The "World System" of the Paris Agreement:
Exploring the Construction, Dissemination, and Implementation of Climate Knowledge through REDD+

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Abstract

Climate change is one of the most pressing social and environmental issues of the 21st century, and will require innovative thinking to understand its complexity. The Paris Agreement, negotiated at the 2015 21st Conference of Parties, marked a monumental international agreement toward collective action on climate change. Through world systems theory and global value chain analysis, this paper explores how climate knowledge is co-constructed, differentially distributed, and consistently negotiated in the frontiers among diverse knowledge systems. These theoretical frameworks allow us to explore how power is manifest in knowledge systems. I argue that this theoretical approach may more broadly acknowledge the role that organizations play when navigating the complex field of climate change. World system theory and global value chains is used to understand the multi-scalar nature of Reducing Emissions through Deforestation and Degradation (REDD+) programs. In doing so, a new framework is proposed for grasping the complex nature of climate knowledge, governance, and policy implementation.

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Introduction

The threat of global climate change is one of the most significant social, political, and ecological challenges of our time. For more than two decades, state and non-state actors have engaged in a process of scientific inquiry, policy negotiation, and more recently adaptation and mitigation efforts. Those involved in organizing, shaping, steering, and implementing science and policy must navigate and manage a system made up of multiple actors with a variety of interests, capacities, and challenges often spanning several sectors (Moser and Ekstrom 2010). Moreover, locally planned decisions and actions often require assistance from, or at least coordination with, higher levels of the state, the market, or civil society, thus bringing additional actors to the table. It is apparent that the institutions, organizations, and mechanisms by which societies currently govern these environmental relationships across scales are inadequate. To address the challenges associated with global climate change, new theoretical frameworks are necessary to explore the multi-scalar nature of climate knowledge, governance, and policy implementation.

This is a timely consideration given the recent breakthrough on global climate negotiations at the 21st Conference of Parties (COP21), known as the Paris Agreement, where the majority of 196 countries agreed to formulate individual Nationally Determined Contributions (NDCs), or national climate plans, to meet internationally negotiated global mean temperature targets by 2100. In contrast to past international climate efforts, including the 1997 Kyoto Protocol (which, while never fully ratified, was a legally binding international agreement), NDC pledges were completely voluntary and represent a new, bottom-up approach to international climate agreements. Given the benefits and risks of this voluntary bottom-up approach, social scientists can contribute to understanding implementation efforts at multiple levels of organization and highlight power dynamics that shape outcomes. To address the problem of power, an overview of the intersections among knowledge system theory, world system theory, and global value chains is provided. Using these theoretical frameworks, I discuss Reducing Emissions from Deforestation and Forest Degradation (REDD+), a key carbon reduction program that was reaffirmed and received major financial commitments at COP21. As

a climate mitigation policy mechanism that has been debated and developed since the Kyoto Protocol in 1997, REDD+ has significant impacts through its distribution of financial resources, multi-scalar impact on local livelihoods and forest-based resources (including other ecosystem services and forest-based resources in addition to carbon sequestration), and types of knowledge used in the process of monitoring, reporting, and verification (MRV) of forest-based carbon. REDD+ projects will constitute a significant portion of many developing countries' NDCs, and thus provides a fruitful illustration to our theoretical framework in the post–Paris Agreement world.

Theoretical Framework

In 1974, Immanuel Wallerstein noted, "Man's ability to participate intelligently in the evolution of his own system is dependent on his ability to perceive the whole" (1974:10). Despite a plethora of literature related to the process of creating climate knowledge to date (Adger et al. 2009; Ballard, Fernandez-Gimenez, and Sturtevant 2008; Berkes and Jolly 2002; Berkes and Turner 2006; Boiral 2002; Bosch, Ross, and Beeton 2003; Davis and Wagner 2003; Fazey, I., Fazey, J. A., and Fazey, D. M. A. 2005; Fazey et al. 2006; Gadgil, Berkes, and Folke 1993; Kempner, Merz, and Bosk 2011; Merritt et al. 2009), social scientists have under-theorized or ignored the inherent power dynamics in this knowledge system. This has challenged our ability to perceive the whole.

