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DCC DIRECCION DE CAMBIO CLIMATICO

PARTNERSHIP FOR MARKET READINESS – COSTA RICA PROGRAM

Program Activity Brief

DECARBONIZATION PATHWAYS MODELING IN COSTA RICA

I. EVOLUTION OF DECARBONIZATION SCENARIOS

Climate and systems modeling in Costa Rica has been used to integrate physical variables to traditional modeling tools. The models have enabled quantitative analysis of the impacts of potential measures throughout the economy with multiple time horizons, all of which inform decision-making in uncertainty. After completing its first NDC in 2015, Costa Rica decided to develop its own emissions scenarios modeling capabilities to support policymaking in decarbonization and climate resilience. The Partnership for Market Readiness-Costa Rica (PMR–CR) program has been critical in supporting those efforts[1]. Figure 1 below shows a brief timeline of some of the major milestones for addressing climate change using systems modeling in Costa Rica (also referred to as decarbonization pathways modeling).

- **2016** — PMR-CR begins work exploring the need for systems modeling in Costa Rica.
- **2017** — The PMR-CR program tailored the TIMES model for Costa Rica's energy context, developing TIMES-Costa Rica (TIMES-CR) model.
- **2018-2019** — Costa Rica's Climate Change Directorate (DCC) adopts TIMES-CR, which is used to inform the design of the National Decarbonization Plan.
- **2019** — The OSeMOSYS-Costa Rica (OSeMOSYS-CR) model is then adopted as the base model.
- **2019-2020** — An updated OSeMOSYS-CR model is integrated with the Robust Decision Making (RDM) methodology.
- **2019** — DCC consolidates different existing tools and models in the Costa Rica's Decarbonization Pathways Integrated Model (CR-DPIM).
- **2020** — Decarbonization pathways modeling assumptions are revised to measure the post-COVID-19 .

Figure 1. Brief Timeline of Major Decarbonization Pathways Modeling Milestones in Costa Rica

1 The emissions scenarios modeling process carried out in Costa Rica in support of decarbonization has had the support of different technical partners. The World Bank's Partnership for Market Readiness program was crucial in the early stages and in current work. Subsequent developments have further received technical assistance from the Inter-American Development Bank (IDB), the Royal Swedish Institute of Technology (KTH), and researchers from the RAND Corporation and the Instituto Tecnológico de Monterrey, as well as from the UN Development Program (UNDP) and the UN Department of Economic and Social Affairs (UNDESA).

Costa Rica's climate policies abide by decisions based on the best available science. At a global level, this implies accepting the scientific consensus of limiting the increase in the planet's average temperature to 1.5 °C to avoid the worst impacts of the climate crisis. At the local level, it involves prioritizing climate actions by following criteria for selecting the most efficient actions for reducing emissions and improving human well-being. This combination of commitment to global goals and local discussions on the prioritization of climate policies was the spirit behind the NDC presented by Costa Rica in 2015 under the Paris Agreement.

The need to focus efforts on systems modeling to address climate change became evident during the construction of the NDC in 2015. This process revealed that Costa Rica lacked at least half of the necessary information to make robust decisions; its past could be understood through its national greenhouse gas inventories but the absence of capacity to project scenarios for its future hindered planning ahead.

At the time, data on historical emissions registered in the National Greenhouse Gas Inventory (*Inventario Nacional de Gases de Efecto Invernadero*, INGEI) were available. Costa Rica was also developing methodological and technological capacities to improve such information through the design of a National System of Climate Change Metrics (*Sistema Nacional de Métrica de Cambio Climático,* SINAMECC). However, there was no national capacity for using the data to analyze possible futures and inform decarbonization and resilience-oriented decisions.

The journey towards building national modeling capabilities began in 2016 with the support of the PMR-CR program, with a focus on developing a suitable energy model (TIMES) for Costa Rica (TIMES-CR). In subsequent years, and after TIMES-CR was adopted by the government, the Climate Change Directorate (DCC), which is entrusted with climate policy making, strengthened its prospective analytical capacity with other platforms and tools to enhance its decision making policy tools. The evolution of decarbonization pathways modeling in Costa Rica is illustrated in Figure 2.

