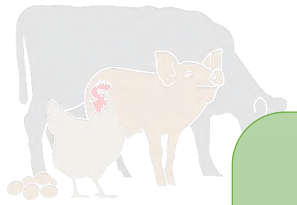
Can BNI-Tropical Forage Bring Double Benefits for Climate Change Mitigation? - A Case Study in South American Cattle Grazing

Manabu Ishitani
Crops for Nutrition and Health
m.ishitani@cgair.org

COP27 Side Event Seminar by MAFF of Japan
November 12, 2022, Egypt

Why are Livestock and Forages Important: The Facts



17

The estim
lives

*(including cattl
and about a d
guinea f*

About **two-thirds** of the world's total agricultural area

The value of livestock as a global asset reaches

USD3.1
ON

for some
illion jobs

How can we reduce the environmental footprint in cattle production systems?

~200 MHa

In **America Latina alone**, have been **degraded** by **overgrazing** and other **unsustainable** production practices.

livestock to climate change, which is about

8.1 billion tCO_2eq

50% Of total agricultural emissions

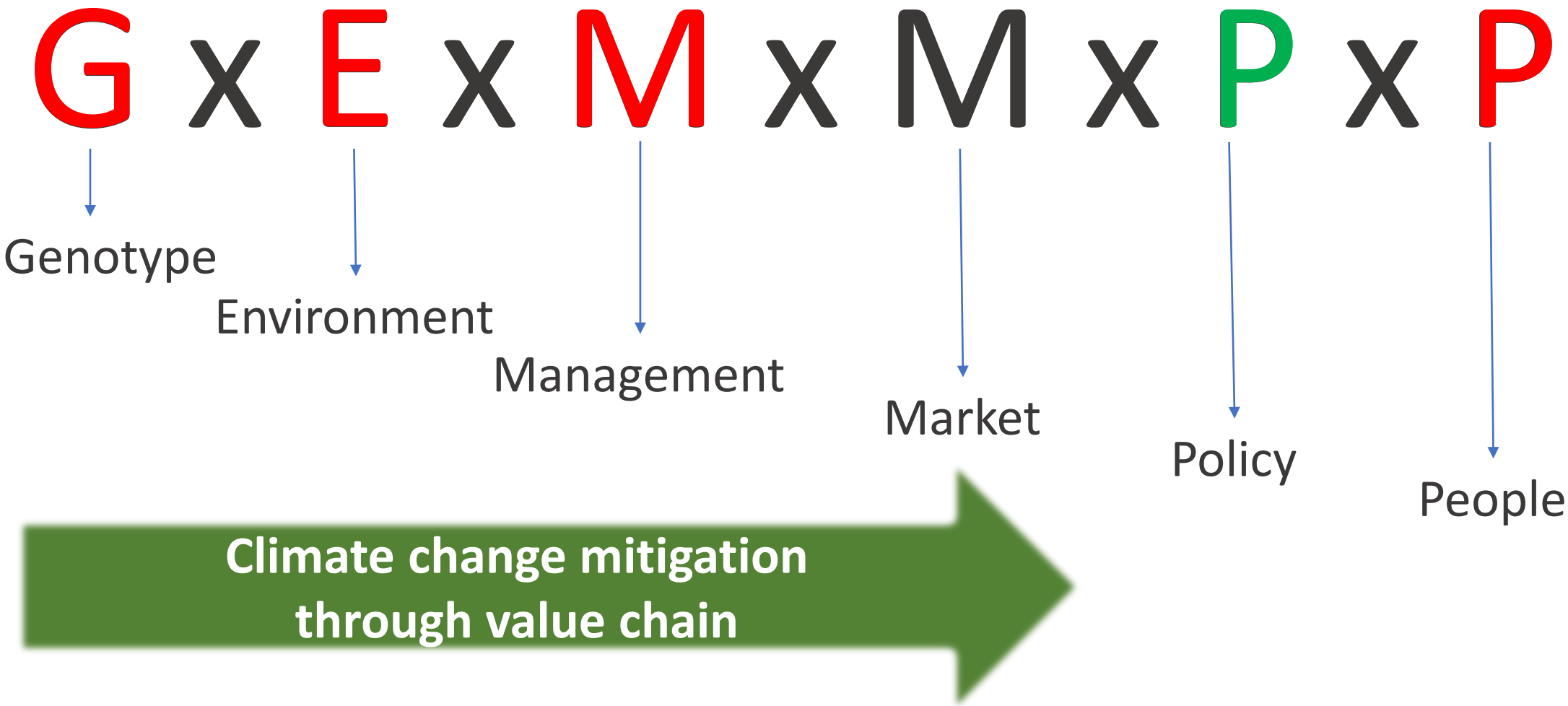
15% of all human-induced greenhouse gas emission

These includes emissions from **deforestation** to make way to pastures

Peters et al., 2013

Alliance Bioversity & CIAT | CGIAR

Sustainability in Agriculture: Complicated



Our Challenges and Strategies in R&D

Challenges: Can we develop **solutions** to **lower GHG emissions** and **actively remove carbon** from the atmosphere through cattle grazing at the farm level?