Global Knowledge Systems

A knowledge system is a particular view that emerges when one studies the social distribution of knowledge-related processes (Holzner and Marx 1979). Knowledge system theory emphasizes the social processes that create and disseminate knowledge and draws heavily on the sociology of knowledge (Mannheim 1955; Holzner and Marx 1979; Pentland 1995). Elaborating on knowledge system theory, Phelps, Heidel and Wadhwa (2012) discuss the knowledge outcomes inherent in knowledge networks. The authors create a typology of knowledge networks from an extensive review of empirical research published on this topic in leading management, psychology, sociology, and economics journals. Within the typology, the authors identify three types of outcomes produced in

knowledge networks: knowledge creation, knowledge transfer, and knowledge adoption. A networked conception of the knowledge system perspective is proposed by Holzner and Marx, because both perspectives take a systematic and process-based approach to the study of knowledge. These two theoretical conceptions of knowledge are then compared in *Table 1*, illustrating their similarities and differences. By comparing these two arguments I explore how knowledge moves through social space. Although both theories offer similar perspectives on the creation and dissemination of knowledge, there are some compelling differences between a system and a network, as *Table 1* illustrates.

The knowledge system approach complements the network approach in the areas of production, distribution, application, and implementation of knowledge. Within knowledge systems, the social activities such as knowledge production, organization, application, and implementation are distinct and yet interdependent functions of the social system of knowledge (Holzner and Marx 1979). Similarly, within knowledge networks, knowledge outcomes are related while remaining conceptually distinct. Once knowledge is created, the knowledge must be transformed through cognitive and social processes to facilitate its transfer, which is often necessary for discrete, embodied knowledge to be adopted and applied (Phelps et al. 2012).

A key dimension missing from the exploration of knowledge systems and knowledge networks is the ability to address the power dynamics inherent in the construction, dissemination, and application of knowledge. World system theory and global value chain analysis allow us to explore how power is manifest in these systems.

World System Theory

World system theory (WST) is a macro-sociological perspective that seeks to explain the dynamics of the capitalist world economy as a total social system:

> A world-system is a social system, one that has boundaries, structures, member groups, rules of legitimation, and coherence. Its life is made up of the conflicting forces which hold it together by tension and tear it apart as each group seeks eternally to remold it to its advantage (Robinson 2011:213).

Table 1. Social Activities and Knowledge Outcomes within Knowledge Systems & Networks

Knowledge Systems (Holzner and Marx 1979)		**Knowledge Networks** (Phelps et al. 2012)	
Production	The creation of new knowledge; in the case of science, knowledge increases exponentially	**Creation**	The generation of new knowledge, typically in the form of ideas, practices, research papers, technical inventions, or products
Organization	The grouping of different kinds of knowledge into coherent bodies		
Storage	The cataloguing and storage of knowledge		
Distribution and Assessment	Knowledge is disseminated through formal or informal channels, which is dependent on the context of the way knowledge is used	**Transfer**	The efforts of a source to share information and knowledge with a receiver and the receiver's efforts to acquire and absorb (i.e., learn) from it
Application	Putting knowledge to use in solving practical problems	**Adoption**	The decision and ability to use or implement a discrete element of knowledge, often in the form of a product, practice or paper
Implementation	Absorption of knowledge into everyday routines of explicitly knowledge-based plans for action		

Source: Adapted from Holzner and Marx 1979; Phelps et al. 2012

The international division of labor is an essential component of world system theory, which geographically divides the globe into three distinct regions—core, semi-periphery, and periphery—determined by their relationship to the capitalist mode of production. Core countries are the powerful and developed centers of the system, and are characterized by service economies, highly skilled production processes, and the export of high-profit consumption goods. Countries within the semi-periphery occupy the intermediate place between the core and the periphery in terms of their wage levels and the goods and services they provide. Semi-peripheral countries seek to trade with both the core and the periphery countries. The semi-peripheral countries play a critical role in the system, diverting pressures from the periphery in the same way that a middle class may defuse tensions between proletariat and bourgeoisie. Countries within the periphery have been forcibly subordinated to the core through colonialism or resource and labor exploitation (Wallerstein 1974). Cheap labor and raw materials flow from the periphery to the core, either directly or through the semi-periphery, and high-profit consumption goods flow from the core to the semi-periphery and periphery countries (McMichael 2012). The world system is dynamic, meaning that certain countries can gain or lose status over time.

Although world systems theorists have been criticized for focusing on the world system as their unit of analysis, McMichael (2012) has argued that the core/periphery relationship can be applied to explore power dynamics within a variety of social systems. This paper argues for an approach that views climate knowledge as the system, and organizations involved in this system as the analytical components. In this scheme, certain organizations, such as the World Bank, the United Nations, and the Intergovernmental Panel on Climate Change (IPCC), can be considered core actors, whereas the central governments of developing countries constitute the semi-periphery, and sub-national organizations comprise the periphery. In the applications section, I explain in depth how the core actors enact power relations that shape categories of knowledge and extract value from the periphery, as world system theory would suggest.

