Newton-Bhabha Virtual Centre on **N**itrogen **E**fficiency of **W**hole-cropping **S**ystems for improved performance & resilience in agriculture

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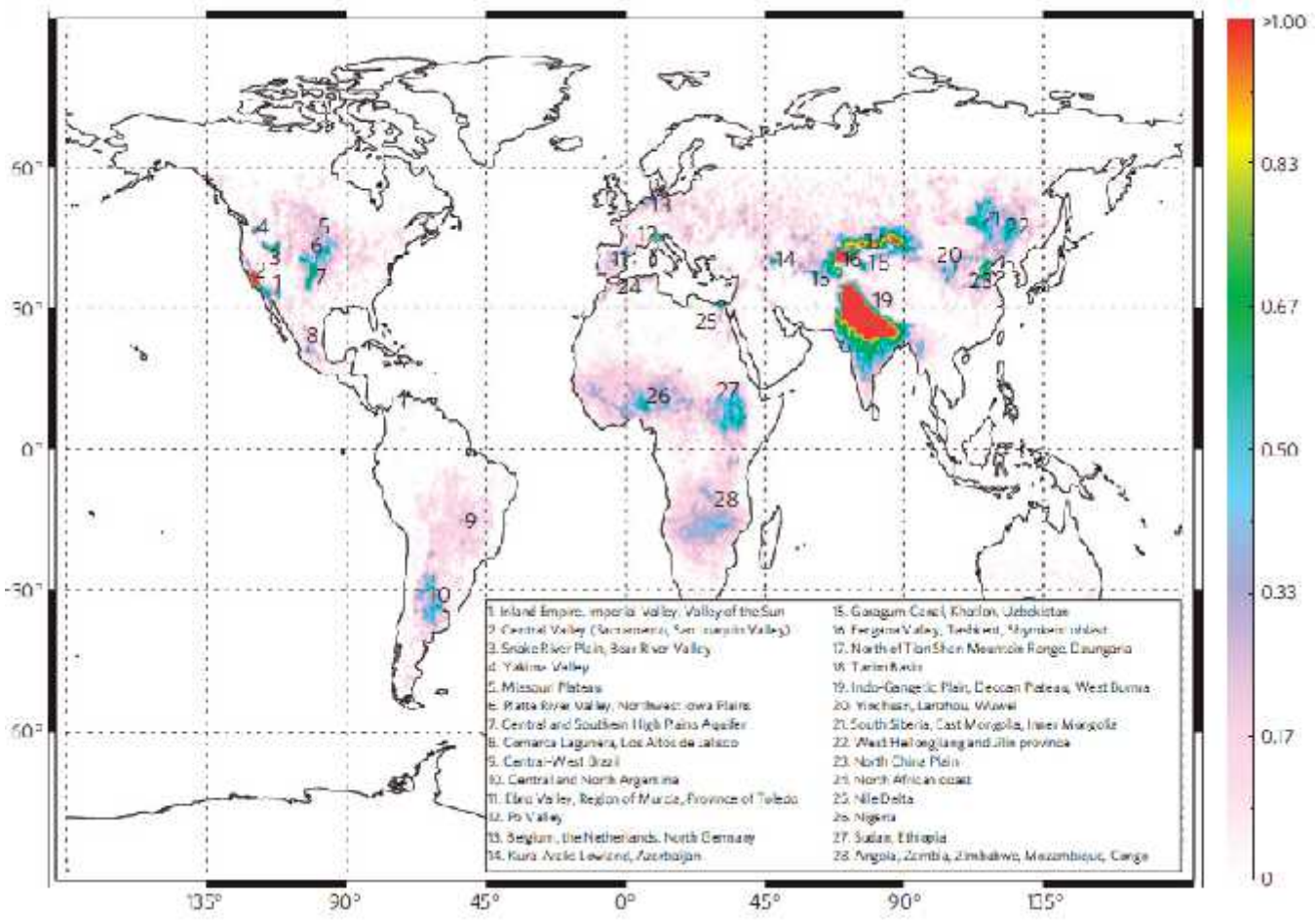
Why India?

