



International
Biochar
Initiative

Biomass Residue to Carbon Dioxide Removal: Quantifying the Global Impact of Biochar

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What's the global potential of biochar?

nature
geoscience

REVIEW ARTICLE

<https://doi.org/10.1038/s41561-021-00852-8>



Biochar in climate change mitigation

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Global Change Biology

Global Change Biology (2016) 22, 1315–1324, doi: 10.1111/gcb.13178

Soil carbon sequestration and biochar as negative emission technologies

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nature
COMMUNICATIONS

OPEN

ARTICLE

Received 29 Oct 2009 | Accepted 14 Jul 2010 | Published 10 Aug 2010

DOI:10.1038/ncomms1053

Sustainable biochar to mitigate global climate change

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Energy 36 (2011) 2011–2016

Contents lists available at ScienceDirect



ELSEVIER

Energy

journal homepage: www.elsevier.com/locate/energy



Biochar as a viable carbon sequestration option: Global and Canadian perspective

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Objective

$$\text{GHG}_{\text{bs}} = \left\{ \sum_i [M_{\text{fs},i} \times Y_i \times F_{\text{C},i}] \times F_{\text{perm}} \times 44/12 \right\} - \text{GHG}_{\text{bp}}^*$$

- Include use of only waste derived feedstocks
- 30% of total crop residues are retained in the field.
- Effects on priming, yield, or GHG emissions from soil are not included.
- Produced at temperature $\geq 600^\circ\text{C}$
- Biochar is the sole product of the pyrolysis process
- Biochar permanence factor (F_{perm}) is a function of soil temperature only
- Net CDR is based only on biochar carbon sequestration.

* Based on: Woolf D, et al.(2021). Greenhouse gas inventory model for biochar additions to soil.
<https://doi.org/10.1021/acs.est.1c02425>



Framework application - 155 countries

Data

- Open data resources (FAOSTAT, WHO, etc.)
 - Crop residues,
 - Manure,
 - Forest and wood waste, and
 - Biosolids
- literature sources
 - Biochar mass yield,
 - Organic carbon fraction
- Average soil temperature of agricultural land
 - Permanence factor

Emissions

- Literature and databases
 - Activity data
 - Emission Factors
- Monte Carlo methodology
 - Uncertainty
- Include
 - Loading operations
 - Transportation (country specific)
 - Pyrolysis pre-heating
 - Electricity (country specific)
 - Plant construction
 - Field application