Global Value Chains

A persistent challenge to world system studies is how to depict and investigate the relationships that sustain and reproduce core-peripheral relations through space and time. To address this, Gereffi and Korzeniewicz (1994) developed "global value chain analysis" to analyze the sequential flow of materials and transformations that comprise the production and sale of a commodity. Under this organizational and political-economic approach, commodity circulation occurs through a series of links that connect different groups of actors together in the process of commodity production and consumption (Schurman and Munro 2009). All chains have a specific territoriality, or geographic configuration, and operate in concrete institutional contexts that establish the rules of the game by which actors in the chain must play. These chains embody a network of actors, and global value chain analysis makes these linkages explicit from input supply, production, distribution, consumption, and disposal. Assessing the theoretical structure of global value chains provides additional insight to a strictly knowledge system perspective by bringing our attention to inputs, where knowledge is produced and distributed, and how climate knowledge is consumed, particularly in relation to a differentiated world system.

One particularly interesting aspect of global value chains is the focus on governance structure. The internal governance of global value chains is one of the main analytical issues in global value chain analysis (Ponte 2009). Governance here refers to, "authority and power relationships that determine how financial, material, and human resources are allocated and flow within a chain" (Gereffi and Korzeniewicz 1994:97). Governance has received considerable attention because governance structures define who is able to participate and how the benefits of participation are distributed along the chain (Gereffi et al. 2001). This brings attention to how power and rewards are embodied and distributed, what entry barriers characterize global value chains, and how unequal distributions of rewards can be challenged.

There are two different types of commodity chains: producer-driven and buyer-driven (Gereffi and Korzeniewicz 1994). Producer-driven chains tend to have high barriers to entry because many commodity chains require capital and technology-intensive production. Buyer-driven chains tend to have low barriers to entry,

and producers are bound to the concerns of the buyers. The producer-driven/buyer-driven dichotomy is relevant to understand the way power is exercised in value chains.

Global commodity chain analysis has the potential to extend beyond empirical boundaries of global economic relations and provides an innovative way to conceptualize climate knowledge. Currently, the understanding is that the scientific community is the main source of climate knowledge. Analogously, this represents a producer-driven approach of climate knowledge. Climate knowledge is framed as a commodity to be given to consumers instead of something that is actively co-created. Furthermore, much like a game of telephone, as the commodity of knowledge is passed through the chain from producers to consumers, the message is warped and scrambled, making it difficult for the public to understand and connect with the knowledge.

Instead, civil society actively participates in the construction of climate knowledge. For example, while climate scientists and meteorologists provide expert knowledge about climate and weather, individuals experience climate and weather and gather experiential and local knowledge about these phenomena through everyday activities. Furthermore, farmers, hunters, and ski area operators are just a few of the professions that must be closely attuned to climate and weather because their livelihoods depend in part upon environmental systems. If experiential and local knowledge is included into our discussion of climate knowledge, the it can be argued that climate knowledge is in fact produced and distributed in a buyer-driven environment. Ski lift operators comment on the amount of snowfall as it changes from year to year; hunters observe changes in habitat that are affected by changes in climate; and farmers catalogue the amount and distribution of precipitation on their fields to plan for future planting. Although many of these professions use local and experiential knowledge, expert climate knowledge informs the decisions associated with farming, hunting, and the ski industry as well. Consequently, climate knowledge is co-produced in a buyer-driven and producer-driven environment. Neither aspect of the knowledge system should be ignored.

Frontiers & Membranes

Although much of the theory and research associated with power in world system theory focuses on the hierarchical division of labor, I focus instead on the areas of intersection between regions, cultures, and especially knowledge systems. Within the world system a frontier has been defined as "a zone where two or more different social systems—state societies, non-state societies and world systems come into sustained contact" (Hall 2009).

Frontiers have been conceptualized as major sources of social change (Bentley 1993), areas of contested ground (Guy and Sheridan 1998), and as membranes that separate cultures or groups of people (Slatta 1997. The definition of frontiers as membranes is especially useful when characteristics of a membrane are considered. As Hall (2009:254) argues, membranes are differently permeable to things passing through them, both to the character of the things passing through and with respect to the direction of the passage. That is, a frontier may simultaneously be a conduit for contact among some things and barriers for others.

