+	−	−	−	−	−	+	+	+	−	−	+	+	+	−
Decompostable Plant Matter	6	+	+	+	+	+	−	−	−	−	−	+	+	+	−	−	+	+	+	−
Microbial Biomass	7	+	+	+	+	+	−	−	−	−	−	+	+	+	−	−	+	+	+	−
Humified Organic Matter	5	+	+	+	+	+	−	−	−	−	−	+	+	+	−	−	+	+	+	−
Inert Organic Matter	4	+	+	+	+	+	−	−	−	−	−	+	+	+	−	−	+	+	+	−
Long Lived Wood Products	0					+														
Fire Wood	0	+	+	+	+	+														
SUM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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FLINT: Operational examples - Canada

31 August 2021; 08:30 - 10:30

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Canada’s National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)

Designed to meet reporting and projection requirements for managed forests (226 Mha)

Core model is CBM-CFS3

In operation since 2006

Working towards spatially-explicit system for managed and unmanaged forests and forested wetlands

Core model is GCBM built on FLINT

Carbon Budget Model (CBM-CFS3)

Forest C dynamics model compliant with IPCC Guidelines.

Core model of Canada's national forest reporting system.

IPCC Gain-Loss Method in annual time steps: attribution of reported emissions to annual activity data (management, fires, insects, LUC).

Seamless transition from reported (past) to projected (future) emission and removals: emission trends, NDC and NCS analyses.

CBM Framework for HWP modelling

Includes uncertainty analyses (Metsaranta et al. 2017)

CBM-CFS3 is freely available with documentation and training.

But limited ability to process spatially-explicit (big) data.

moja global

Generic Carbon Budget Model (GCBM)

Science modules of CBM-CFS3 on moja.global's FLINT platform.

Spatially-explicit (30 m, 1 ha) (~ 200 million ha simulated so far)

Managed & unmanaged forests

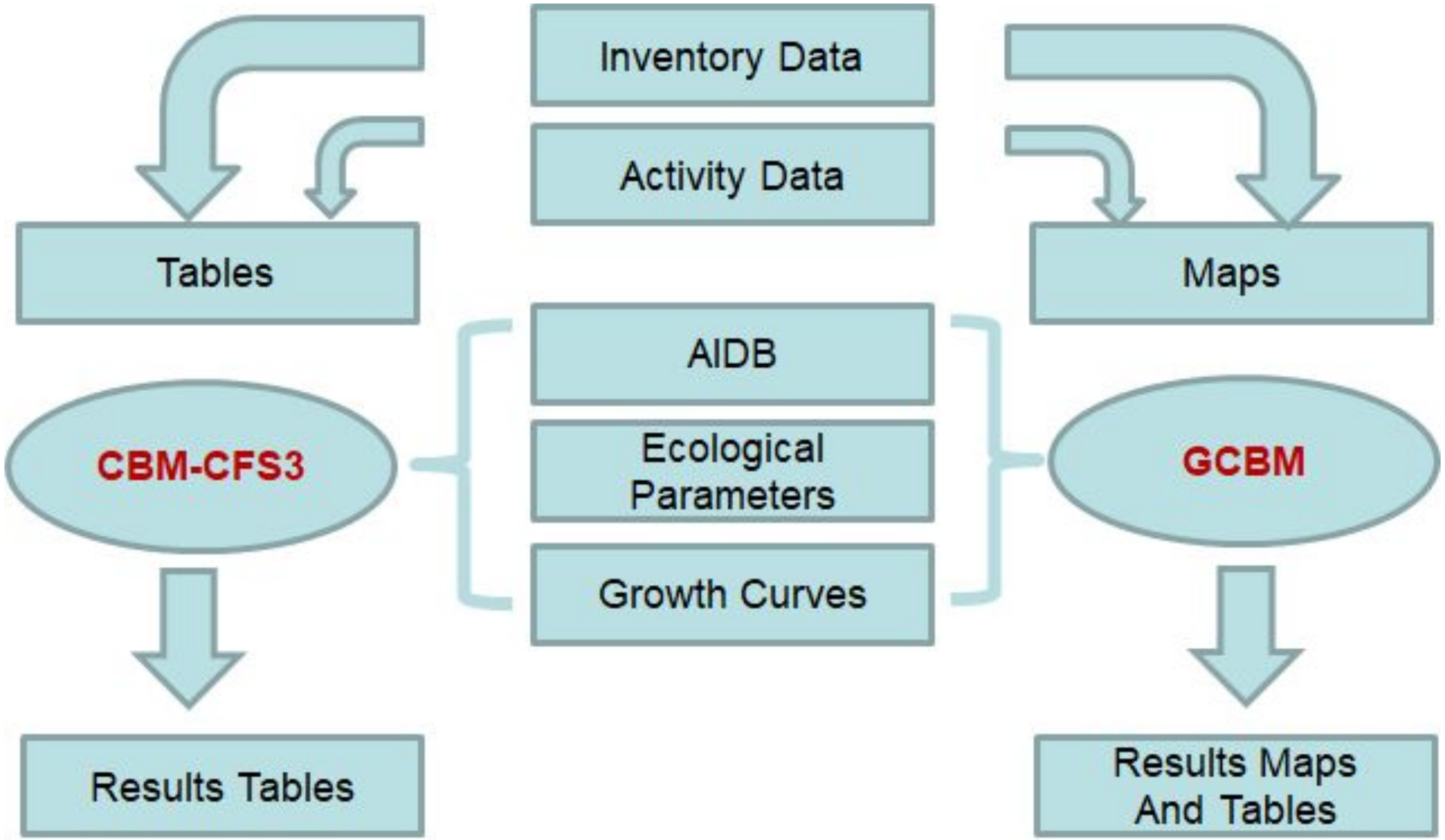
New science modules

- completed: mosses, peatlands (64 Mha @ 1 ha resolution)
- ongoing: climate sensitive growth & mortality, fire severity from RS data, albedo
- early stages: improved forest inventory from RS data