A global hotspot for nitrogen losses



Global ammonia column (mg m^{-2}) from IASI satellite
Clarisse et al., *Nature Geoscience*

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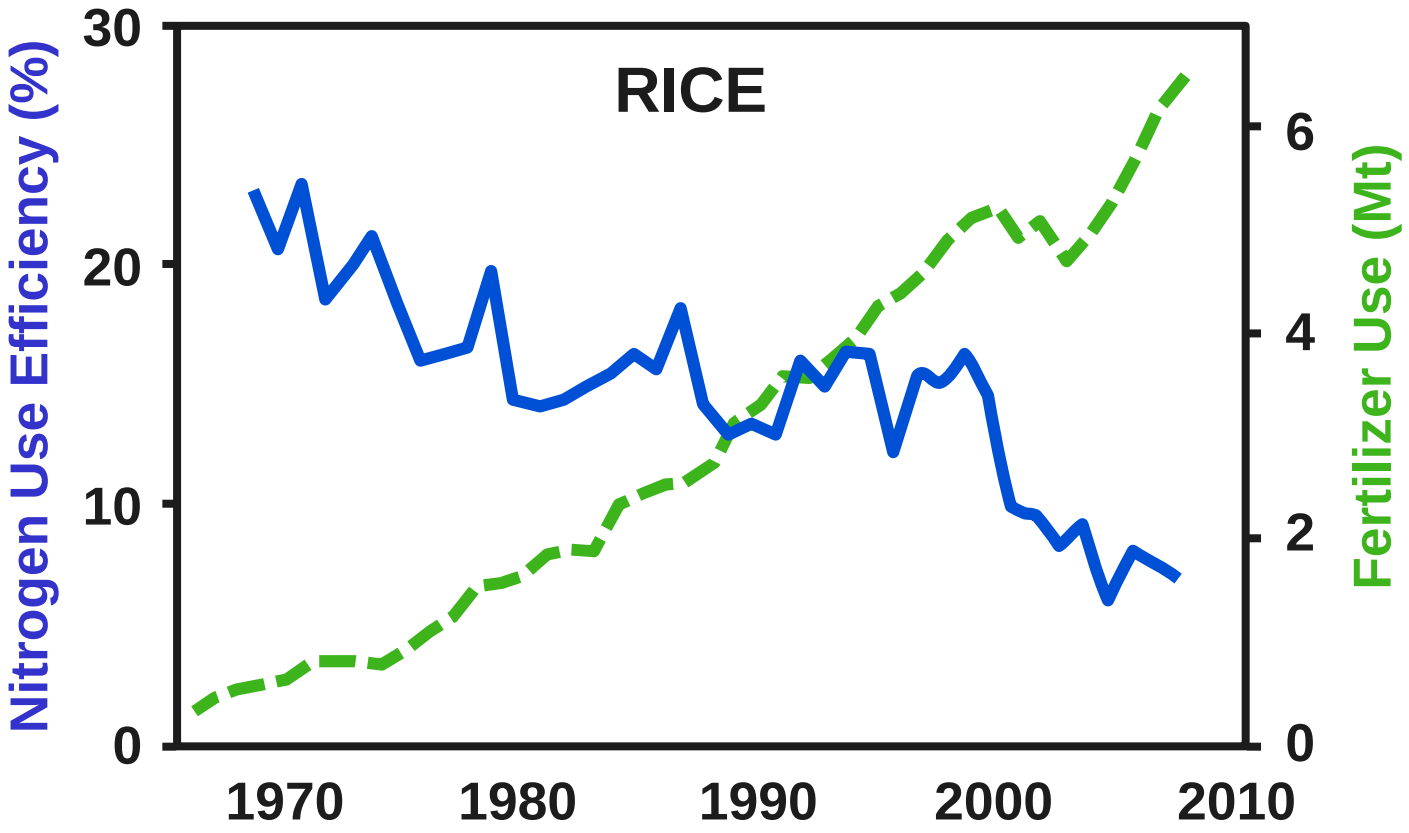
Nitrogen fertilizer use & NUE in India



A 20% increase in National NUE for India:

Saving 2.8 Mt N = £1.7 billion / year

Sutton et al., 2016

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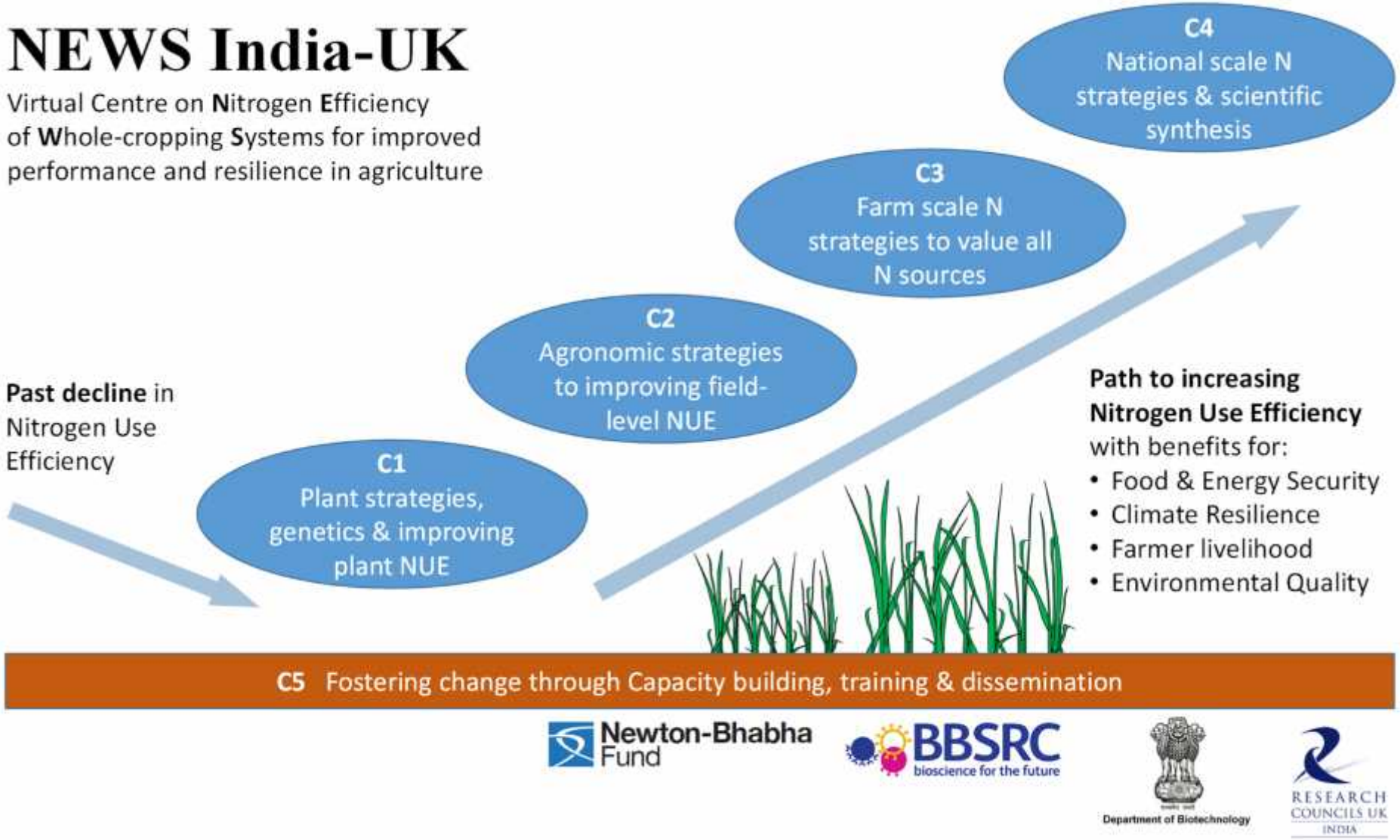
Project structure



Science objectives

1. To characterize and explain plant NUE differences, including phenotypic ranking, functional understanding and existing GM varieties
2. To compare the effectiveness of agronomic, biological and combined approaches to improving NUE
3. To quantify the relationships between NUE improvement and measured reduction in N losses
4. To test how better use of all available N resources can improve farm NUE in rice-wheat rotations
5. To establish a national N agricultural budget for India to examine scenarios of improved N management and resilience, and the associated environmental benefits

Hypotheses

1. Traits for improved plant NUE are coupled to other characteristics including rooting, drought and biochemistry
2. Agronomic ways to limit NH_3 and NO_3^- loss will raise crop NUE while reducing N_2O loss
3. Combining options to improve plant & agronomic NUE will give additive gains
4. Better recycling of organic N sources must address the economic and social barriers