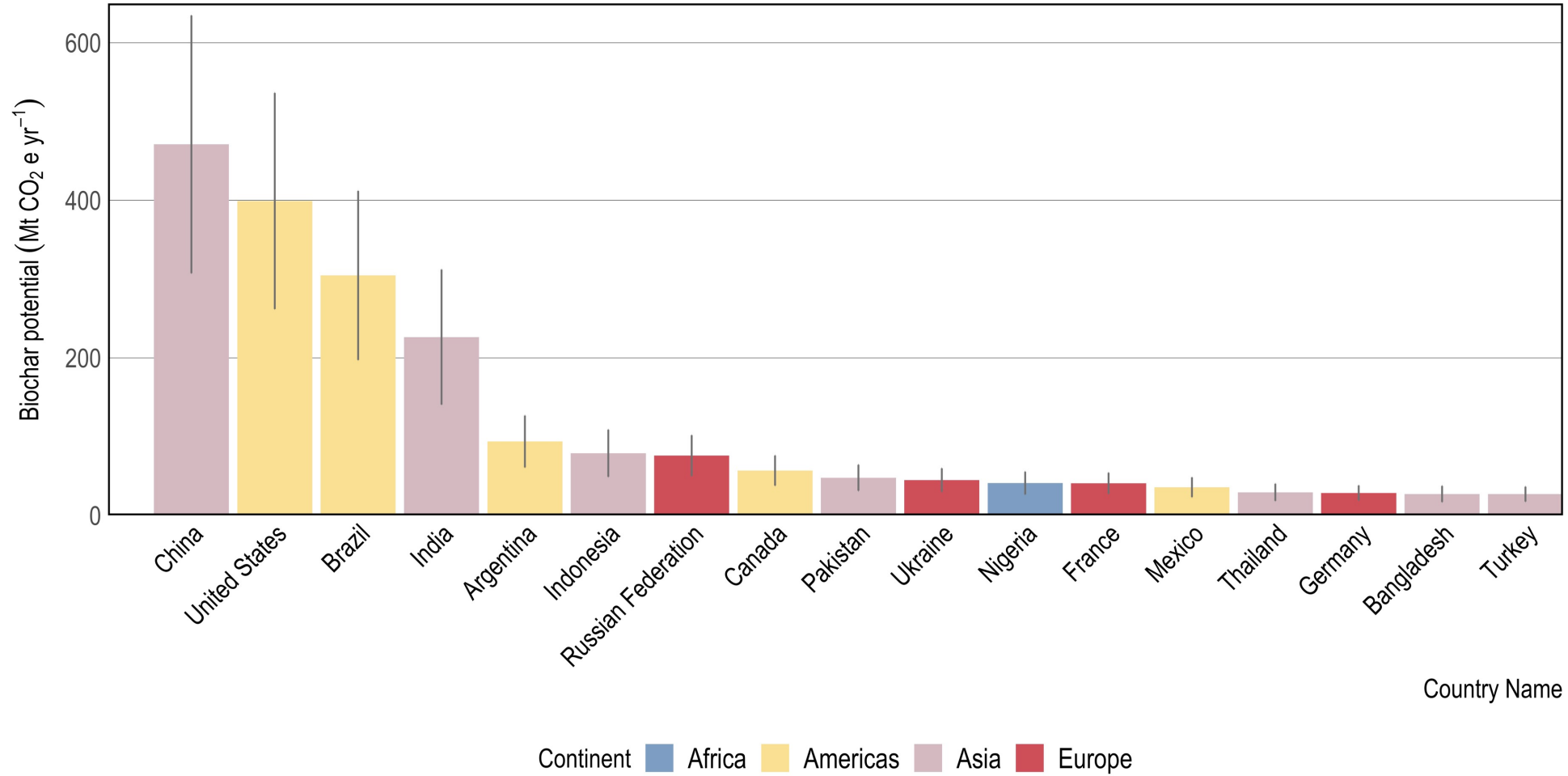
Result Summary

- **7.37 billion t** global annual biomass residue feedstocks
- **1.99 billion t** global annual biochar production
- **2.65 billion t CO₂e** global annual CDR potential
- Average biochar CDR potential of **6.23 ± 0.24%** of national GHG emissions in 155 countries
- **>10%** of national GHG emissions in **28 countries**