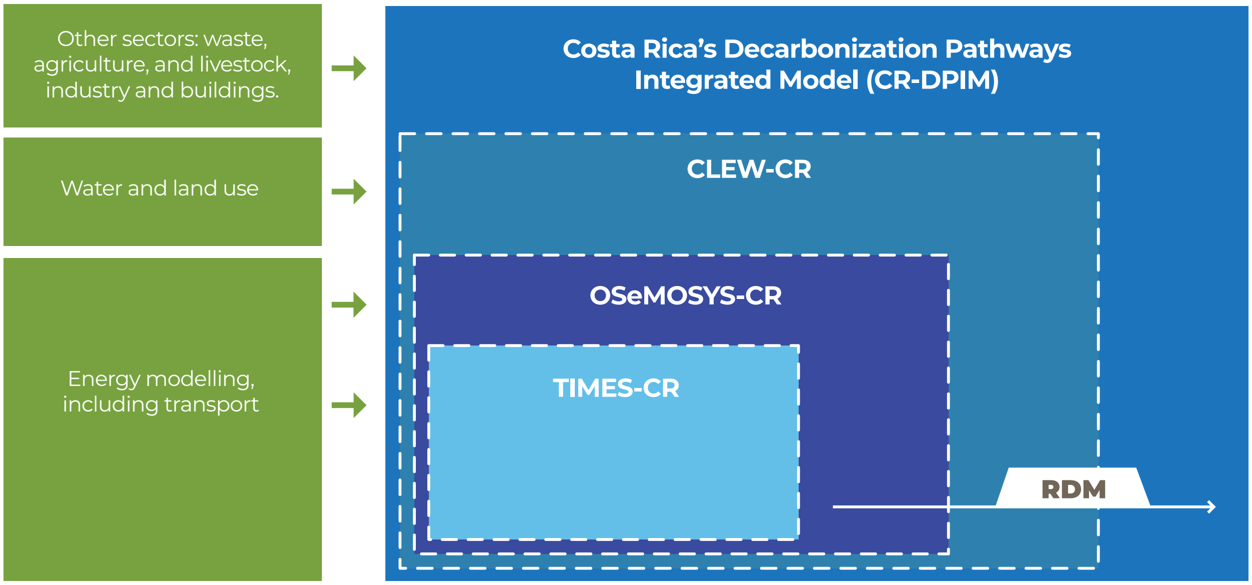

Figure 2. Evolution of Decarbonization Pathways Modeling in Costa Rica

The country's modeling capabilities have increased substantially over time, beginning with the TIMES-CR foundations and later enhanced with the addition of new modeling capabilities (as shown in the green column). Building upon this progress, Costa Rica's Decarbonization Pathways Integrated Model (CR-DPIM) now combines all existing models.

The First Model Supporting Climate Action: TIMES-CR

TIMES-CR was the first model developed to support the country's decision making on climate action. It is based on the TIMES modeling platform, which is the most widely used cost-optimization methodology to inform strategic planning and public policy globally.

The PMR-CR program tailored the TIMES model for Costa Rica's energy context to develop the TIMESCR model. This process culminated in 2017 with an optimization of the energy sector, including transport, that incorporated multiple economic and sectoral variables into the model, as outlined in Figure 3 below.

This process included the training of a multi-institutional analytical team with participants from the University of Costa Rica, Ministry of Environment and Energy (*Ministerio del Ambiente y Energía de Costa Rica*, MINAE) Sectorial Directorate of Energy, the Costa Rican Electricity Institute (ICE), the Ministry of Public Works and Transportation (MOPT), and the Central Bank of Costa Rica (*Banco Central de Costa Rica,* BCCR). This was the first multi-institutional analytical team and its participants provided their expert judgment and validated the TIMES-CR model.

TIMES-CR directly informed the design of the National Decarbonization Plan's goals, making the plan the first significant climate policy instrument based on robust energy modeling for Costa Rica complemented with basic models for other sectors.