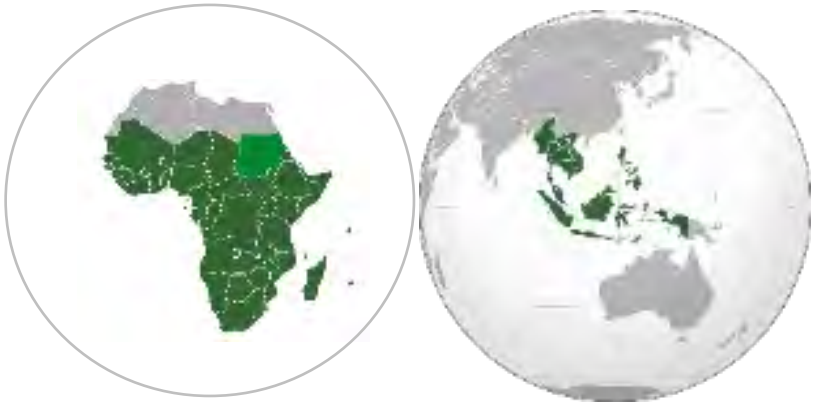
Strategies:

Genetic Mitigation **+ Agronomic** Mitigation

A Variety of Livestock Production Systems in the Global South

Latin America & the Caribbean

Permanent grasslands



Sub-Saharan Africa & Southeast Asia

photo credit: ILRI/Alan Duncan

Cut and carry

Alliance Bioversity & CIAT

CGIAR

Genetic mitigation

Agrobiodiversity – the Key to Food Security, Climate Adaptation, Mitigation and Resilience

37,987
Bean accessions

6,643
Cassava accessions

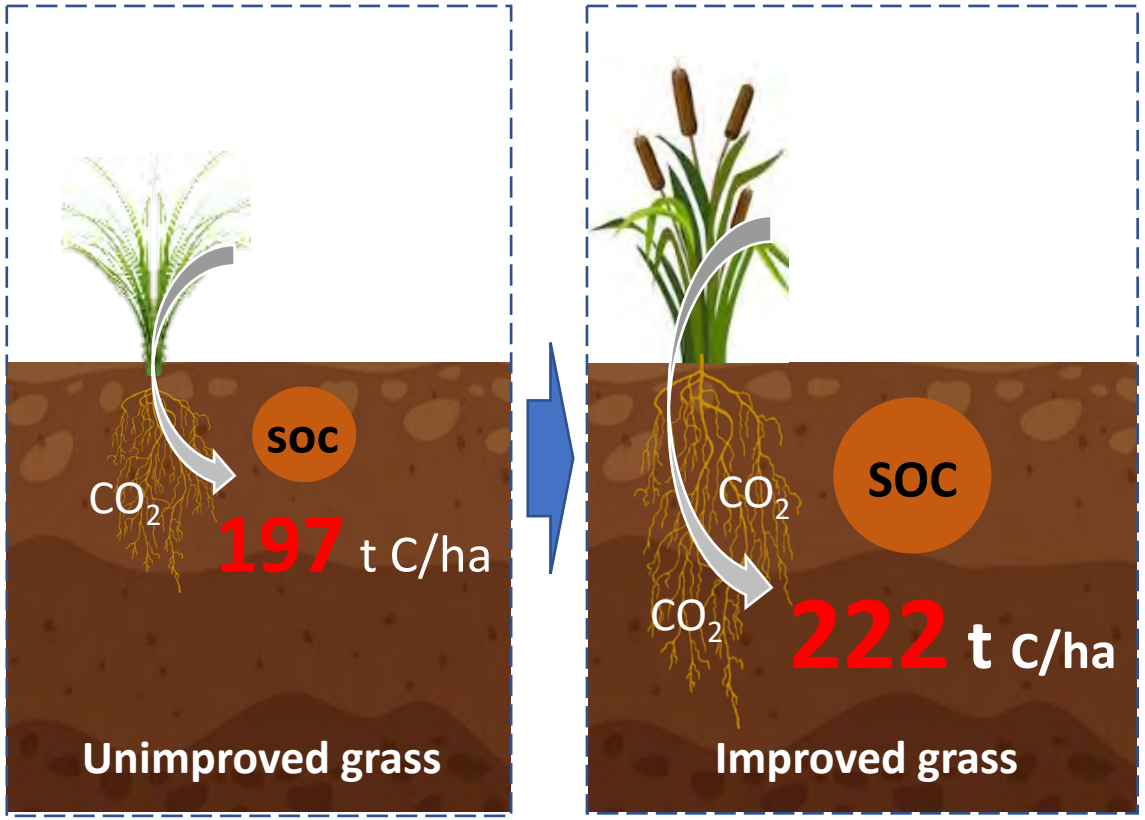
44,000
Tropical forage accessions

Alliance germplasm (gene) bank:
Conserving the world's largest collections of beans, cassava and tropical forages