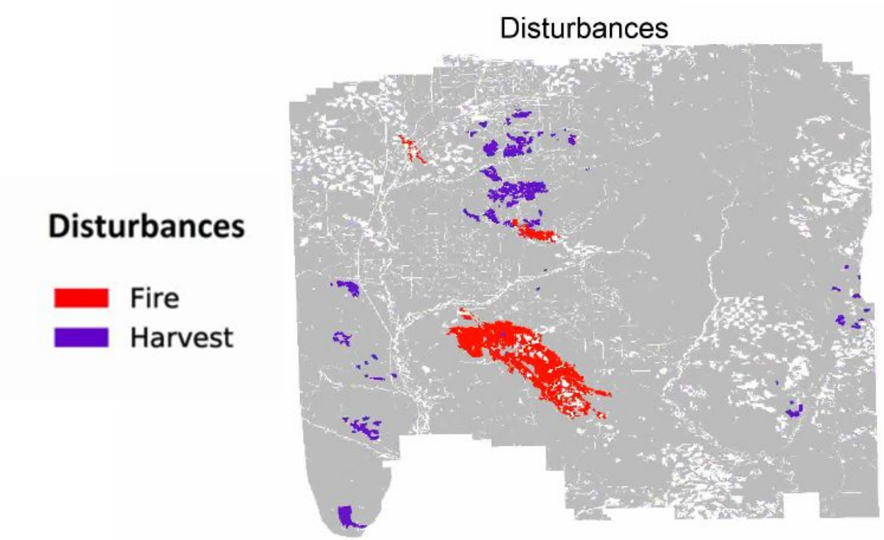
Runs on workstations, computing cluster or cloud-based.

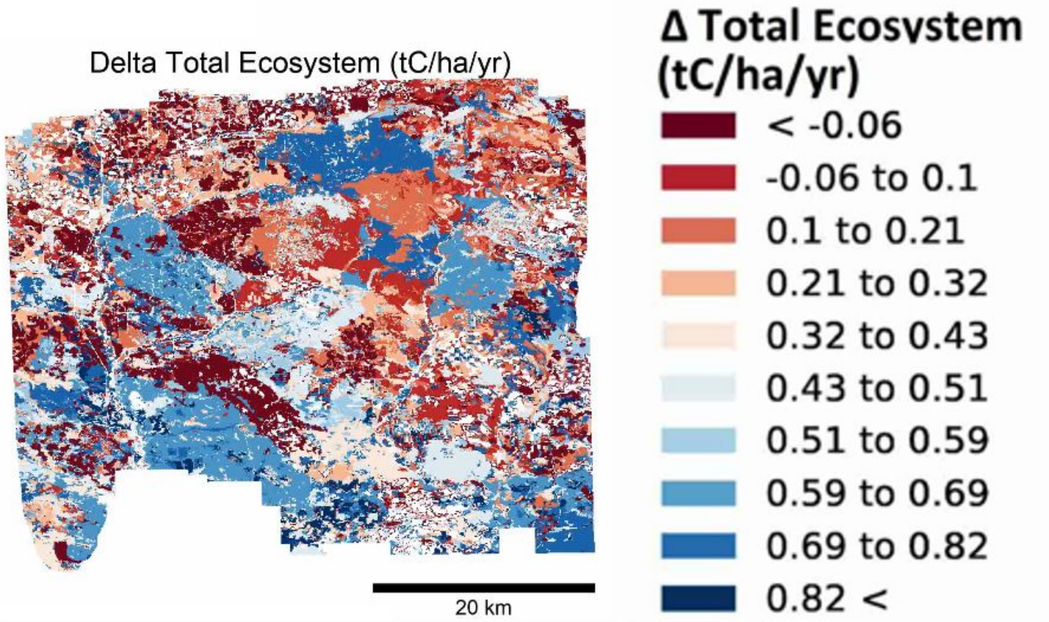
Open source, online training available.