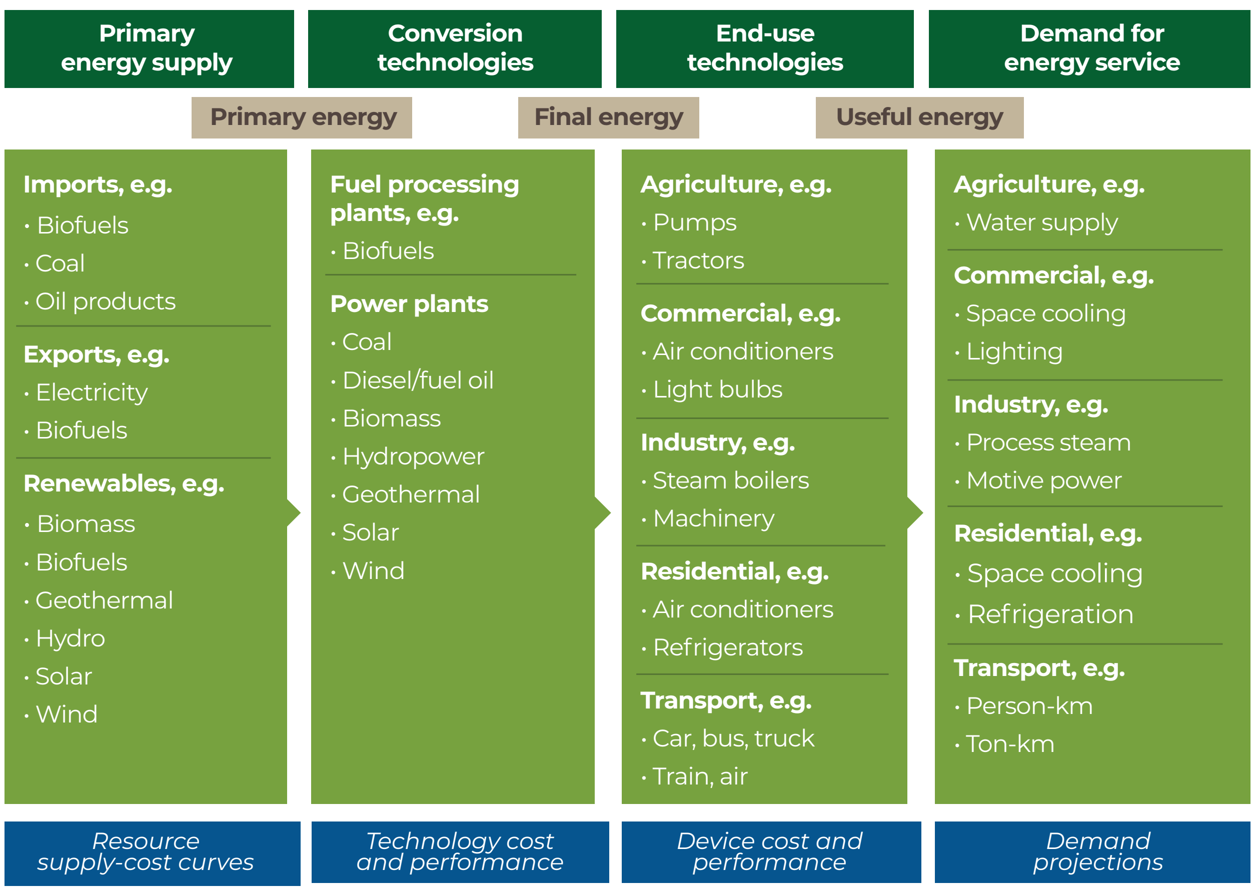

Figure 3. Outline of TIMES-CR Variables

The process of developing the TIMES-CR model paved the way for subsequent decarbonization pathways modeling exercises. It also helped reinforce this line of work within the Climate Change Directorate.

Evolving towards Open Source: OSeMOSYS-CR

To develop a more robust climate policy that uses a more comprehensive model incorporating models from different sectors, Costa Rica decided to use an open platform for further modeling, known as the Open Source Energy Modeling System (OSeMOSYS3). This involved migrating the TIMES-CR data and parameters to develop and implement an OSeMOSYS3 application for Costa Rica (OSeMOSYS-CR).

The open source system helped create a more robust model and an additional level of transparency. The latter occurred because transparent practices for data sharing are part of the framework for developing the quantitative tools. OSeMOSYS-CR also allowed for greater flexibility to incorporate sectoral data into the platform and enable deeper levels of analysis by modifying and expanding source code. In addition, it enables the integration of the systems modeling ecosystem into other institutional systems and its replication in other countries. Using an open source tool can generate substantial savings in software licenses and maintenance, particularly for projects that require software with highly customized features.