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C1: Plant strategies, genetics & improving plant NUE

Genetic Tools

IIRR panel

120 *Indica* cultivars, 8 seasons, NUE cultivars

To be screened

- Bengal & Assam Association Population (UoA) 300 *aus* cultivars, 2 million markers
- 3000 Genomes project cultivars (IRRI) a subset of 3000 cultivars, unlimited markers
- IIRR crosses (8 high x low NUE cultivars)
- 7,000 activation tagged lines (from UoH)

Nitrogen Use Efficient Rice

Alanine Amino Tranferase (AAT) transgenic products

Validation of candidate genes

Main Outputs

- Superior cultivars
- QTLs for molecular breeding
- Candidate genes
- Validation of Nitrogen Use Efficient Rice

Data acquisition

Field phenotyping

(IPU, IARI, IIRR)

Fields with recommended & low N inputs

- Assess for at least 4 seasons
- Measure field traits + N and C

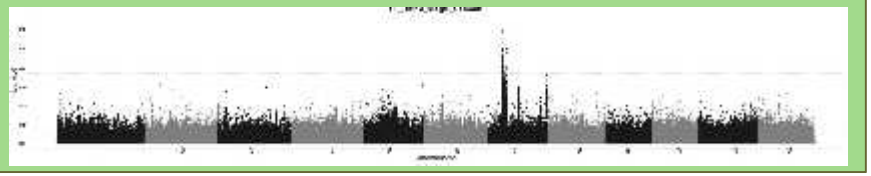
Transcriptomics and Proteomics

(IPU, IIRR) **(AMU)**

3-9 cultivars to be agreed based on performance outcomes

Data analysis

- Genome wide association mapping
- QTL mapping
- Mutant selection
- Transcriptomics and proteomics



C2: Agronomic strategies to improve field-level NUE

IARI, CEH, IPU, IIRR

Stage 1: Agronomic options Review & test performance at the field scale.

- Fertilizer & org. placement, slow release, inhibitors, (urease, [de-]nitrification etc).
- Focus on rice-wheat rotations.
- Jointly establish full N fluxes: incl. micromet, ^{15}N & org N

Outputs

- NUE & N loss coupling shown
- 'Most Promising' methods agreed

Stage 2: Combine agronomic & plant NUE options

Test synergies at the field scale

- Leading agronomic & plant options applied in comprehensive experiment with stats support.
- Field AAT GM if permission
- Full performance assessment, with all N losses measured.

Outputs

- Combined performance demonstrated
- Quantification of the synergies

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C2: Experiment 1

Assessment of NUE & fluxes as affected by sources, timing and N management practices in rice-wheat cropping system

Treatments

1) Control (No N)
2) Prilled urea
3) Neem coated urea (NCU)
4) Sensor based water application + NCU (LCC based application)
5) 50% N through farmyard manure + 50% N though NCU + biofertilizers

Measurements

- Phenological crop growth stages
- Crop growth and yield
- NH_3 volatilization
- N_2O emission
- NO_3^- leaching
- Soil Available N
- N uptake

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C2: Experiment 2

Field screening of rice genotypes for higher nitrogen use efficiency

Treatments

- Neem coated urea (NCU)
- N doses - 3 (0, 50% RDN, 100% RDN) RDN- Recommended dose of N
- Genotypes: 10

Measurements

- Soil Available N
- N uptake in straw and grain
- Residual Soil Fertility
- NUE, Agronomic Use Efficiency
- Leaf area index, dry matter accumulation
- Biomass partitioning and yield
- Grain quality parameters