Transition from spatially-referenced to spatially-explicit approach

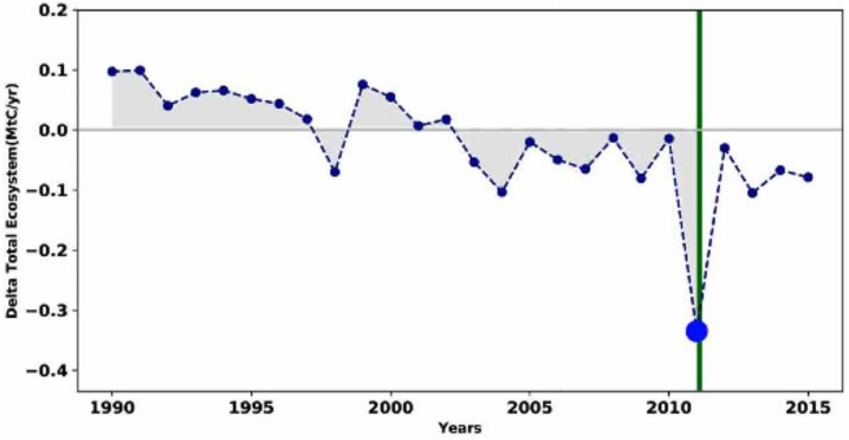


Example results for region in boreal forest of Canada





Spatially-explicit, annual activity data (fire, harvest, etc.) to generate time series of C stocks, stock changes and GHG fluxes for each pixel and for landscape totals.



GCBM example applications

30 m resolution application to 1.3 Mha in the oil sands region of AB

RESEARCH Open Access

Cumulative effects of natural and anthropogenic disturbances on the forest carbon balance in the oil sands region of Alberta, Canada; a pilot study (1985–2012)

C. H. Shaw[1], S. Rodrigue[1], M. F. Voicu[1], R. Latifovic[2], D. Pouliot[3], S. Hayne[4], M. Fellows[5] and W. A. Kurz[5*]

