INSIGHTS

# PATHWAYS FOR SUSTAINABLE AGRICULTURAL PRODUCTION IN BRAZIL

## NECESSARY INVESTMENTS AND POTENTIAL GAINS OF INCREASING EFFICIENCY

INPUT Iniciativa para o Uso da Terra

CLIMATE POLICY INITIATIVE

Increasing agricultural productivity plays a key role in the efforts to combine agricultural growth and forest protection by allowing farmers to produce more using the same area.[1] However, for agricultural productivity to increase, farmers must invest considerable resources to modernize their operations – purchasing equipment and spending more in fertilizers.[2] The existence of these capital requirements to increase efficiency has important implications for the rural credit policies.

This publication summarizes the findings from a recent research project by Climate Policy Initiative (CPI/PUC-Rio) which computes the capital costs of maximizing Brazil's agricultural production without increasing deforestation. **The researchers find that Brazil can increase crop output by 79-105% and beef output by 27% without deforestation.** To achieve the production gains farmers would need to use more inputs and accumulate capital. **This transition would mean increases of 44-51% in operational costs and of 48-52% in the value of farm equipment.** This research provides unique insights in potential policy changes needed in Brazil to help farmers overcome the constraints they face to invest in modern technologies, inputs and equipment. **This way, the country can help ensure the transition to higher agricultural production and avoid additional deforestation.**

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1 Climate Policy Initiative (2013). **Production and Protection: A First Look at Key Challenges in Brazil.** Available at: https://climatepolicyinitiative.org/wp-content/uploads/2013/12/Production-and-Protection-A-First-Look-at-Key-Challenges-in-Brazil.pdf.

2 For one example of the relationship between agricultural growth and input use, see: Assunção, J., & Bragança, A. (2015). **Technological Change and Deforestation: Evidence from the Brazilian Soybean Revolution**. INPUT Working Paper. Available at https://www.inputbrasil.org/wp-content/uploads/2015/08/Technological_Change_and_Deforestation_Working_Paper_CPI.pdf.

# POTENTIAL TO INCREASE AGRICULTURAL OUTPUT

CPI analysts measure Brazil's potential to increase agricultural models using stochastic frontier models. These models estimate efficiency levels in both crop and beef production for each municipality. This enables them to quantify the potential to increase production through simulations that eliminate inefficiencies by making all municipalities operate in the model's technological frontier.[3] The models fix the area available for farming and ranching, meaning that production gains must come from the land currently available without the removal of native vegetation. Furthermore, the methodology allows the researchers to evaluate how crop output would be affected under two different scenarios: one in which producers are not allowed to convert pastures to cropland and another in which conversion is allowed.

Analysts find that eliminating country-level inefficiencies would result in substantial increases in crop output. **In the scenario where farmers are unable to convert pasture to cropland, crop output could increase by 79%. In the model that allows pasture to cropland conversion, results show a potential to increase crop output by nearly 105% without deforestation.** This difference between the two scenarios implies that allowing the conversion of low productivity pastures into high productivity cropland adds an additional 26 percentage points to the nation's potential to increase crop output.

Eliminating inefficiencies at the biome-level or state-level, provides smaller, but nonetheless relevant gains. At the biome-level, eliminating inefficiencies would generate output increases of 52% if pasture to cropland conversion is not possible, and 59% if conversion is allowed. Moving to the state-level shows potential output increases of 46% without conversion and 49% with pasture to cropland conversion. **This suggests that local-level inefficiencies can primarily be addressed by increasing productivity of existing cropland.**