Adding land and water: OSeMOSYS-CR + CLEW

The modeling team used the flexibility of OSeMOSYS-CR to integrate additional models into the initial exercises in energy. This involved using an integrated assessment tool to support policy and planning, known as the Climate, Land, Energy, and Water (CLEW) framework. The climate parameters were based on modeling results from other national and international institutions. The work, therefore, focused on the creation of hydrological and land use models within OSeMOSYS-CR that could be integrated with the existing energy model.

The land use modeling framework overall represents supply chains of goods and services produced by the different land cover/use system types, as shown below in Figure 4. In this context, land supply, demand, and land use change are conditioned by, for the most part, national and international market forces, policies, and institutional factors. Institutional factors, however, are the ones usually mediating the influence of market and policy forces on land changes. The changes in land cover's overall characteristics and properties also involve water and energy inputs, based on the type of activity being carried out and land management decisions.

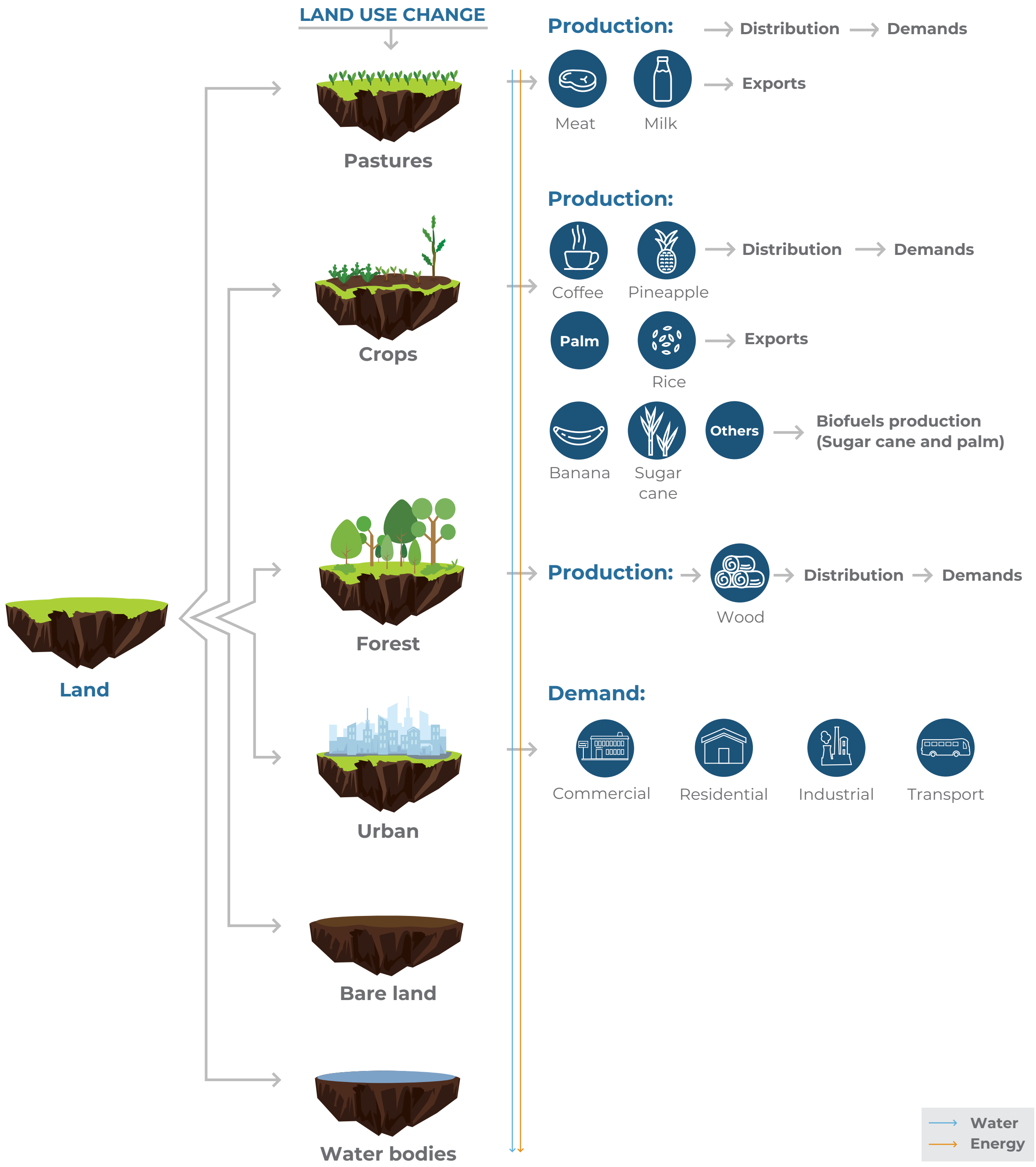

Figure 4. Structure of the Land Modeling Employed

The water modeling framework reflects the hydrological processes of the water balance linking water supply with demand, as illustrated in Figure 5 and Figure 6 below.

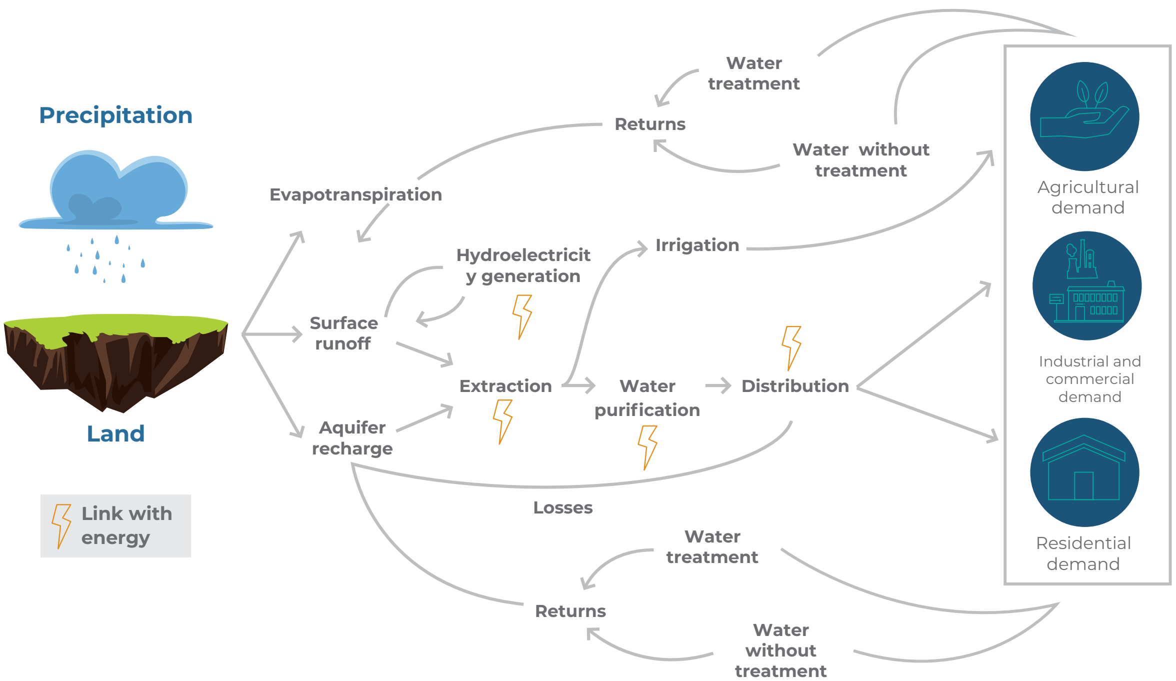

Figure 5. Water Sector Model General Structure (linking water supply with demand in different sectors such as energy, agriculture, and industry through the hydrological cycle)