Further, when frontiers are viewed from a distance, say from the center of a knowledge system, they are seen as thin lines with sharp definition that form distinct boundaries. As climate scientists look out from within their discipline, the boundary between science and non-science appears clearly defined. However, when viewed up close, say at the border between scientific and experiential knowledge, the edges between boundaries can be unclear. These fuzzy zones of transition between different systems, be they political, cultural, or knowledge-based, are often highly contested and volatile.

Conceptualizing the boundaries of climate knowledge as a membrane allows us to explore the social construction of this knowledge. As information about global climate change is generated by scientists at the core of the climate science community, it is simultaneously generated by individuals who experience (or don't experience) the effects of climate change on the ground. Pielke Jr. notes that global environmental change issues such as climate change represent a "complex interface of science and decision making in which science is 'co-produced' by various sectors of society, and separation of 'facts' and 'values' cannot be achieved" (2004:407).

Finally, the membrane metaphor for frontiers in the world system allows us to explore the dissemination of climate knowledge. Knowledge, tools, strategies, and mechanisms to cope with and adapt to global climate change can be thought to flow through chains and networks of actors (Spaargaren, Mol, and Buttel 2006). As information is disseminated, it passes through links of a chain, or nodes of a network. This information may flow up the chain from the public to scientists (in the case of indigenous knowledge of climate change) or down from scientists to the public. Each of these links or nodes can be conceptualized as a frontier in which two different systems intersect. I apply world system theory, global value chain analysis, and the concept of frontiers to a case study of REDD+.

Reducing Emissions from Deforestation and Forest Degradation (REDD+)

REDD+ is an international policy project aimed at reducing emissions from deforestation and forest degradation, conserving and enhancing forest carbon stocks, and sustainably managing forests. This project emerged as a central global policy instrument of the Paris Agreement for greenhouse gas reduction, particularly for the immediate 2016–2020 period. Preceding climate negotiations, including COP19 in Warsaw and COP20 in Lima, made tremendous progress on REDD+ as a mechanism to incentivize the enhancement of carbon stocks and halt land-use change in developing countries. Specifically, the Warsaw REDD+ agreements established frameworks for measuring and monitoring, financing, and social safeguards, and the Lima COP resulted in major financial commitments to the REDD+ program.

Under this project, developed country donors, corporations, nongovernmental organizations, and individuals will compensate developing countries for verified forest emissions reductions. Although many proposals suggest that REDD+ implementation should take a nested approach, which integrates international, national, and local policy arenas and empowers local communities (Forsyth 2009, Pedroni et al. 2009, Sikor et al. 2010), large international organizations have driven the negotiations to date that have raised concerns about the recentralization of forest governance (Phelps et al. 2010).

Leading the design and implementation of REDD+ is the United Nations, through the Food and Agriculture Organization, the United Nations Environmental Program, and the United Nations Development Program. As of 2008, these organizations have collectively combined their efforts into a program known as UN-REDD. The World Bank is also participating through the Forest Carbon Partnership Facility (FCFP).

National governments are likely to coordinate and lead REDD+ activities with sub-national activities being developed in cooperation with government agencies. Cautioning against the recentralization of forest governance, Phelps et al. (2010) note that recipient national governments are becoming the principal forest stakeholders and are expected to avoid leakage, ensure permanence, and provide reliable MRV. REDD+ incentives resulting from successful implementation would be issued exclusively to centralized governments by the United Nations Framework Convention on Climate Change. Carbon trading through sub-national activities would be an exception, but these organizations would still be required to make their accountability transparent to national governments in order to avoid double counting. Demands associated with carbon-oriented forest management, such as establishing reliable baseline data and brokering deals between buyers and sellers, would benefit from economies of scale, coordination, and standardization that centralized governments could provide. Carbon accounting, and the MRV associated with carbon accounting, is a major driver defining the role of centralized governments in REDD+.

Governments have portrayed themselves as more capable and reliable than local communities at protecting the national (carbon) interest (Fry 2011). National REDD+ programs intending to trade carbon credits, either on a global market or to international carbon funds, will require extensive data related to forest conditions and changes in these conditions over time. Under these programs, countries will only be able to make claims related to forest stocks compared to an agreed upon reference emission level, or benchmark averaged for a whole forested territory. Governments will strategically target areas where reductions in forest biomass are most cost-effective, requiring spatially differentiated data on drivers, opportunity costs, and probable biomass growth rates, very little of which is currently available (Van Laake 2011). In order for countries

to demonstrate emission reductions or carbon stock enhancements with sufficient accuracy to attract potential buyers of carbon credits, these countries must have high-quality assessments for the reduction in emissions from above-ground biomass due to deforestation and degradation. This is often at the expense of local community participation.