Alliance Bioversity & CIAT
CGIAR

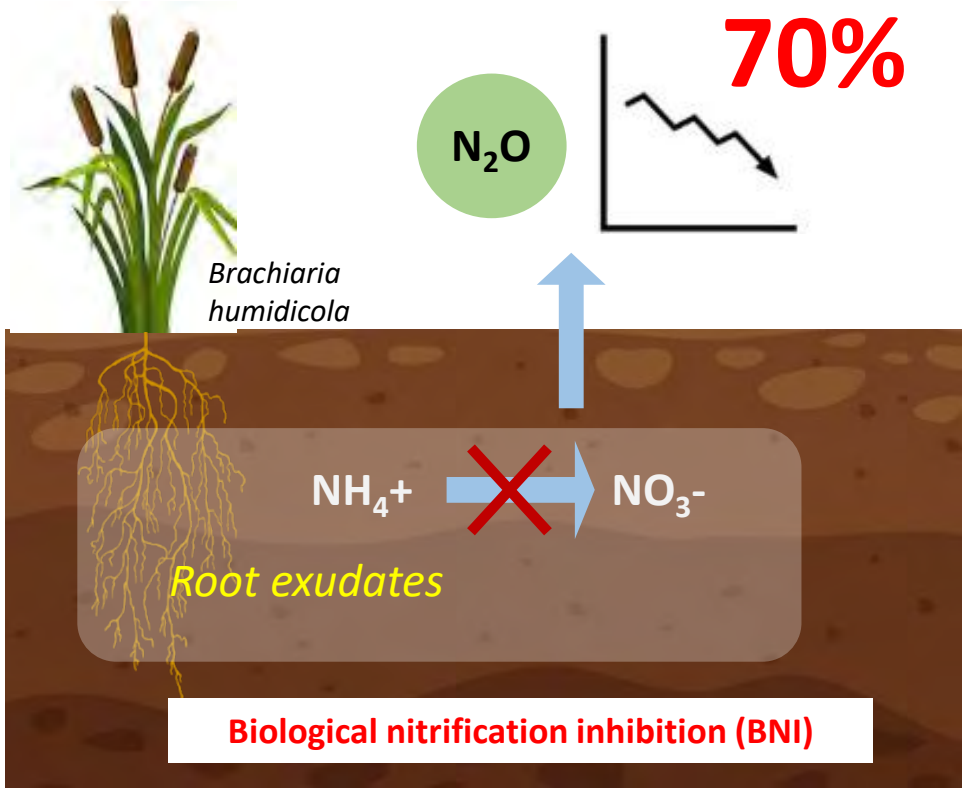
Super Grass with Two Benefits for Climate Change Mitigation