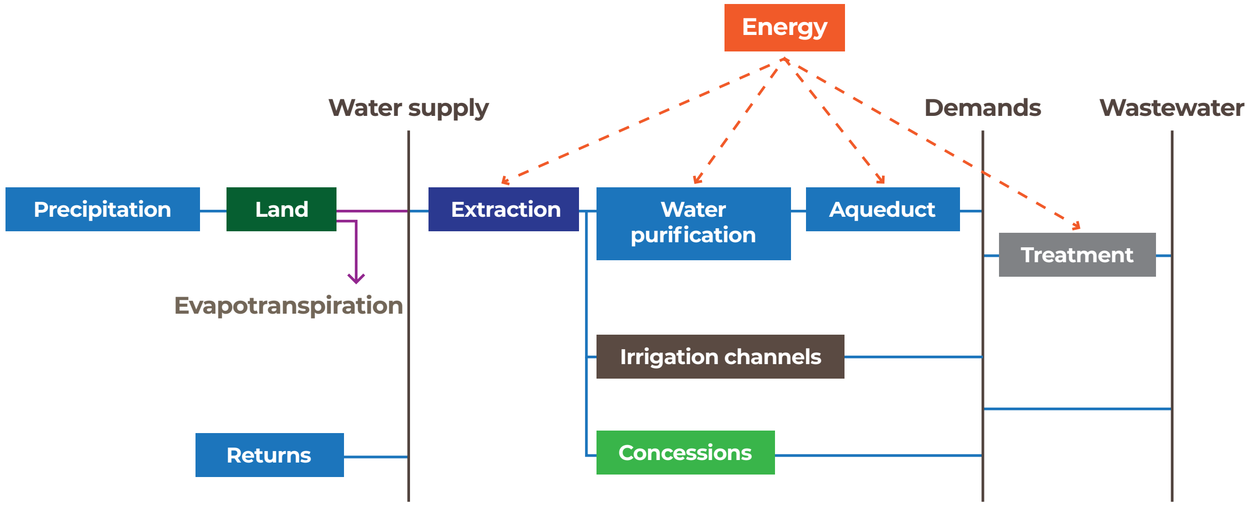

Figure 6. Water Sector Model Simplified Structure

Regional hydroclimatic variations could not be included in the national scale model. Therefore, rainfall is homogenously distributed over the whole territory. The future projections are based on the Representative Concentration Pathway (RCP) 8.5, which was selected based upon input from the stakeholder workshop that is considered a desirable scenario for decision making. The second input for this model considers water returns, which are implemented as a residual capacity of the system, assuming that 50 percent are directed to surface water bodies and 50 percent to groundwater, according to the assumptions of the BCCR water accounting system.

Key Findings of the CLEW Modeling

In addition to the specific results of each of the models described, the consolidation of data-based climate policy decision making has been the product of a continuous process of evolution, integration, creation of local capacities, and support from national and international partners.

The net emissions in the Agriculture, Forestry, and Other Land Use (AFOLU) sector remain almost constant in the business-as-usual (BAU) scenario, and they reduce to about 2 million tons of CO2 by 2050. The AFOLU sector benefits significantly from the reduction in emissions from the livestock sector (enteric fermentation), followed by the measures to promote forest plantation and secondary forest growth.

Figure 7 summarizes the measures considered in the BAU scenario versus the Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C (SR15) scenario for forest, crop, pasture, and urban cover, as well as emissions or removals from each of the coverage areas. It also quantifies the level of insertion of the technologies included by 2050.