Sub-national REDD+ activities may be characterized by the co-existence of state and community-based authorities in the regulation and sanctioning of natural resource governance practices, which can create added complexity in dealing with conflicts and how benefits are distributed. The rise of REDD+ as a part of the global response to climate change reflects the growing recognition of both the scale of emissions from tropical forests loss and degradation, and the potential benefits and co-benefits of REDD+ related policy interventions (Angelson 2009). Potential co-benefits are many, including: the prospective immediacy of its benefits, the potential to support biodiversity conservation and deliver other environmental services, and its potential to contribute to poverty reduction and improve rural livelihoods (Kanowski, McDermott, and Cashore 2011).

However, the ways in which incentives should be made available to local actors, and particularly to remote and rural poor communities, remains unclear. Tenure and management authority over community forests often exist outside of established statutory rights, further complicating questions of carbon credit ownership. There is an inherent tension that exists between perceived co-benefits and carbon benefits, which raises questions about equity, allocation, and access to REDD+ (Corbera and Schroeder 2011).

A nested approach to REDD+ may reorient policy away from the current focus on separable international, national, and local policy arenas to a more systematic consideration of how forest governance functions across multiple scales, and how traditional state-based policy measures can be integrated with networked, bottom-up, public-private, and market-based governance initiatives. As it is, REDD+ has transitioned into a mix of multi-level, multi-purpose, and multi-actor projects that permeate multiple spheres of decision-making and organizations. This creates contested interests and claims that translate into multiple implementation actions

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running ahead of policy processes (Corbera and Schroeder 2011; Cerbu, Swallow, and Thompson 2011).

The role of power in this process, while significantly lacking a theoretical basis, has not been completely ignored by scholarship. For REDD+ to be successful, substantial capacity building and institutional change to avoid disproportionate distribution of benefits to local community elites still necessary (Hansen, Lund, and Treueal 2009). Moreover, resource access and use largely favors economic development over conservation, which leads to inequitable outcomes (Pedroni et al. 2009). The significant financial resources that could become available under REDD+ might exacerbate, rather than address, institutional and social factors that contribute to forest loss and degradation, such as elite capture of benefits and corrupt behaviors (Hansen et al. 2009; Sikor et al. 2010). The broad goals of REDD+ (i.e. limiting carbon emissions from deforestation and enhancing carbon stocks) translate into many time- and place-specific objectives that encompass more regionally and locally specific resources than the generalized term "forest" can efficiently signify (Thompson et al. 2011). REDD+ thus requires governing many types of knowledge, including those related to land cover, livelihood activities, ecosystem services, and multi-scaled organizational capacities (Angelson 2009).

Application of Theories to REDD+ and the Paris Agreement

The following draws on examples in the published literature of REDD+ and applies the theoretical frameworks discussed previously in the climate knowledge system (world systems theory, global value chains, and membranes and frontiers) to gain some theoretical and practical insight into power and knowledge dynamics around global climate change and policy responses.

World System Theory and REDD+

Leading up to the Paris Agreement, a core group of organizations had facilitated and coordinated the negotiations around REDD+. Several financial and political commitments resulted from COP20, including powerful UN negotiators such as Norway ($1.7 billion), Germany ($64 million), the FCPF ($825 million), the Forest Investment Program ($639 million), the World Banks BioCarbon Fund ($280 million), and the Green Climate Fund

($10 billion). These commitments illustrate a high degree of power and vested interest in REDD+. Another core organization, the IPCC, is the paragon of expert scientific knowledge about climate change. The prestige associated with the IPCC legitimizes the knowledge created and disseminated by this organization. Further, these organizations have the power to dictate the rules of financial incentives, set reference emission levels and future reduction targets, and control the international carbon market.

Funding for REDD+ could take three forms: a fund created from developed countries to build capacity in developing countries for a shift to a market-based approach; carbon credits obtained by developing countries sold at auctions (from countries and private companies); and carbon credits sold on carbon markets that are fully fungible with other carbon credits (Angelson et al. 2009). Within these options, there is a clear international division of labor established, with hierarchical relationships between the core, semi-periphery, and periphery organizations. These core organizations are the powerful and developed centers of the system providing the fund-based financing, the early-action readiness and demonstration funding, and establishing future markets (Cerbu et al. 2011). Table 2 illustrates the composition of REDD+ actors, both in the policy process and in national implementation plans. Consider how the composition provides a perspective to assess the core, semi-periphery, and periphery structure of the climate knowledge world system.