Carbon sequestration into soil



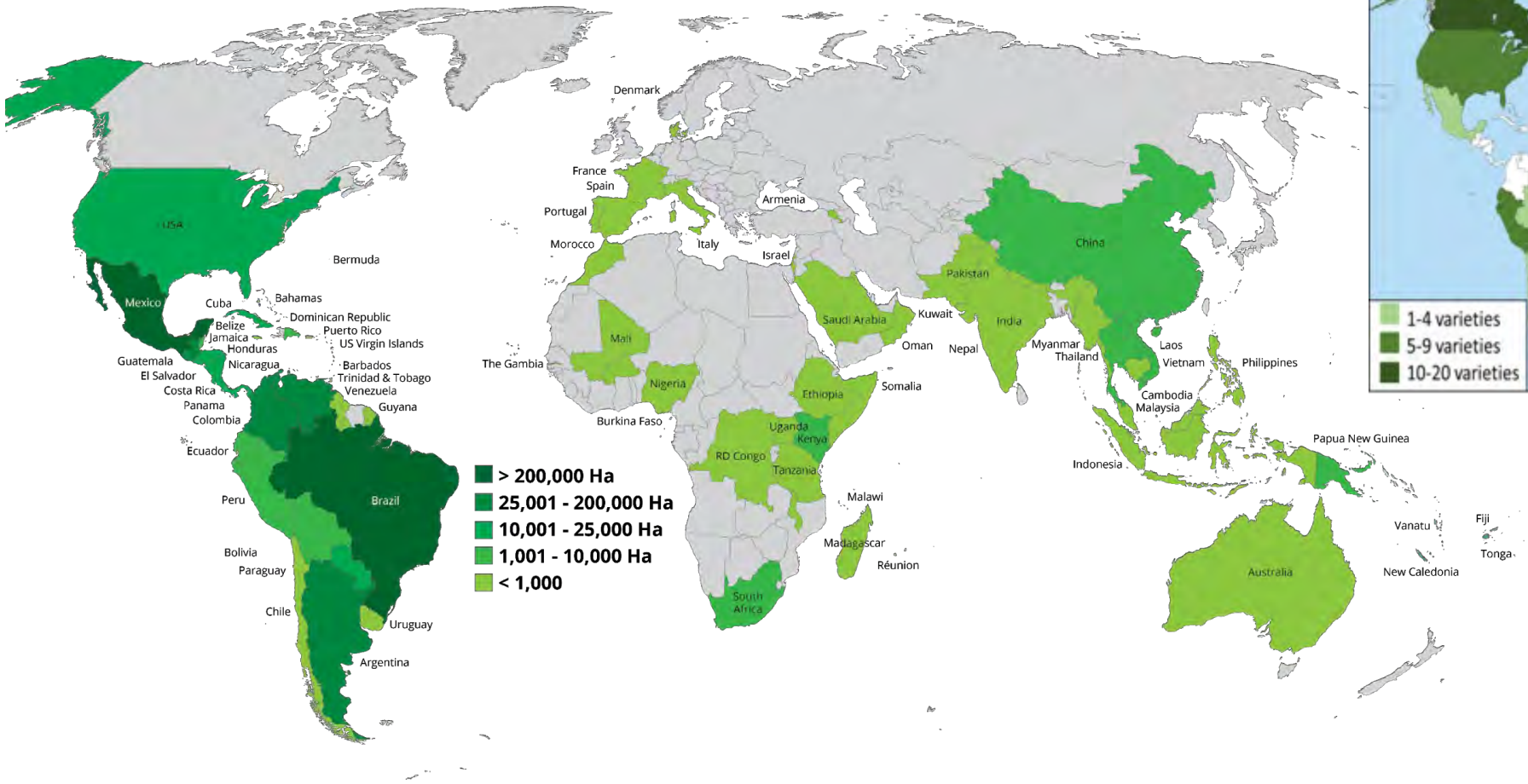
Fisher *et al*. 1994. Letters to Nature

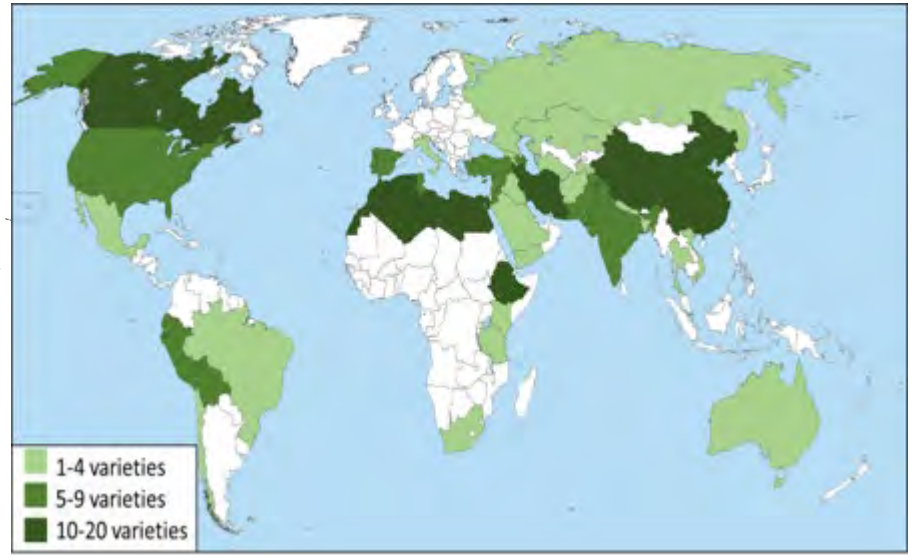
Lower N_2O emissions



Subbarao *et al*. 2009. PNAS

Scaling: Global Uptake of CGIAR Brachiaria: Rapid Growth in Latin America since 2001, Expanding in East Africa Since 2018