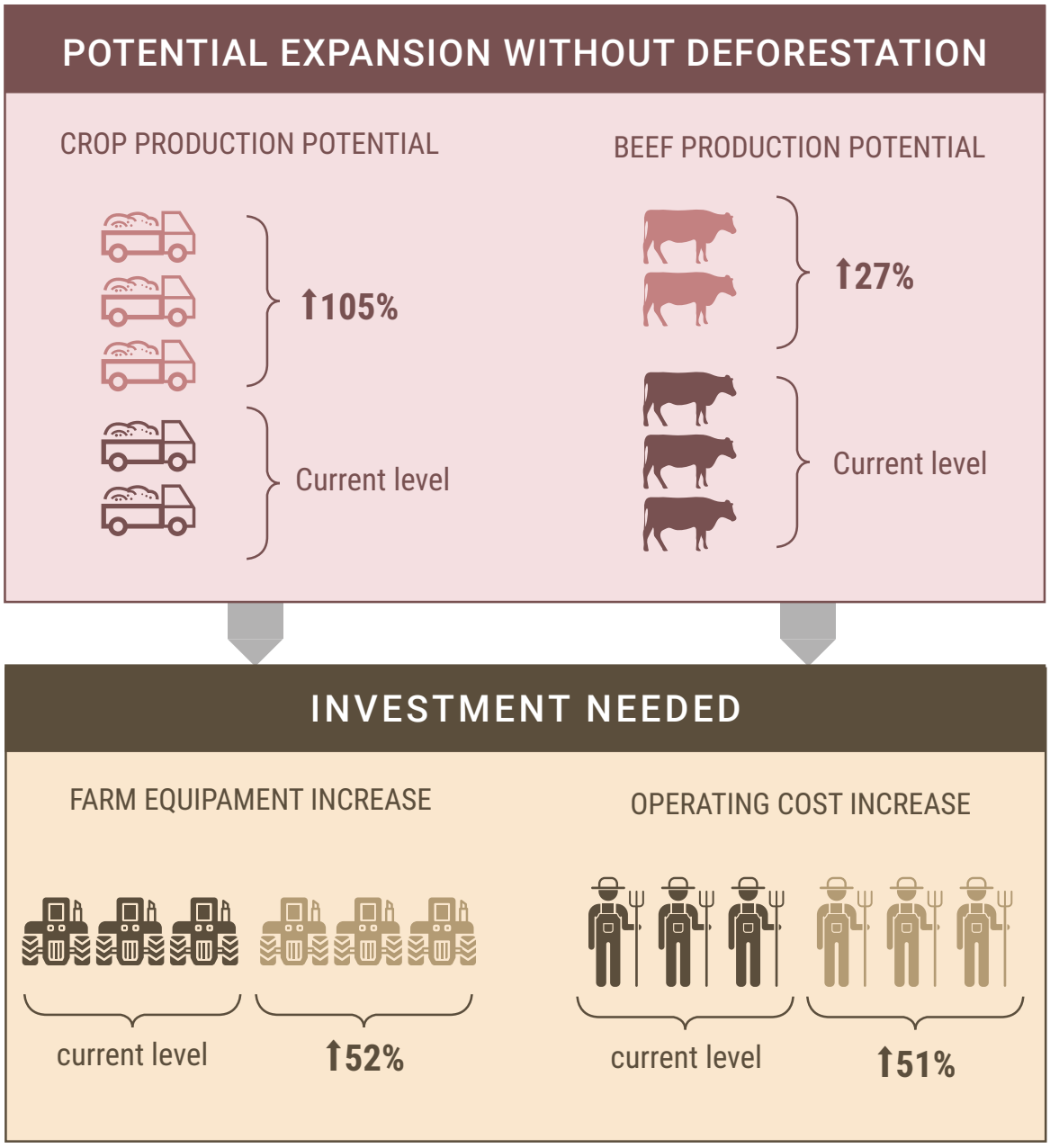
Eliminating inefficiencies in beef production generates much smaller gains than in crop production. Eliminating country-level inefficiencies generates gains slightly below 27%, biome-level gains close to 20%, and state-level gains of about 14%. In general, this indicates that productivity in cattle ranching is more homogeneous throughout the country than productivity in crop cultivation.

3 The technological frontier is simply the efficiency level of the most efficient municipality in the country.

# COSTS OF INCREASING AGRICULTURAL OUTPUT

CPI researchers find that substantial increases in costs and capital are needed to maximize production in Brazil. Efficient production requires more resources, thus farmers' inputs (labor, materials and equipment) increase with the efficiency of their crop and beef production. **This means that efforts to eliminate inefficiencies will demand additional inputs, and in turn, compel farmers to increase their operational costs and capital stocks in order to transition their production (Figure 1).**

**Figure 1:** Investments at country-level needed for achieveving the potential to maximize output considering the conversion of pasture into cropland.




***Source:*** *Climate Policy Initiative using data from the 2006 Agricultural Census*

In more detail, Table 1 shows the increase in the value of the farm equipment (capital stock) required to enable farmers to eliminate inefficiencies in different scenarios. These increases range from 31.2% to 51.6% of the current value of the farm equipment depending on the scenario. The table also shows that substantial increases in operational costs would also be required to maximize agricultural output at the country, biome and state-levels. These increases range from 29.4% to 50.5% of the current operational costs depending on the scenario.