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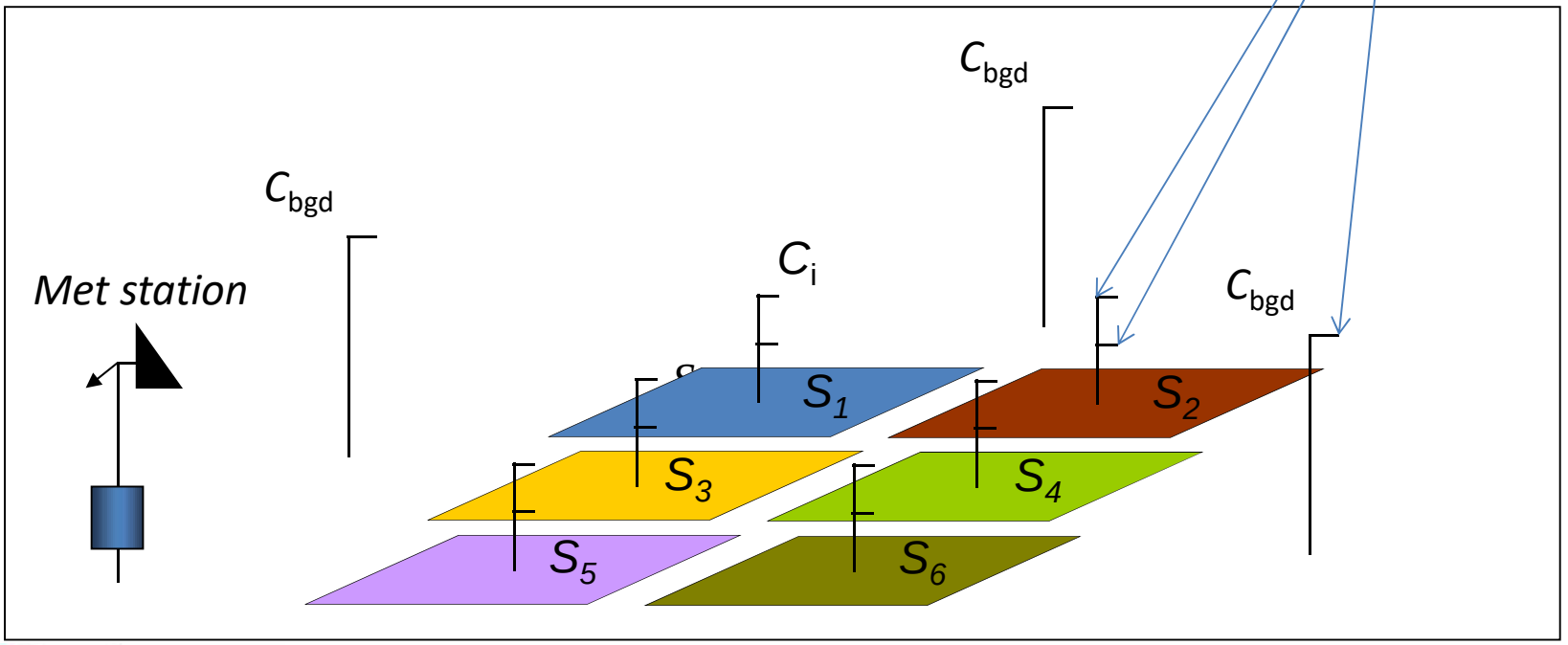
C2: Planned fieldwork for next year

- Campaign NH_3 different methods (e.g. comparing chamber with gradient method)
- New method INRA (passive samplers & modelling)