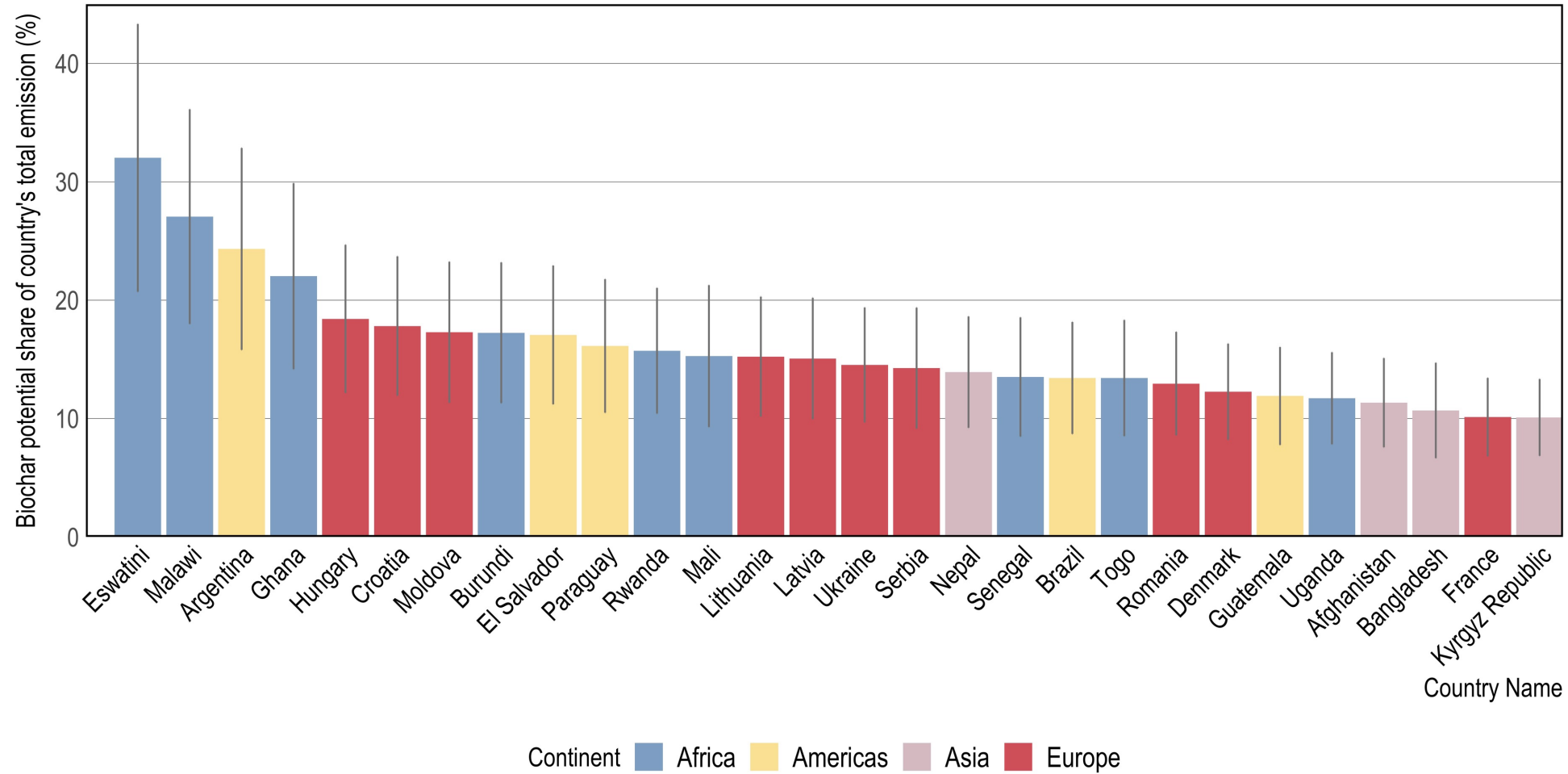
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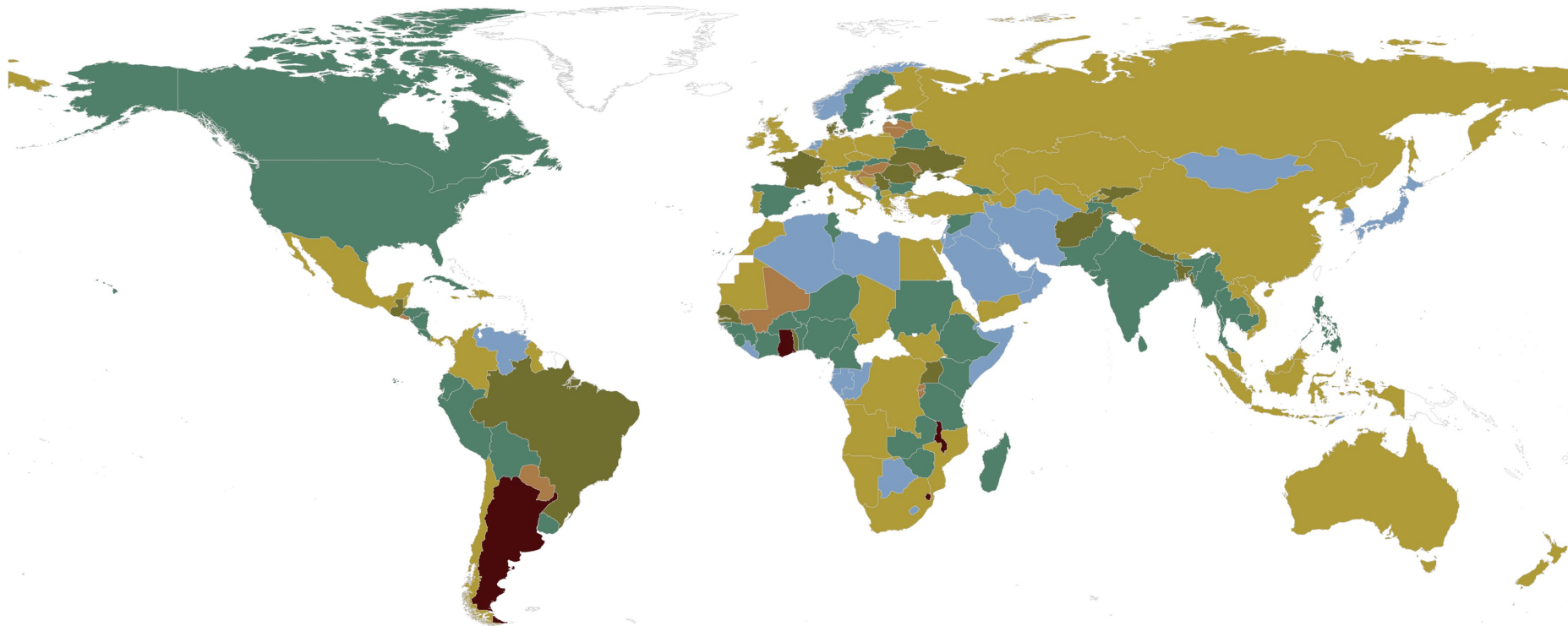
Biochar CDR potential (Mt CO₂e yr⁻¹)