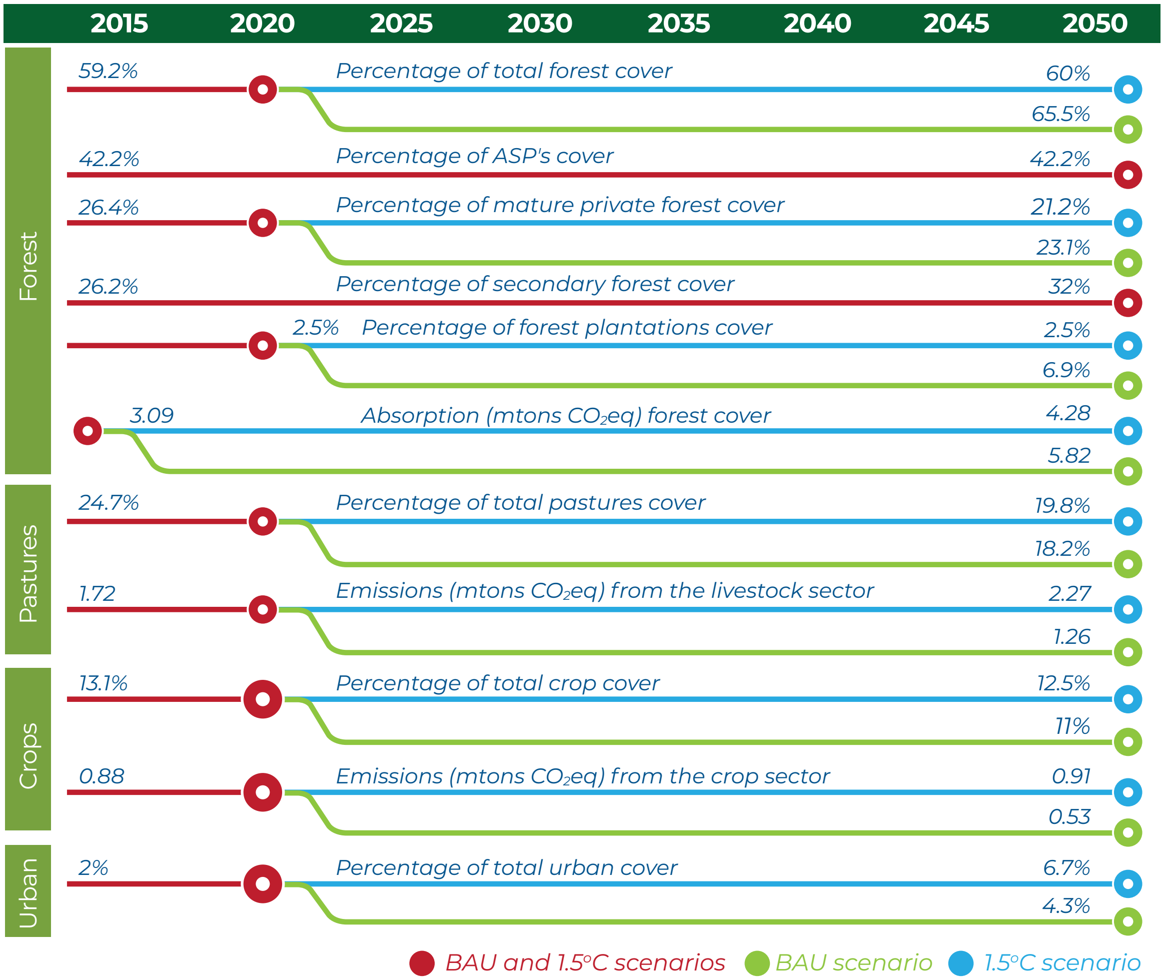

Figure 7. Considerations for Policy Scenarios in the Land Sector

The physical water availability of the country is similar for both the BAU and SR15 scenarios, as exogenous projections are obtained using the same climate model. The scenario used in this report is rather pessimistic (RCP 8.5 was used for climate projection and input into the model as a consensual result of the second stakeholder workshop), but it allows for elaborating a conservative analysis for the SR15. Further modeling and graphs can be found in the full report from the modeling teams.

Using Robust Decisions: RDM

To further strengthen the modeling, the updated OSeMOSYS-CR model was integrated with the Robust Decision Making (RDM) methodology. RDM helps identify potential robust strategies, characterizing their potential vulnerabilities, and assessing their advantages and disadvantages.

This methodology focuses on conditions of "deep uncertainty"; that is, conditions where it is difficult or impossible to know how a system will react to certain circumstances, or where the probable distribution of key parameters is unknown, as is often the case with climate change. RDM allows decision makers to integrate mature and complex models, such as OSeMOSYS-CR, with simpler models to describe other sectors.

Using the RDM framework, the national modeling team created 1,101 future scenarios for Costa Rica with a diversity of parameters with the aim of improving information for decision making. The results were used to explore costs and benefits and other implications of the National Decarbonization Plan in uncertainty.

A Comprehensive Model: CR-DPIM

With strengthened modeling capacity and knowledge, the DCC consolidated the different existing tools and models into Costa Rica's Decarbonization Pathways Integrated Model (CR-DPIM). Figure 10 below shows how the process of adding new inputs to modeling capabilities (the blue row) led to different model iterations (green row). The results, in turn, impacted key climate decision-making and planning in Costa Rica (brown row).