In this knowledge system, the semi-periphery is composed of the national governments of developing countries. These centralized governmental organizations play a critical role in the system, mediating direct intervention from the core and diverting social justice and livelihood pressures from the periphery. Moreover, as indicated in Table 2, the semi-periphery plays pivotal roles, including: establishing and managing protected areas, reforming land-use policies and planning, establishing (or preventing) land-carbon tenure, brokering carbon deals, and enforcing compliance (Phelps et al. 2010). Ultimately, it is the characteristics of the national governments in the semi-periphery that will determine where REDD+ activities occur. In a recent meta-study of REDD readiness and demonstration activities, Cerbu et al. (2011) found measures of good governance at the national scale had a significant

Table 2. International Division of Labor in the Climate Knowledge System

	Organizations	Roles
Core	• World Bank (Forest Carbon Partnership Facility) • United Nations (UN-REDD) • Developed countries such as Netherlands, Germany, Norway, and England have developed funding programs • Multi-national corporations • Intergovernmental Panel on Climate Change	• Establish future markets • Early-action readiness funding • Fund-based finance • Science reports calling for reducing emissions from forest sector
Semi-Periphery	• Developing countries national governments • Public-private partnerships of existing carbon forestry projects operating in voluntary markets • Media	• Establish and manage protected areas • Reform land-use policies and planning • Establish land carbon tenure • Broker carbon deals • Negotiate with stakeholders • Enforce compliance
Periphery	• Sub-national projects • Communities • Existing community forest projects • Local government units • Private landholders	• Pursue sustainable forest management and carbon stock enhancements • Provide reliable monitoring • Provide social services and rural development

effect on the number of demonstration projects in a particular country. Their results also reveal the relative unimportance of human needs and opportunity costs of the land (Cerbu et al. 2011).

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Table 3. Types of Actors Involved in REDD Demonstration and REDD Readiness Activities

Organizational Category	Total Share of Actor Involvement in REDD+ Projects (%)	Total Share of Actor Involvement in *National* REDD Readiness Activities (%)
NGO/Non-Profit/Charity	35.8	26.0
Multi-national Corporation	27.3	7.3
Government	18.4	46.9
University/Research	8.8	8.3
Bi/Multilateral Development Organization	4.6	11.5
Local/Indigenous Community	0.4	0

Given the large sum of monies attributed to REDD+ activities, semi-periphery nations will be trying to position themselves relative to other semi-periphery organizations. For example, countries such as Nigeria and Sri Lanka with large forested acreage and high levels of deforestation will likely compete with each other for REDD+ funding. Domestically, REDD+ countries can manage or deliver funds via national budgets (held centrally or decentralized), independent funds (public or private), and direct project investment (private or public). However, without the recognition and transfer of forest rights/carbon rights to local and indigenous peoples and the access and participation in the process, equitable distribution of carbon benefits is unlikely to occur.

The semi-periphery is likely to continue to manipulate the periphery, exploiting the labor involved in forest conservation while simultaneously extracting the economic benefits and preventing their flow to the periphery. The periphery is made up of sub-national organizations, including, but not limited to, private landholders, local and indigenous communities, and local government units. The "+" extension to REDD is explicitly included to recognize livelihood interests, and a significant body of research investigates this element of climate mitigation strategies. Unfortunately, few successful examples have been recorded. Rather, most research warns against

the capacity of REDD+ to backslide on decades of progress toward decentralized forest governance movements that prioritize livelihood interests (Beymer-Farris and Bassett 2012, Phelps et al. 2010).

Establishing participatory MRV processes is the clearest pathway to effective and equitable REDD+ nested forest and climate governance. It has been shown that community-based approaches can produce data that will pass stringent quality-control procedures (Fry 2011). A broad spectrum of studies has illustrated evidence of accuracy, cost-effectiveness and sustainability, and particular cultural relevance for local monitoring projects (see Fry 2011 for a review). However, this will entail restructuring the flows of goods and services in the value chain.