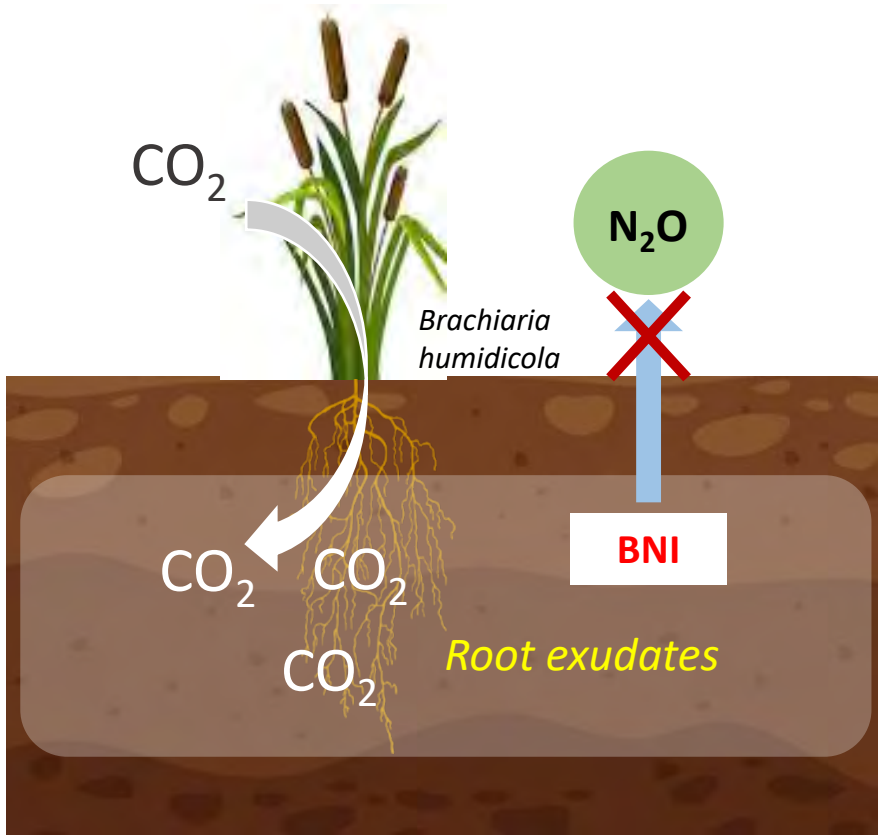
Alliance Bioversity & CIAT

CGIAR

How to Best Use Improved Grasses for Measurable Impacts?

Genetic Mitigation

"Super grass"



G x **E** x **M**

\+ **Agronomic** Mitigation

Field Trial at CIAT HQ to Test Productive and Environmental Parameters with Grass-Legume Combinations

Agronomic mitigation

Treatments:

T1: *Brachiaria brizantha* cv Toledo.
T2: *Brachiaria brizantha* cv Toledo + *Canavalia brasiliensis.*
T3: *Brachiaria brizantha* cv Toledo + *Canavalia brasiliensis* + *Leucaena diversifolia.*
T4: *Brachiaria* hybrid cv Cayman.
T5: *Brachiaria* hybrid cv Cayman + *Canavalia brasiliensis.*
T6: *Brachiaria* hybrid cv Cayman + *Canavalia brasiliensis* + *Leucaena diversifolia.*

T1 T2 T3 T5 T4 T6
T3 T1 T2 T4 T6 T5
T2 T3 T1 T6 T5 T4

Better Agronomic Practices Matters for the Mitigation

Results

Experimental field

10.6 ha
Naturalized pasture

90%
reduction

3.1 ha
Brachiara humidicola

1.2 ha
Hybrid.
Cayman +
Canavalia

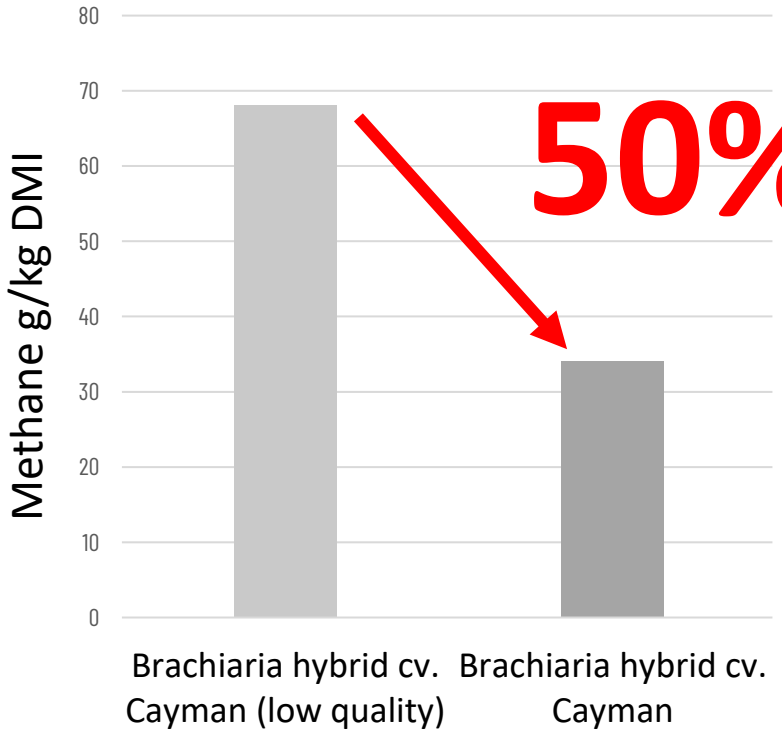
Projection of the area needed to produce **800kg/cattle live weight/year**