Biochar CDR potential relative to national GHG emissions (%)



Biochar CDR potential relative to national GHG emissions (%)

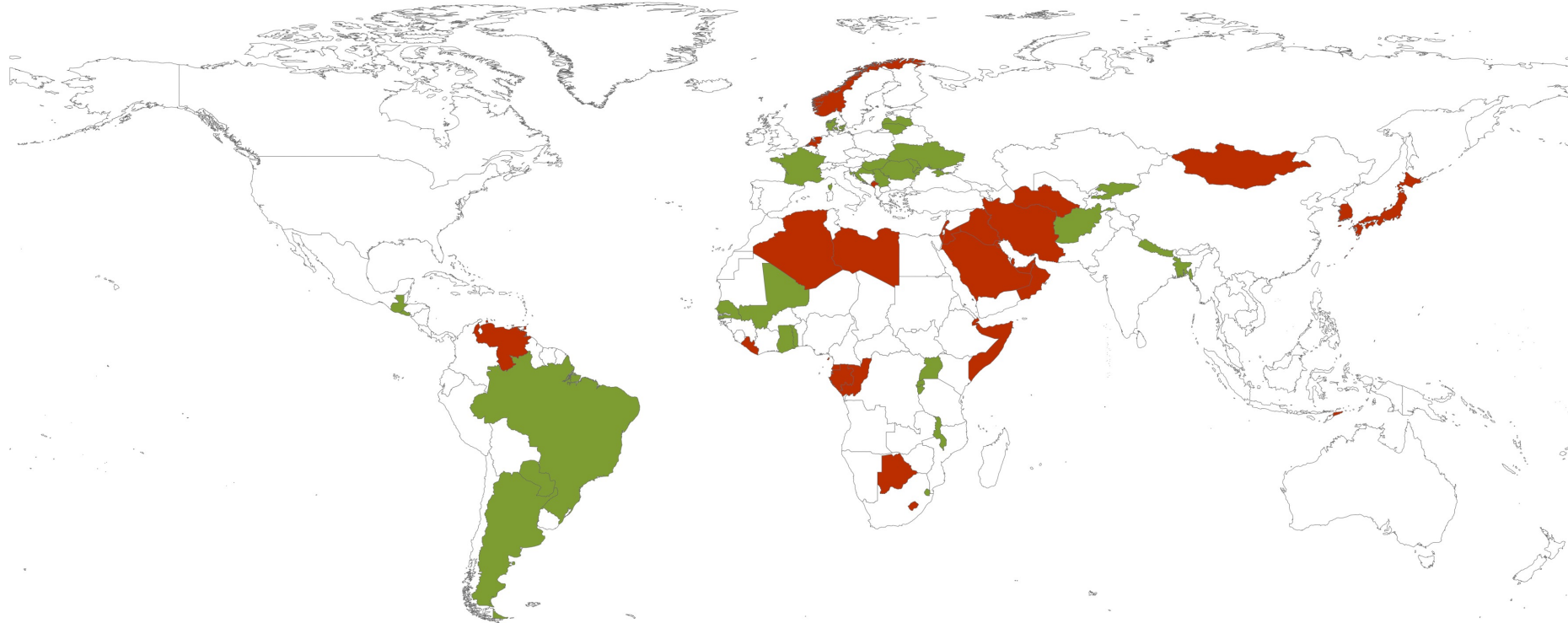


Biochar potential share of country's total emission (%)