Global Value Chain and REDD+

Internal governance structures of global value chains determine how financial, material, and human resources are allocated and flow within a chain, and can take one of two forms: producer-driven or buyer-driven (Gereffi and Korzeniewicz 1994). Applying a global value chain analysis to our case study is illustrative in two ways. First, how climate knowledge is produced and distributed is considered. The current conception of the proper way to distribute climate knowledge is through the producer-driven model. The IPCC, UN-REDD, and the FCPF produce the knowledge, both the earth system science of climate change, and more specifically how forest sector resources contribute and can help mitigate those changes. Because this knowledge flows from the core to the periphery, it maintains hegemonic ways of knowing, legitimizing certain types of information and data (e.g. satellite imagery of forest cover), and discrediting other perspectives (e.g. stories of forest change and traditional land-use practices). A buyer-driven approach would focus on the users of this climate knowledge, the people in the periphery who are engaged daily in living and managing the land, and integrate this local knowledge into the more general system of climate knowledge.

Additionally, global value chain analysis can assess carbon as a commodity (see figure 1). From this perspective, core actors serve as end-of-the-chain buyers, whereas periphery actors serve as producers of this natural commodity. Similar to traditional

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commodity value chain governance, the governance of REDD+ is wrought with power asymmetries that manifest through authority. Some actors have power over others, creating winners and losers within a global value chain, and some actors dominate others and appropriate the value generated in these value chains. Power asymmetries are driven by the distribution of benefits, leading to inequitable economic and environmental outcomes between core and periphery actors. Carbon as a commodity creates a membrane, where the very meaning of forests and trees is socially and culturally contested by participating stakeholders and shaped by the governance of the value chain.

Phelps et al. (2012) illustrate how carbon credits, emissions reductions, and payments are distributed through REDD+. Figure 2 illustrates how Phelps's model can be adapted using global value chain analysis. As local communities (periphery) reduce emissions, these reductions are recorded and managed by national governments (semi-periphery) that report their carbon credits to international organizations such as the UNFCCC (core). These core organizations in turn distribute payments to national governments of developing countries, which offer incentives for local communities to reduce emissions. The flow of information, funding, and carbon credits

Figure 1. REDD+ Initiatives Explained Using the World Systems Theory Framework
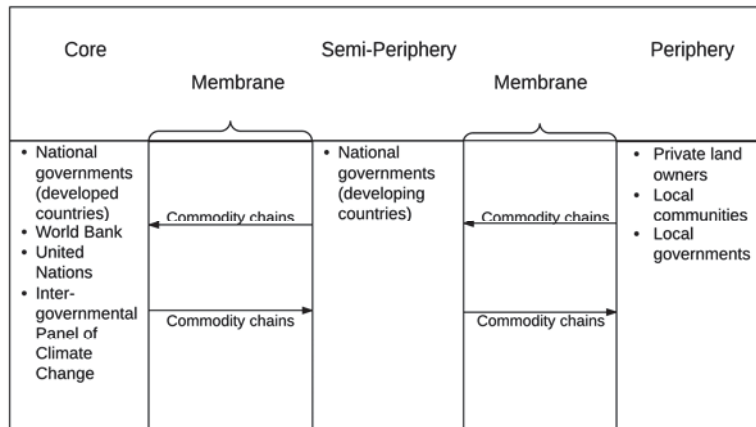
Source: Adapted from Phelps et al. 2010

Figure 2. Distribution of Incentives and Payments under REDD+
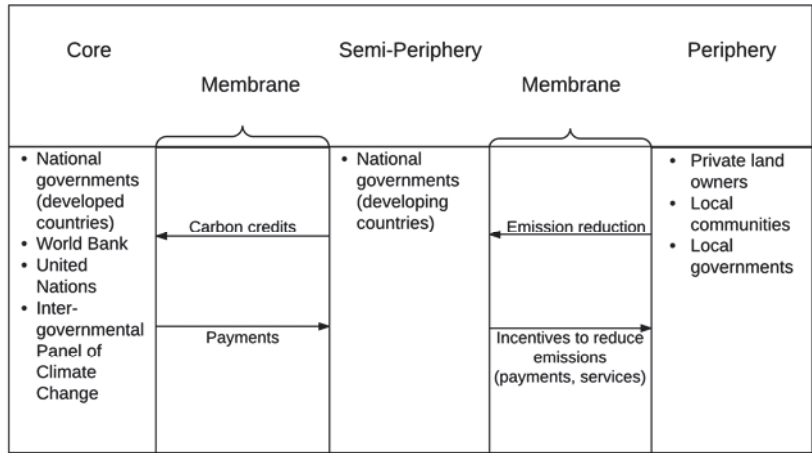
Source: Adapted from Phelps et al. 2010