Implications

+

Grazing Management is Key to Enteric Methane Emission

***Brachiaria* hybrid cv. Cayman**



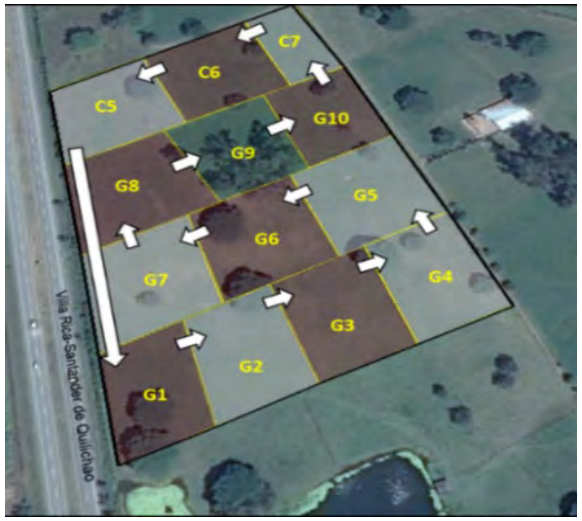
50% reduction

Gaviria *et al.* 2020. Front. Vet. Sci

Deployment of Solutions and Scaling Up at Farm Level

Target farms

MAFF project sites

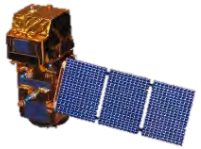


Campina farm
Plot size: 0.26 and 0.54 ha

Inputs

Remote sensing data

Drone



Satellite

Ground-truth data

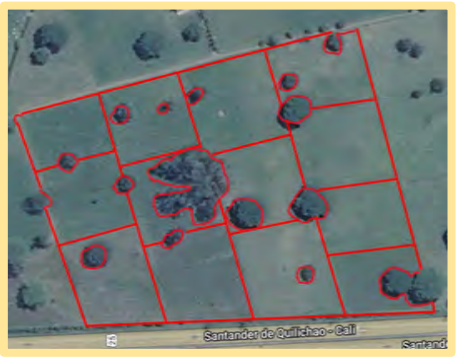
Expected outputs

- Find **overgrazing plot/area**
- **Predict biomass** in each plot at a scale for the **best rotation schedule**
- **Effectively manage** grazing plots with **digital tools**