0 - 2%	2 - 5%	5 - 10%	10 - 15%	15 - 20%	20 - 100%	NA
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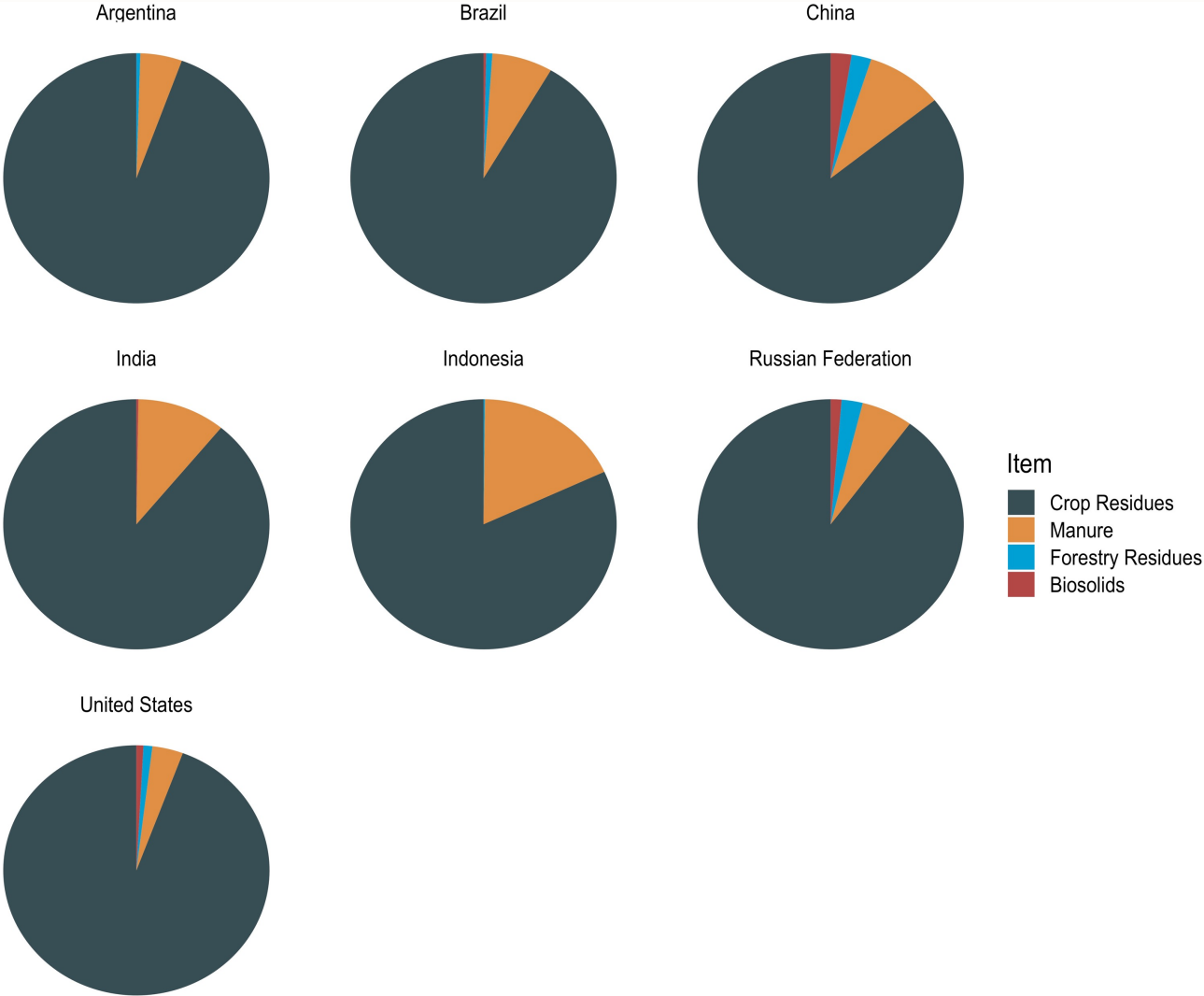
High and low biochar impact regions