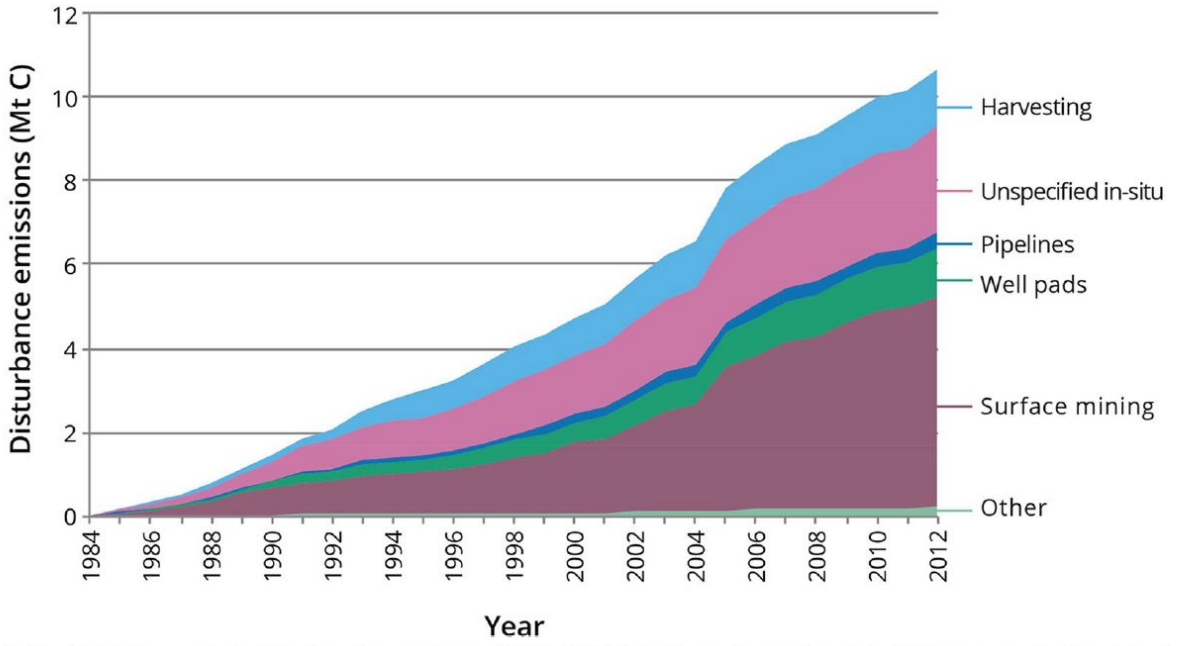


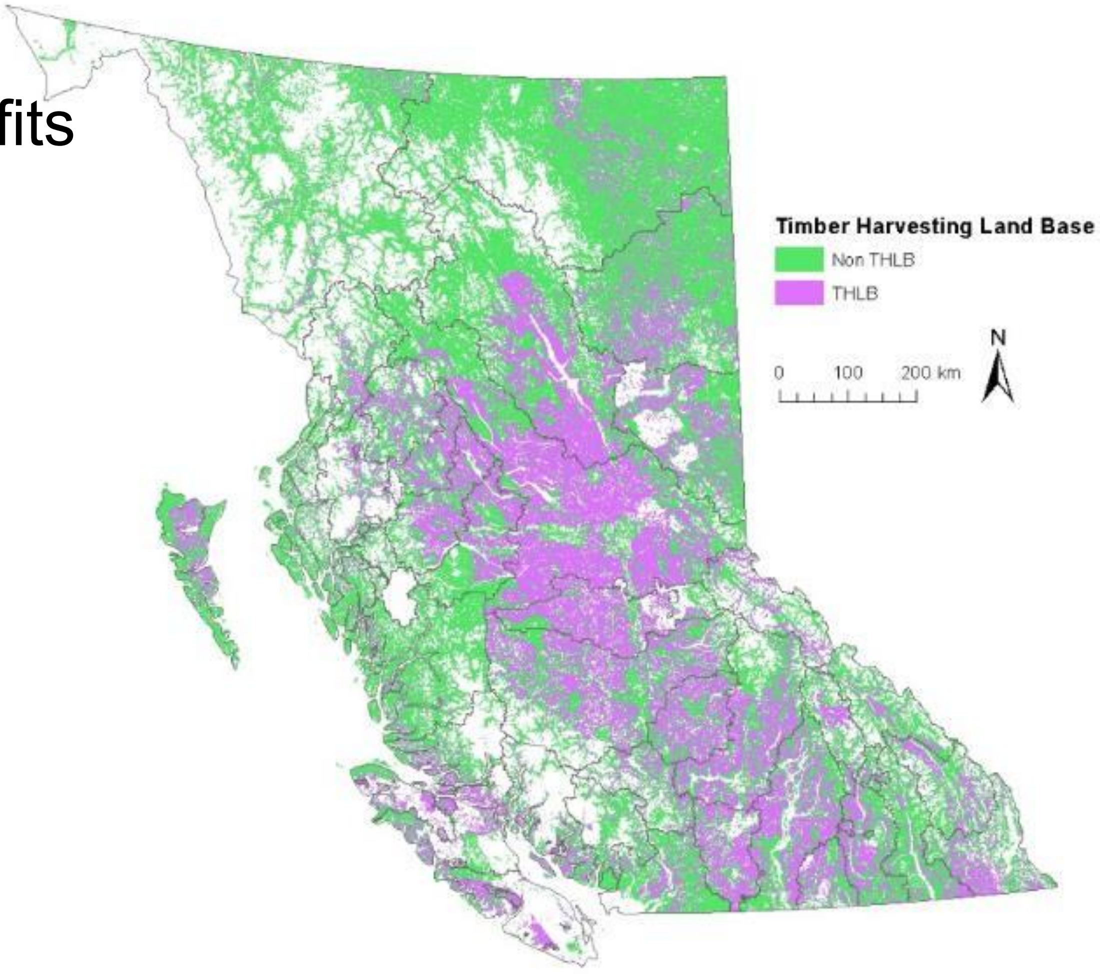
Fig. 9 Cumulative disturbance emissions in the pilot study area (1985–2012) from forest harvesting and different types of oil and gas development disturbances. "Other" includes seismic lines, industrial sites, and municipal lands

Shaw et al. 2021
https://doi.org/10.1186/s13021-020-00164-1

GCBM example applications

BC-wide NCS analysis at 1 ha resolution (60 Mha) projections to 2070.

Includes fully integrated HWP, substitution benefits and economic analyses.



Smyth *et al. Carbon Balance Manage* (2020) 15:21
https://doi.org/10.1186/s13021-020-00155-2

Carbon Balance and Management

https://doi.org/10.1186/s13021-020-00155-2

RESEARCH Open Access

Climate change mitigation in British Columbia's forest sector: GHG reductions, costs, and environmental impacts

C. E. Smyth[1*], Z. Xu[2], T. C. Lemprière[3] and W. A. Kurz[1]

GCBM example applications

- **Natural climate solutions** (NCS) analysis for Canada (Nature United) – analysis of afforestation as one of 24 NCS pathways in Canada (national scale) Drever et al. 2021.
- Analysis of C impacts of Forests Ontario **50 million trees program** (Magnus et al. 2021)
- Analysis of forest carbon balance in 31 of Canada's **national parks** (conservation-based mitigation strategies) – highlights the impacts of increasing wildfires on cumulative GHG balance 1990 to 2020 (Sharma et al., in review)
- Research on wildfire and carbon to increase forest resilience in western North America.
- International applications in South Korea, Chile and Mexico.

Summary

- The development of the open-source, modular GCBM on the FLINT platform is ongoing
- GCBM is deployed for several projects in Canada and internationally.
- Current science focus on
  - environmentally-sensitive growth and yield modelling,
  - expanded application of boreal peatland model,
  - improved representation of forest carbon management activities (natural climate solutions), and assessment of wildfire risks and mitigation options.
  - Improved representation of tree planting outcomes
- Ongoing activities to link to remote sensing derived information.
  - Improved representation of wildfire severity (based on dNBR).
- Goal is to use GCBM in Canada's National Forest Carbon Monitoring, Accounting and Reporting System

- Online training is under development

GCBM Contacts: Werner.Kurz@Canada.ca
Max.Fellows@Canada.ca

Open source: https://github.com/moja-global/moja.canada

moja global

Publications at:

https://cfs.nrcan.gc.ca/authors/read/13977

https://scholar.google.ca/citations?user=nhemay8AAAAJ&hl=en

Natural Resources Canada | Ressources naturelles Canada

Canada

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FLINT: Operational examples - Chile

31 August 2021; 08:30 - 10:30

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FLINT: Emissions trading interface