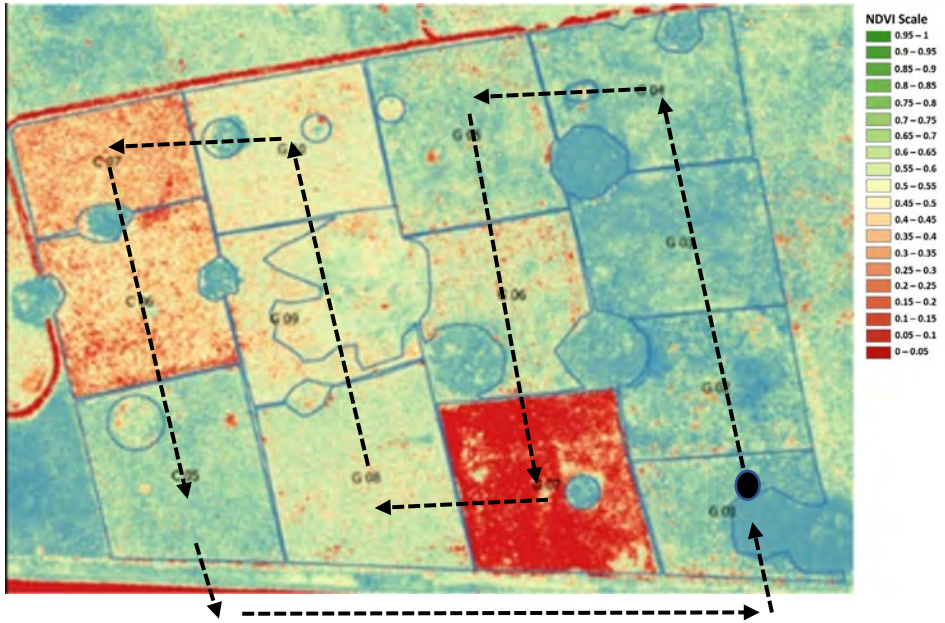
Data-driven grazing management

Alliance Bioversity & CIAT
CGIAR

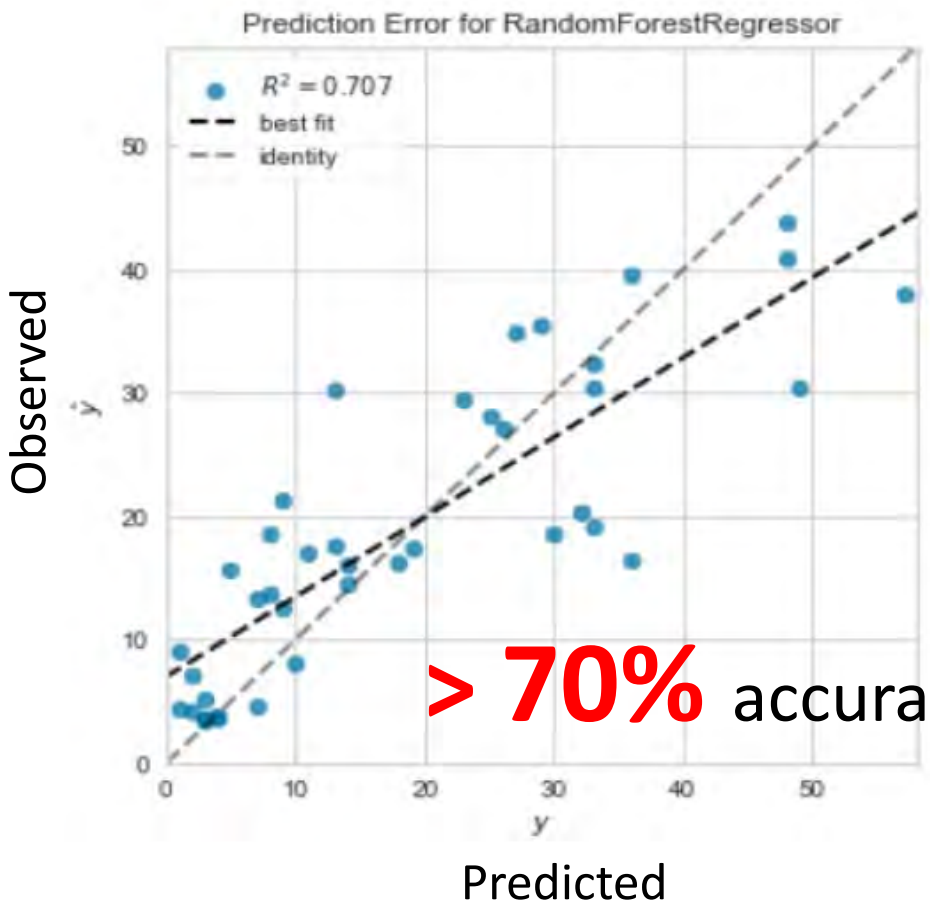
Biomass Prediction by AI Model for Precise Grazing Management



Vegetation index map
by drone data



Cattle grazing plots with rotation at Campina farm

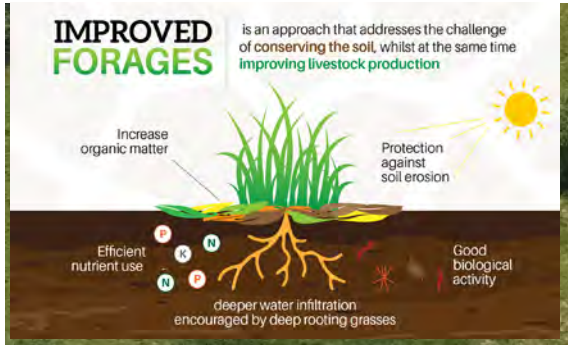


Alvarez-Mendoza *et al.* 2022 Remote Sensing submitted

Alliance Bioversity & CIAT

CGIAR

Best Mix Scenario for Productivity and Environment



High BNI Brachiaria hybrids
Treatments:
1)675
2)675 + *Centrosema molle*
3)679
4)679 + *Centrosema molle*
5)1149
6)1149 + *Centrosema mole*

6 treatments and 3 blocks

Concluding Remarks – Moving Forward

"**Green recovery**" in **ag-food systems** is paramount to achieving **net zero GHG emissions by 2050** while sustaining productivity

- ✓ Well-managed tropical forages can help intensify production in less area (**sustainable intensification**)
- ✓ Some improved grasses exhibit **BNI** abilities that increase NUE and **reduce nitrous oxide emissions**
- ✓ **Grazing management and productive grasslands** are crucial to **reducing emissions**

- ❑ **Inclusive agricultural value chain** to facilitate the **transformation**
- ❑ **Digital inclusion of youth** to create ag-food jobs in the green recovery