under REDD+ programs thus illustrates how knowledge and carbon commodities are distributed in this system through global value chains.
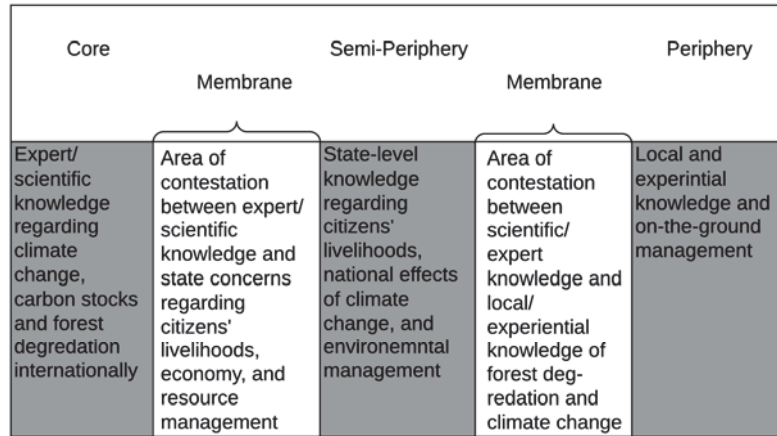
Frontiers and Membranes and REDD+

REDD+ commodifies carbon through market-based processes related to forest conservation. Carbon trading is an expression of neoliberal globalization that integrates current climate knowledge with market logic. It treats Earth's capacity to regulate climate stability as a measurable commodity, and functions under the assumption that the commodity can be allocated cost-effectively via international markets. Rather than being consumed, the carbon credit is continually repackaged and reused, and framing it as a commodity moreover involves complex contradictions (Lohmann 2010). The commodification of carbon is thus a quintessential Polanyian fictitious commodity (Polanyi 1944).[1]

Furthermore, the commodification of carbon turns forests into a zone where two different social systems come into contact: a frontier. Treating the forest as a frontier or membrane of global

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[1] Polanyi's concept of fictitious commodities refers to those things treated as market commodities which are not created for the market.

Figure 3. Frontiers and Membranes in REDD+ Initiatives

Core	Membrane	Semi-Periphery	Membrane	Periphery
Expert/ scientific knowledge regarding climate change, carbon stocks and forest degredation internationally	Area of contestation between expert/ scientific knowledge and state concerns regarding citizens' livelihoods, economy, and resource management	State-level knowledge regarding citizens' livelihoods, national effects of climate change, and environemntal management	Area of contestation between scientific/ expert knowledge and local/ experiential knowledge of forest deg- redation and climate change	Local and experintial knowledge and on-the-ground management

Source: Adapted from Phelps et al. 2010

climate change knowledge and mitigation highlights a fuzzy boundary between different types of knowledge and different types of knowledge systems. When the market system and the knowledge system intersect, the relative weight of differing loci of power and authority must be negotiated through social interaction. As noted previously, a frontier may simultaneously be a conduit for contact among some things and a barrier for others (see figure 3). As these negotiations take place, funding and knowledge flows among actors in the system. Whether funding or knowledge is transferred from one actor to the next is dependent on the permeability of the membrane between the two, which is determined by the power dynamics between the actors.

Conclusion

Our theoretical framework supports a view that understandings of climate change knowledge need to be cognizant of inherent power dynamics that shape the way that knowledge is constructed, governed, and implemented through policies. This approach is necessary for advocating a nested approach to climate change. Moreover, I argue that climate change knowledge is an emergent property of networked organizations. These networked organizations influence, and are influenced by structural power

dynamics associated with the international division of labor within the climate knowledge system that shapes the way knowledge is constructed, governed, and implemented. This theoretical framework recognizes that much of climate change knowledge and governance takes place outside formal government organizations and involves increasingly complex linkages and collaborations among multiple public and private organizations. In this view, experiential practice contributes to the emergent wisdom of networked actors and organizations governing complex systems, each informing one another in a collaborative form of rationality.

Instead of viewing power as an inscribed capacity of individuals and organizations that enable them to exercise control over others and dominate them, a networked conception of power conceives it as a medium to achieve diverse ends (Bixler et al. 2016). We believe this is the intent of REDD+ programs, but a more conscious effort must be made to recognize the multi-scaled and multi-sectored nature of climate change knowledge and the ways it flows through chains. A linear approach to the development of social, environmental, and even technical standards related to climate change fails to grasp the complexity of the system. Through the framework provided in this paper, we argue for a networked conception of knowledge creation and power related to governance. Thinking of power and knowledge in this relational sense provides an opportunity to consider the contingent, politically contested nature of global climate change networks and possibilities for various actors to achieve their respective goals and fundamentally alter the dynamics of creation, transfer, and adoption of climate change knowledge.

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