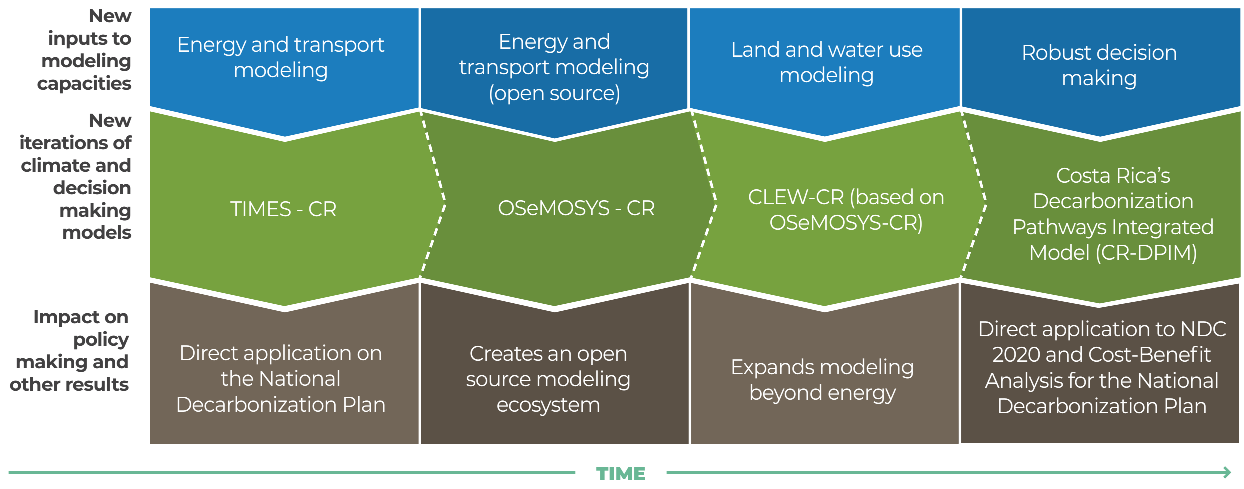

Figure 10. New Model Inputs and Iterations that Impacted Climate Decision Making in Costa Rica

CR-DPIM currently functions as a modeling and data processing center, which offers additional strength to the construction of evidence-based climate policy and planning.

CR-DPIM incorporates CLEW, which had expanded the capabilities of OSeMOSYS-CR, and other smaller models that integrate other sectors that generate emissions. After the completion of the CLEW project in mid-2020, the Costa Rican team is currently working on integrating the model into the CR-DPIM, thus ensuring that all future modeling instruments can be integrated on the same basis, including exercises aimed at updating the NDC 2020 of Costa Rica.

The CR-DPIM uses internally consistent projections of national economic activity, developed with a general equilibrium model provided by BCCR, to run the Integrated Economic-Environmental Modeling Platform (IEEM). CR-DPIM is also connected to SINAMECC, which functions as the mechanism for data collection, monitoring, and reporting.

Looking Ahead

Now that the CLEW model has been completed at a national scale, the next step for the modeling ecosystem is to bring even more detail and resolution to the model with data from regions within Costa Rica. If achieved, an apparent mass of trees and water can be modeled independently as trees in a specific geography and specific bodies of water. This sort of regionalization of the model is necessary because water is not easily transported over long distances and forests types and crop varieties vary according to the different areas of the country, supporting different ecosystems and economic activities. It is therefore important to have spatially-explicit information on natural assets in addition to information on the stock of assets, to make better policy decisions that more directly support local communities. This exercise is underway at the Ministry of Planning and Economic Policy (MIDEPLAN). The open source aspect of the modeling ecosystem was a key factor for this Ministry to decide to align its national development planning with climate goals and international commitments.

Finally, in the face of the coronavirus disease (COVID-19) pandemic, national modeling capacities in support of decarbonization have been critical in efficiently incorporating emerging shocks into the exploration of possible futures. Along these lines, local teams are currently reviewing the assumptions altered by the health crisis to measure the post-COVID-19 effects. This includes forecasting the impact of foreseen measures in the National Decarbonization Plan on the sustainable recovery of the country. The results of this process will be available in the second quarter of 2021.

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