Alliance Bioversity & CIAT CGIAR

References

1. D. M. Villegas, A.Arévalo, M. Sotelo, J.Nuñez, D. Moreta, I. Rao, M. Ishitani, G.V. Subbarao, J. Arango (**2022**) Phenotyping of Urochloa humidicola grass hybrids for agronomic and environmental performance in the Piedmont region of the Orinoquian savannas of Colombia. **Grass and Forage Science** 2022**:**1-10. DOI: 10.1111/gfs.12582
2. C.I. Alvarez-Mendoza, D. Guzman, J. Casas, M. Bastidas, J. Polanco, M. Valencia, F. Montenegro, J. Arango, M. Ishitani and M. Selvaraj (**2022**) Predictive Modeling of Above-ground Biomass in Brachiaria Pastures from Satellite and UAV Imagery using Machine Learning Approaches **Remote Sensing** Submitted
3. Lombardi, B., Loaizab, S., Trujillo, C., Arevalo, A., Vázquez, E. Arango, J. and Chirinda., N. (**2022**). Greenhouse gas emissions from cattle dung depositions in two *Urochloa* forage fields with contrasting biological nitrification inhibition (BNI) capacity. **Geoderma** 406:115516. doi: 10.1016/j.geoderma.2021.115516 / Handle / Google Scholar
4. Notenbaert AMO., Douxchamps S., Villegas DM., Arango J, Paul BK., Burkart S., Rao I., Kettle CJ., Rudel T., Vázquez E., Teutscherova N., Chirinda N., Groot JCJ., Wironen M., Pulleman M., Louhaichi M., Hassan S., Oberson A., Nyawira SS., Pinares-Patino CS. and Peters M (**2021**) Tapping Into the Environmental Co-benefits of Improved Tropical Forages for an Agroecological Transformation of Livestock Production Systems. ***Front. Sustain. Food Syst.*** 5:742842.
5. Canisares, L.P., Rosolem, C.A., Momesso, L., Costa, C.A., Villegas, D.M**.,** Arango, J., Ritz, K., Cantarella, H. (**2021**). Maize-Brachiaria intercropping: A strategy to supply recycled N to maize and reduce soil N2O emissions?. **Agriculture, Ecosystem, and Environment**. 319: 107491.
6. Gaviria, X., Bolivar, D., Rosenstock, T., Molina-Botero, I.C., Chirinda, N., Barahona, R., Arango, J. (**2020**). Nutritional quality, voluntary intake and enteric methane emissions of diets based on novel Cayman grass and its associations with two *Leucaena* shrub legumes. ***Front. Vet. Sci.*** 1. 7:764. doi: 10.3389/fvets.2020.579189 / Handle / Google Scholar
7. Triviño NJ, Perez JG, Recio ME, Ebina M, Yamanaka N, Tsuruta S, Ishitani M and Worthington M (**2017**) Genetic diversity and population structure of Brachiaria species and breeding populations. **Crop Science** 57:2633–2644.doi: 10.2135/cropsci2017.01.0045
8. N. Chirinda, L. Arenas, S Loaiza, C. Trujillo, M. Katto, P. Chaparro, J. Nuñez, J. Arango, D. Martinez-Baron, AM. Loboguerrero, LA. Becerra Lopez-Lavalle, I. Avila, M. Guzmán, M. Peters, J. Twyman, M. García, L. Serna, D. Escobar, D. Arora, J. Tapasco, L. Mazabel, F. Correa, M. Ishitani, M. Da Silva, E. Graterol, S. Jaramillo, A. Pinto, A. Zuluaga, N. Lozano, R. Byrnes, G. LaHue, C. Alvarez , I. Rao and R. Barahona (**2017**) Novel Technological and Management Options for Accelerating Transformational Changes in Rice and Livestock Systems. **Sustainability** 9, 1891; doi:10.3390/su9111891
9. G.V. Subbarao,, J. Arango, K. Masahiro, A.M. Hooper, T. Yoshihashi, Y. Ando, K. Nakahara, S. Deshpande, I. Ortiz-Monasterio, M. Ishitani, M. Peters, N. Chirinda, L. Wollenberg, J.C. Lata, B. Gerard, S. Tobita, I.M. Rao, H.J. Braun, V. Kommerell J. Tohme., M. Iwanaga. (**2017**) Genetic mitigation strategies to tackle agricultural GHG emissions: The case for biological nitrification inhibition technology. **Plant Science** 262 165-168.
10. I. RAO., M.Ishitani., et al. (**2014**) Climate-smart crop-livestock systems for smallholders in the tropics: Integration of new forage hybrids to intensify agriculture and to mitigate climate change through regulation of nitrification in soil. **Tropical Grasslands** 2: 130−132
11. Subbarao GV, Sahrawat KL, Nakahara K, Rao IM, Ishitani M, Hash CT, Kishii M, Bonnett DG, Berry WL, Lata JC (**2013**) A paradigm shift towards low-nitrifying production systems: the role of biological nitrification inhibition (BNI). **Ann Bot.** 112:297-316.
12. G. V. Subbarao,, K. Nakahara, M. P. Hurtado, H. Ono, D. E. Moreta, A. F. Salcedo, A. T. Yoshihashi, T. Ishikawaa, M. Ishitani, M. Ohnishi-Kameyama, M. Yoshida, M. Rondon, I. M. Rao, C. E. Lascano, W. L. Berry, and O. Ito (**2009**) Evidence for biological nitrification inhibition in Brachiaria pastures. **Proc. Natl. Acad. Sci. U.S.A**. 106: 17302–17307
13. M.J. Fisher, I.M. Rao, M.A. Ayarza, C.E. Lascano, J.I. Sanz,, R.J. Thomas & R.R. Vera (**1994**) Carbon storage by introduced deep-rooted greases in the South American savanna. **Nature**. 371: 236-238.

Alliance Bioversity & CIAT

CGIAR

Thank you!

Manabu Ishitani, Ph.D.
Crops for Nutrition and Health
m.ishitani@cgiar.org
WhatsApp: +57 3205667474