31 August 2021; 08:30 - 10:30

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global

FLINTpro: how FLINT works

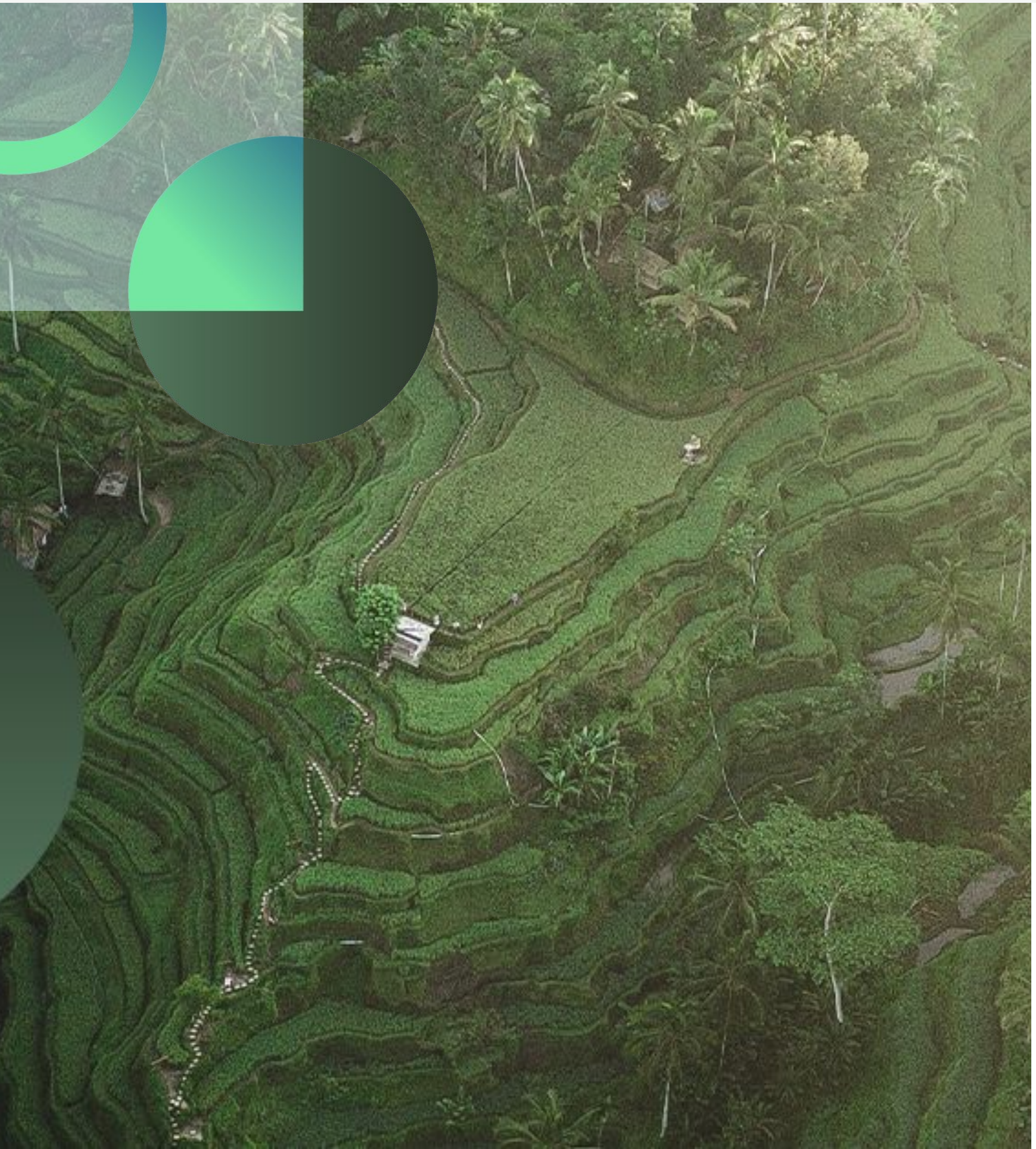
31 August 2021; 08:30 - 10:30

Demonstration:

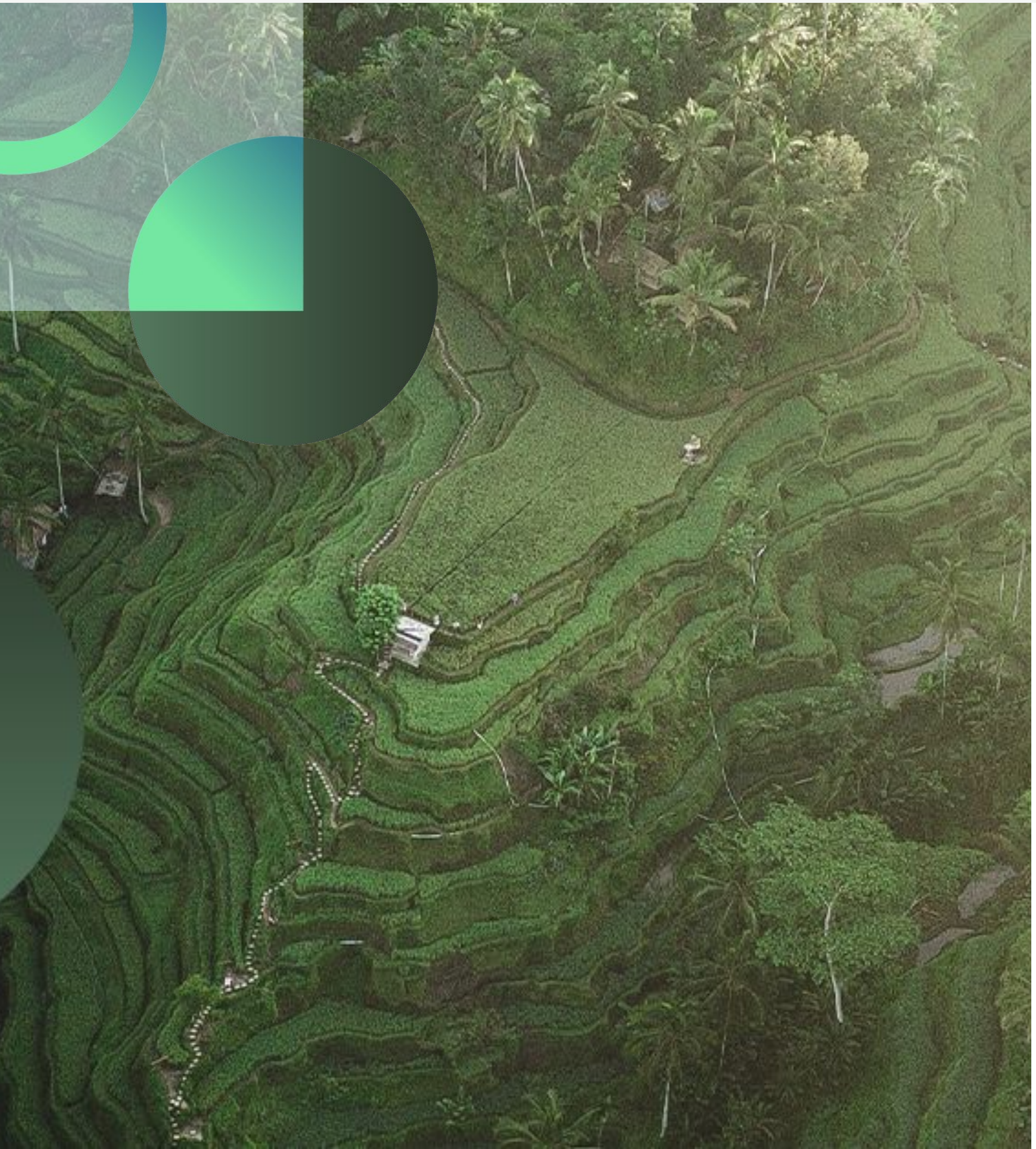
Example trading interface

Demonstration:

FLINTpro: building models, reviewing results



Questions

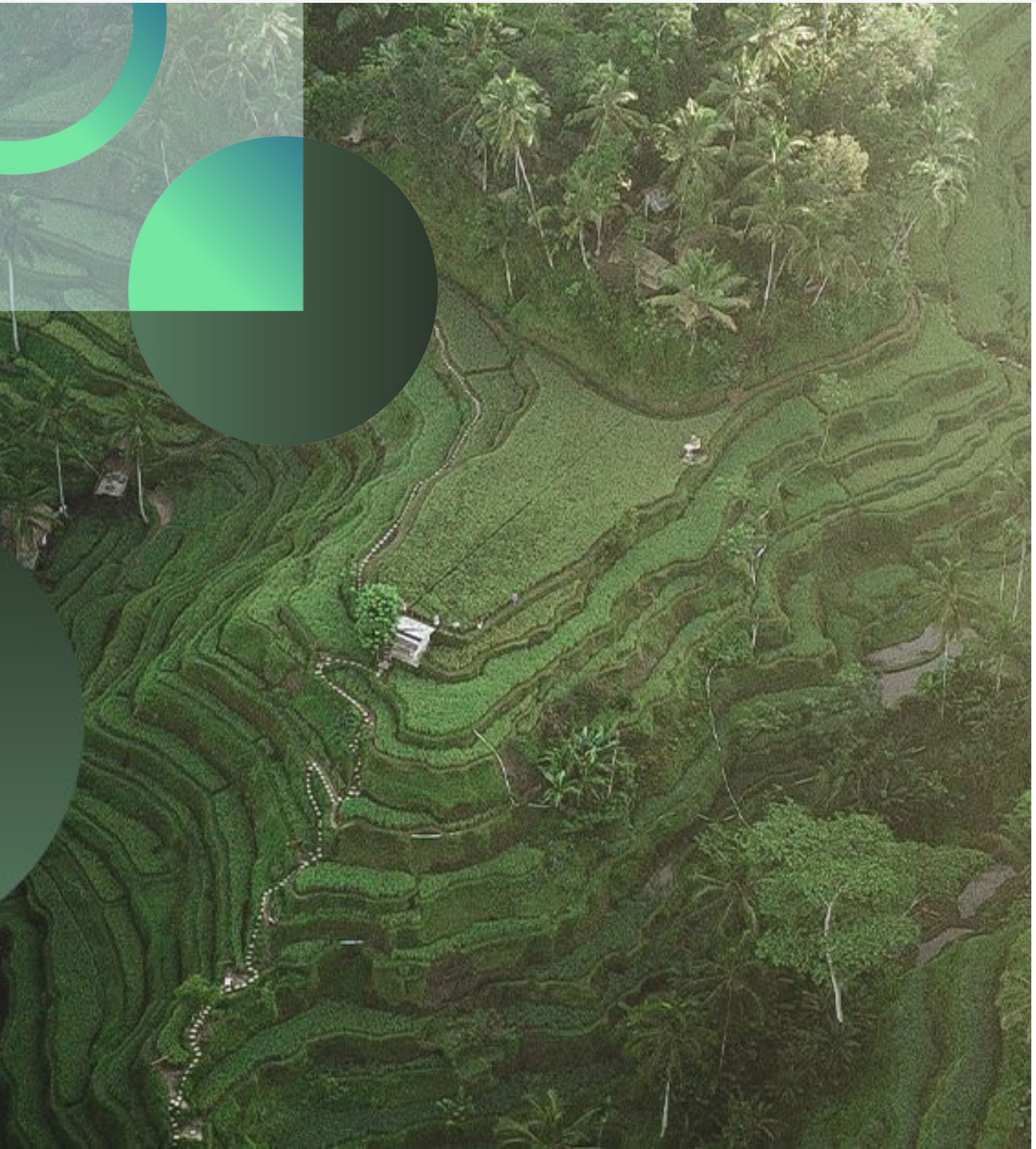


DAY 4

moja global

Contributing to moja global and the FLINT: creating a community of users

2 September 2021; 08:30 - 10:30



The core aspect of moja global is to foster collaboration between countries on the use of advanced MRV tools for the land sector.

This section will address how to work with and contribute to moja global to reduce costs, increase reliability and support broader use.

- Management structure of moja global, and how to become involved.
- Contributions to the FLINT code: examples from Google summer of code/documentation, country support (Canada), corporate support (Mullion), government support (UNFCCC, Kenya, Canada, Australia, USA)
- How to contribute, types of contributions and what contribution means.
- Development of new models for use with the FLINT, including deforestation prediction algorithms, new emissions models and other metrics

What sort of contributions?

- Code
- Promoting use and contributions
- Provide user feedback, Reporting bugs, FAQs, Test
- Suggesting additional functionality
- Documentation of the code, operating manual
- Intros to new contributors, Support users, Write Replies
- Work on the decision making procedures, Write minutes
- Comms materials, Update the website, Write newsletters, Build a mailing list, etc.

moja global

Why Contribute to Open Source?

- Fixing Bugs
- Adding Functionality
- Reduce Dev Cost
- Build Capacity
- Find mentor
- Teach to learn
- Grow Reputation

Your participation is good for moja global

USER:
Visibility, credibility, reputation, attract other users, contributors, service providers, donors

CONTRIBUTOR:
Feedback, lessons, improved code, documentation, features, reliability, funding

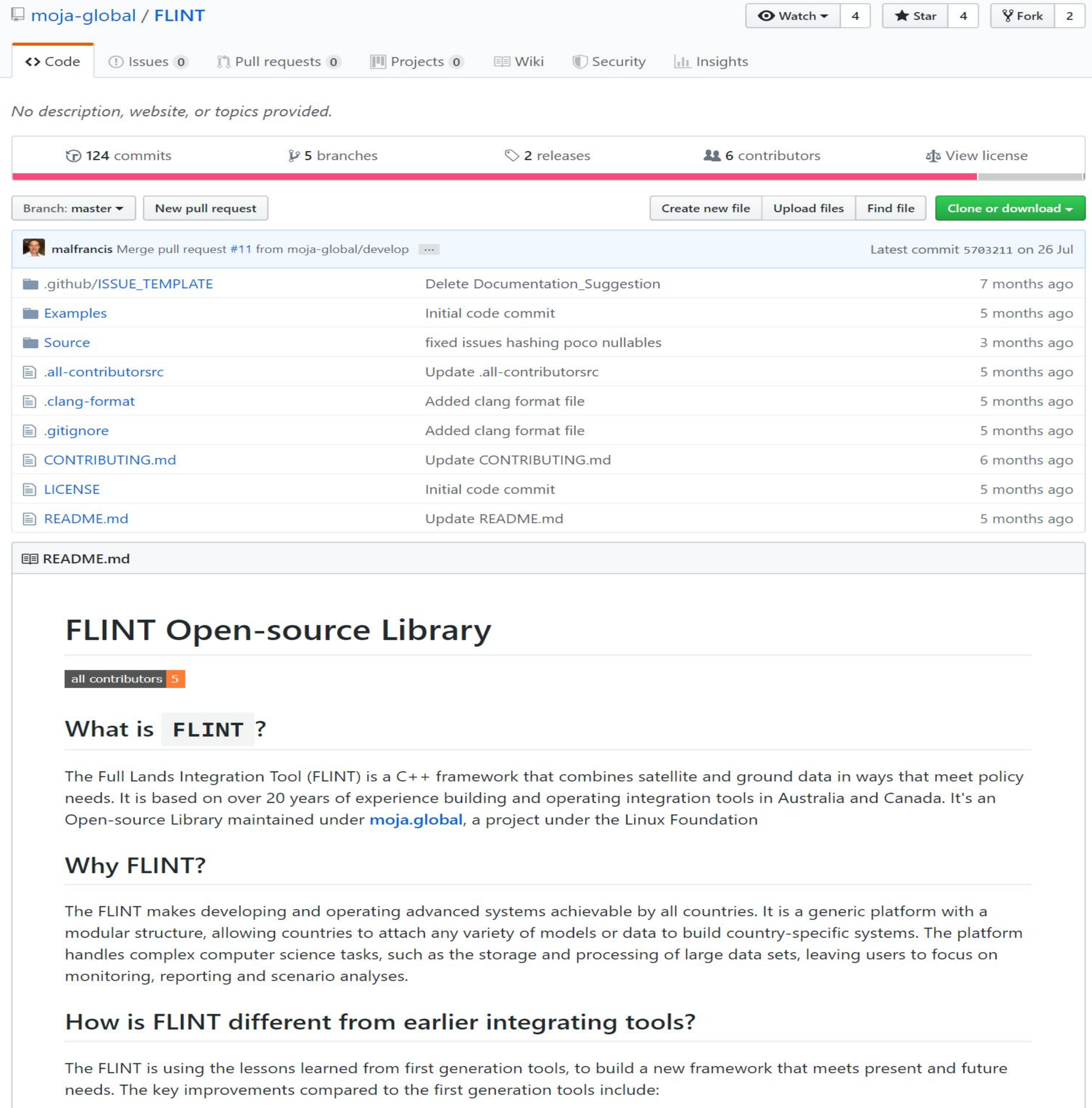
BOARD MEMBER:
Strategy, meet user needs, global exchange of expertise, commitment to collaboration