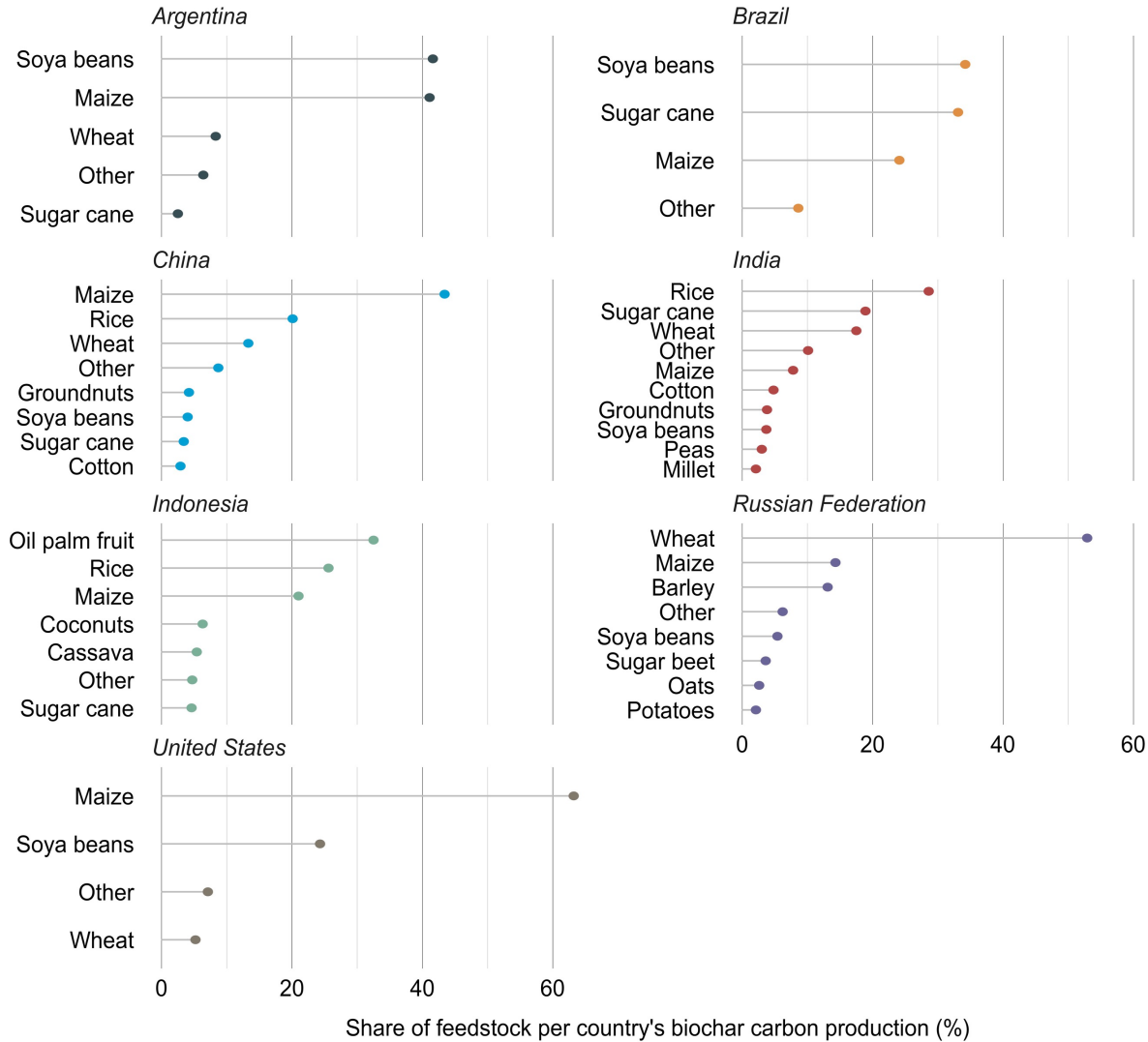
Biochar potential share
of country's total emission (%) ■ ■ ■
< 2 % NA > 10 %