**Table 1:** Increased Value of Farm Equipment and Operational Costs Needed to Maximize Agricultural Output

| | Investment in Farm Equipment Required to Maximize Output | | | Investment in Operational Costs Required to Maximize Output | | |
|---|---|---|---|---|---|---|
| | Country-Level | Biome-Level | State-Level | Country-Level | Biome-Level | State-Level |
| Conversion of pasture into cropland considered | 51.6% | 35.5% | 31.2% | 50.5% | 34.8% | 31.3% |
| Conversion of pasture into cropland **not** considered | 47.5% | 34.7% | 31.5% | 43.7% | 31.7% | 29.4% |

***Source:*** *Climate Policy Initiative using data from the 2006 Agricultural Census*

It is important to stress these figures represent requirements. There are no guarantees that capital injections will generate production gains. For this to occur, the financial system would have to distribute the additional capital efficiently and farmers would have to use it accordingly.[4] To facilitate this process, Brazil must simultaneously address a number of government and market failures that might keep this from happening. **Thus, the numbers reported by CPI analysts represent the minimum amount of capital required to maximize agricultural production in Brazil.**

4 For a broader perspective on financial challenges for sustainable production in Brazil, see: ASSUNÇÃO, Juliano and SOUZA, Priscila. Technical Report. **Financial Challenges and Proposals for Sustainable Production in Brazil.** Rio de Janeiro: Climate Policy Initiative, 2018. Available at: https://www.inputbrasil.org/publicacoes/desafios-financeiros-e-propostas-para-producao-sustentavel-no-brasil/?lang=en

# CONCLUSION

This brief outlines the capital costs associated with maximizing Brazil's agricultural production. It shows that Brazil has a significant potential to increase crop and beef output without additional deforestation. However, to achieve these production gains farmers will need to use more inputs and accumulate capital, meaning increases in both their operational costs and the value of their farm equipment. As Brazil seeks to promote more sustainable agricultural production, it must also create the mechanisms and policies necessary to support this transition and address broader challenges to address inefficiencies.

# NOTES ON DATA

## DATA SOURCES

This analysis uses municipality-level information from the 2006 Agricultural Census. This dataset has information on land use, revenues, costs and farm equipment. The main outcomes in the analysis are crop output, beef output, operating costs, and the value of farm equipment. Crop output is defined as the log of crop revenues; beef output is defined as the log of the number of cattle; operating cost is the sum of all costs incurred by farms including costs of wages, seeds, fertilizers, herbicides as well as other services farms often purchase; the value of farm equipment is the value of the all the vehicles, machines, and equipment the farm owns. All variables are reported in 2006 prices. We use the *Índice de Preços ao Consumidor Amplo (IPCA)* – the official inflation index in Brazil – to bring the values to prices of September 2018. We then convert the values to USD using the exchange rate of September's last business day (R$ 4.05 / 1 USD). Information from the 2006 Agricultural Census is supplemented with geographic information collected from different sources. Information on the area available for farming is built from the MapBiomas dataset. Information on soil types and agricultural suitability is collected from maps constructed by Embrapa. Information on rainfall and temperature comes from the Matsuura and Willmott dataset.

## METHODOLOGY

This analysis is done in two steps. To measure the potential to increase output, Stochastic Frontier Analysis (SFA) is used to estimate productivity. This method offers a flexible way of simultaneously estimating production function parameters and inferring production efficiency. Efficiency is reported in a zero to one scale, which reports the municipality's relative productivity in comparison to the most productive municipality in the country. This implies the potential to increase output is just the inverse of the efficiency level. Because closing the country-level efficiency gaps might not be feasible, the potential to increase output is also computed under alternative scenarios in which only biome or state-specific gaps are eliminated. For this, efficiency levels are normalized with respect to the most efficient municipality of the biome (state). To measure the costs to obtain these output gains, flexible functions connecting efficiency in crop and beef production with operational costs and the value of farm equipment are estimated. These estimates are then used to predict the increase in costs that would be connected to eliminating efficiencies in crop and beef production.

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*The opinions and conclusions expressed in the analysis are those of the authors and do not necessarily represent the views of partners and other stakeholders.* ***The Land Use Initiative (INPUT □ Iniciativa para o Uso da Terra)*** *is a dedicated team of specialists who work at the forefront of how to increase environmental protection and food production. INPUT engages stakeholders in Brazil□s public and private sectors and maps the challenges for a better management of its natural resources. Research conducted under INPUT is generously supported by the Norway□s International Climate and Forest Initiative (NICFI), Children□s Investment Fund Foundation (CIFF), World Wildlife Fund (WWF) and Instituto Clima e Sociedade (iCS) through grants to Climate Policy Initiative.*