  1) Source inferred with FIDES-3D or Windtrax

  Loubet et al. 2001, 2009, 2010, Carozzi 2012

  2) Aerodynamic gradient close to the ground



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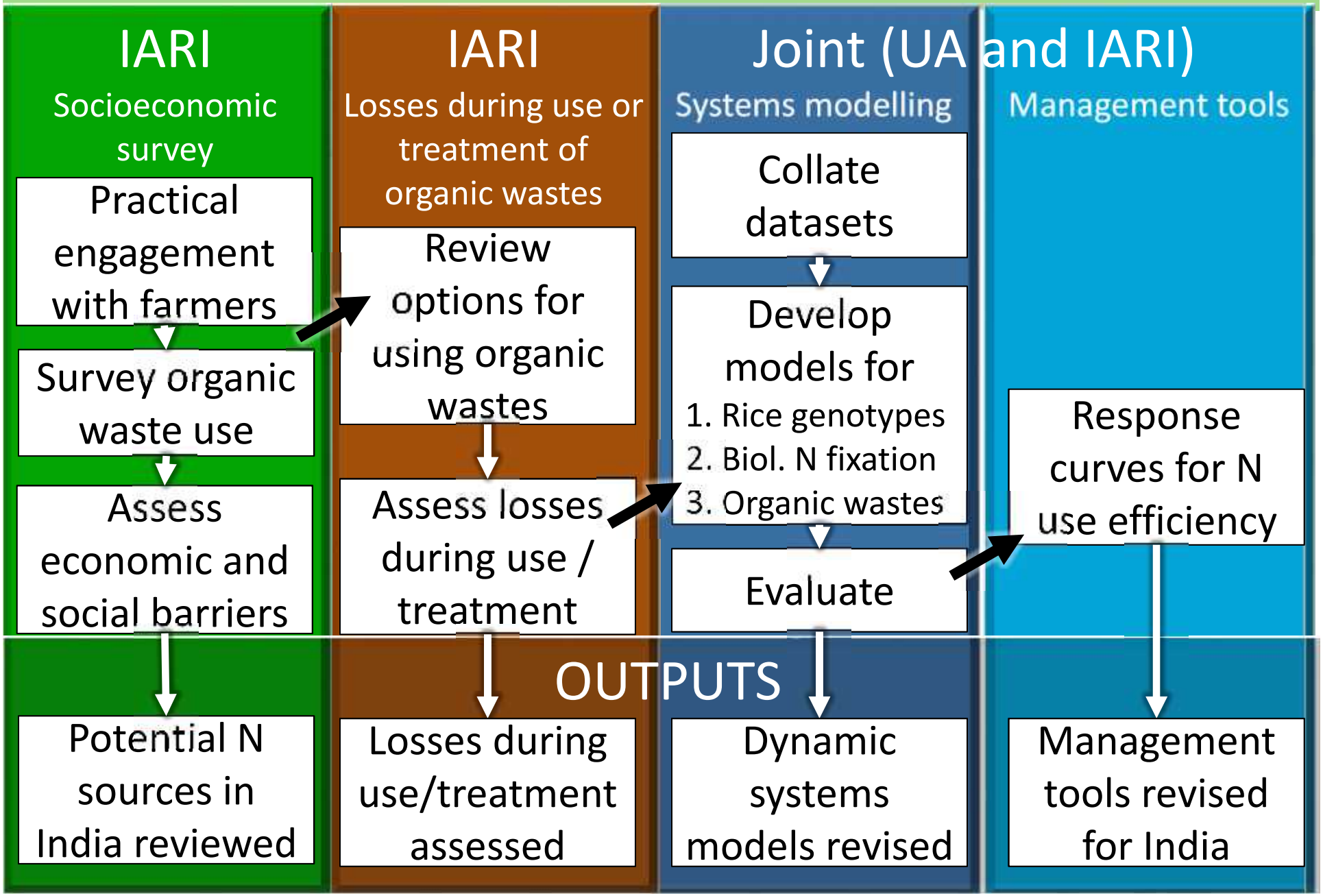
C3: Farm scale strategies to value all N sources



C4: National N Strategies & Scientific Synthesis

Stage 1: Refine agricultural N budget for India

- Share expertise on NH_3, N_2O N_2 & NO_3 emissions models
- Improve data collation to support model application
- Applying national loss models to establish N budget

Stage 2: Synthesize science and address scenarios of change

- Incorporation of findings from C1-C4 and other VJCs.
- Construct scenarios of N saving opportunities & the food, environment & energy benefits.
- Barriers & economic implications.

Outputs

- Key N flows quantified through models with assessed reliability

Outputs

- Materials to support government & others on N opportunities & needs.

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C5: Capacity building, training & dissemination

1. Annual centre workshops plus electronic meetings
2. Senior and Junior Fellowship Scheme (open to researchers outside project): methods training in novel N flux methods, experiments, analysis, writing etc.
3. Stakeholder engagement, nationally and internationally incl. with FAO, UNEP & INMS

Outcomes, Benefits & Impact

- Key advances in rice NUE performance, learning from natural variation and GM techniques
- Capability increase in 'full N fluxes' to show performance and identify the best agronomic options
- Demonstration of extent of synergy between agronomic and plant NUE approaches
- Better valuation all farm organic N sources, highlighting opportunities, providing tools and addressing barriers
- National picture of the potential for increasing resilience in food, energy, climate and environment from better N management
  - India Currently Loses: $10 billion/year as fertilizer value
  - India Societal Costs: $75 (38 to 151) billion/year

⇒ More profitable farming with less pollution

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Thank you!

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