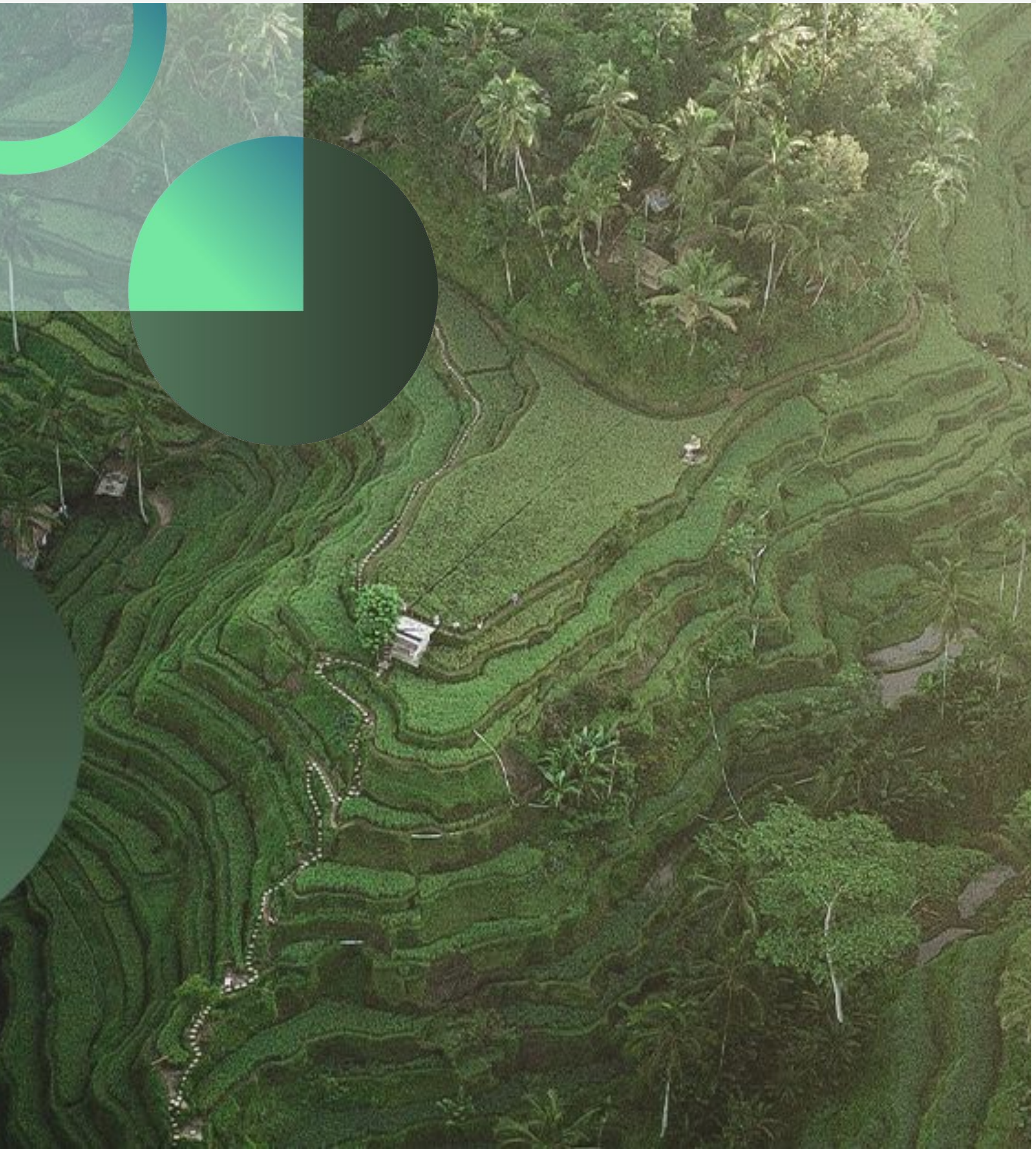
Participation is free

- Licence: Free to use but share improvements
- Licence is Irrevocable: Free forever
- Contributions are voluntary (apart from sharing improvements.)
- Sustainability and Rapid Improvement is dependent on contributions

Demo of the GitHub account

https://github.com/moja-global/FLINT





Summary and questions

moja global

The End