Principal source of feedstock



Agricultural residues



Path Forward

- Detailed data
 - biomass residue production
 - residue-to-product ratio (RPR)
 - soil temperature
 - etc.
- Include indirect benefits
 - Avoided fossil fuel emissions
 - Crop yield
 - GHG ER from soils



Acknowledgements



International Biochar Initiative

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Samer Fawzy

Camila Aquije



QUEEN'S
UNIVERSITY
BELFAST

Ahmed Osman

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ORIGINAL RESEARCH

Open Access



Biomass residue to carbon dioxide removal: quantifying the global impact of biochar

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Abstract

The Climate Change Conference of Parties (COP) 21 in December 2015 established Nationally Determined Contributions toward reduction of greenhouse gas emissions. In the years since COP21, it has become increasingly evident that carbon dioxide removal (CDR) technologies must be deployed immediately to stabilize concentration of atmospheric greenhouse gases and avoid major climate change impacts. Biochar is a carbon-rich material formed by high-temperature conversion of biomass under reduced oxygen conditions, and its production is one of few established CDR methods that can be deployed at a scale large enough to counteract effects of climate change within the next decade. Here we provide a generalized framework for quantifying the potential contribution biochar can make toward achieving national carbon emissions reduction goals, assuming use of only sustainably supplied biomass, i.e., residues from existing agricultural, livestock, forestry and wastewater treatment operations. Our results illustrate the significant role biochar can play in world-wide CDR strategies, with carbon dioxide removal potential of $6.23 \pm 0.24\%$ of total GHG emissions in the 155 countries covered based on 2020 data over a 100-year timeframe, and more than 10% of national emissions in 28 countries. Concentrated regions of high biochar carbon dioxide removal potential relative to national emissions were identified in South America, northwestern Africa and eastern Europe.

Highlights

- Biochar production via biomass pyrolysis is one of few carbon dioxide removal (CDR) technologies that can be deployed at scale.
- Modeled biochar CDR potential of nearly every country, based on available biomass residues and national average soil temperature.
- Biochar can offset over 10% of national emissions in many countries, with concentrated impacts in three global regions.

Keywords Pyrolysis, Biochar, Waste biomass, Carbon sequestration, Negative emissions technologies (NETs), Nationally Determined Contributions (NDCs)

Lefebvre, D., Fawzy, S., Aquije, C. A., Osman, A. I., Draper, K. T., & Trabold, T. A. (2023). Biomass residue to carbon dioxide removal: quantifying the global impact of biochar. *Biochar*, 5(1), 65. <https://doi.org/10.1007/s42773-023-00258-2>

