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An aggregated and dynamic analysis of innovations in campus sustainability

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Abstract

Purpose – This paper aims to compose a systematic understanding of campus sustainability innovations and unpack the complex drivers behind the elaboration of specific innovations. More precisely, the authors ask two fundamental questions: What are the topics and modes of implementation of campus sustainability innovations? What are the external and internal factors that drive the development of specific innovations?

Design/methodology/approach – The authors code and analyze 454 innovations reported within the Sustainability Tracking Assessment and Rating System (STARS), the campus sustainability assessment tool of the Association for the Advancement of Sustainability in Higher Education. Using descriptive statistics and illustrations, the paper assesses the state of environmental innovations (EIs) within STARS. Then, to evaluate the role of internal and external drivers in shaping EIs, the authors have produced classification and regression tree models.

Findings – The authors' analysis shows that external and internal factors provide incentives and a favorable context for the implementation of given EIs. External drivers such as climatic zones, local income and poverty rate drive the development of several EIs. Internal drivers beyond the role of the agent of change, often primarily emphasized by past literature, significantly impact the implementation of given EIs. The authors' work also reveals that EIs often move beyond traditional mitigation approaches and the boundaries of campus. EIs create new dynamics of innovation that echo and reinforce the culture of a higher education institution.

Originality/value – This work provides the first aggregated picture of EIs in the USA and Canada. It produces a new and integrated understanding of the dynamics of campus sustainability that complexifies narratives and contextualizes the role of change agents.

Keywords Campus sustainability, Sustainability reporting, Innovations, AASHE/STARS, Drivers of innovations

Paper type Research paper

Introduction

For several decades, higher education institutions (HEIs) have played a major role in promoting and implementing sustainable development (SD). Through changes in their operation, curriculum and institutional framework, HEIs champion SD on their campuses. However, to reach their full potential and have transformative impacts, efforts relative to campus sustainability require constant enhancement. To promote campus sustainability, HEIs have launched multiple initiatives, from international declarations on education and sustainability (Dyer and Dyer, 2017) to the creation of campus sustainability networks and assessments (Disterheft *et al.*, 2013). Such initiatives aim to develop pathways toward enhancing campus sustainability through the establishment of clear sustainability benchmarks and diffusing successful innovations.

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"Environmental innovations" (EIs), also called "eco-innovations" or "green innovations", are defined by the Oslo Manual as the:

> [. . .] implementation of a new or significantly improved product (good or service), or a process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (OECD/Eurostat, 2005).

Hence, EIs relate not only to technological innovations or physical operations but also to all the aspects of an organization (Antonioli *et al.*, 2013). Applied to the field of campus sustainability, EIs extend beyond the physical dimensions of sustainability in the same way that campus sustainability includes educational and institutional dimensions (Disterheft *et al.*, 2013). However, efforts to elaborate a systematic understanding of the nature of campus sustainability innovations and of the drivers behind the development of those innovations remain limited. Indeed, past research on EIs and campus sustainability has mostly focused on individual case studies or on small clusters of case studies that can render only a partial view of EIs (Lidstone *et al.*, 2015). A small number of macro-scale investigations have been conducted using systematic literature reviews; however, they remain limited in their findings because of their methodological approach (Hoover and Harder, 2015).

In the past decades, sustainability reporting and the development of campus sustainability assessments (CSAs) have become tools to assess the efficacy of campus sustainability initiatives (Yarime and Tanaka, 2012; Arroyo, 2017). Although past literature has investigated the role of CSAs in establishing sustainability benchmarks and promoting organizational change (Arroyo, 2017), no research has been conducted on the EIs diffused through CSAs. However, as a repository of information on EIs, CSAs offer the opportunity to conduct a more robust macro-scale analysis of EIs.

It is crucial to understand the nature and the drivers behind the adoption of innovations so as to define strategies and policies to efficiently promote campus sustainability. This work aims at providing the first aggregated picture of EIs in the USA and Canada by composing a systematic understanding of campus sustainability innovations and unpacking the complex drivers behind the elaboration of specific innovations. More precisely, the authors ask two fundamental questions:

Q1. What are the topics and modes of implementation of campus sustainability innovations?

Q2. What are the external and internal factors that drive the development of specific innovations?

To answer these two questions, the authors analyze innovations reported through the Sustainability Tracking Assessment and Rating System (STARS), the CSA of the Association for the Advancement of Sustainability in Higher Education (AASHE), the leading campus sustainability network in North America (Urbanski and Filho, 2015). In this work, the authors code and analyze 454 innovations reported within STARS. Descriptive statistics and analyses of the result of the coding are used to assess the state of EIs within STARS. Classification and regression tree (CART) models are produced to evaluate the roles of internal and external drivers in shaping EI. The authors then conclude by discussing the contours of a new picture of campus sustainability provided by this study and some recommendations for future research and strategies to promote campus sustainability.

Literature review

In the past two centuries, US universities have championed major social changes in response to challenges of significant scale, such as SD (Caeiro *et al.*, 2013). In one example, to respond to the horror of slavery, many college students and professors became major actors in the Underground Railroad in the 1830s (Slater, 1995). Following a long history of pioneering social change, in the past 40 years, HEIs have been leaders in promoting social change toward sustainability (Disterheft *et al.*, 2013). From the first Earth Day in 1970 (Rome, 2003) to the more recent divestment movement (Grady-Benson and Sarathy, 2015), HEIs have continued to echo and amplify social movements and calls for addressing SD through social change over the years.

HEIs are inherently agents of change as learning institutions that modify their practices and organization to address societal challenges (Senge, 2006). For instance, campus-based anti-slavery movements in the nineteenth century led to the admission of students of color (Slater, 1995). In the 1980s, HEIs utilized divestment from South African companies as a weapon to fight the Apartheid (Teoh *et al.*, 1999). More recently, HEIs' anti-tobacco campaigns have occurred concomitantly with divestment from the tobacco industry and smoking bans across US campuses (Wander and Malone, 2004). Similarly, sustainability initiatives often lead to radical changes within HEIs. For instance, Orr relates how the construction of the Adam Joseph Lewis Center for Environmental Studies, a student-designed green building at Oberlin College, increased the credibility of students on campus and modified their role relative to strategic planning and operations (Orr, 2005). Within and beyond campus sustainability, innovations characterize the nature of HEIs.

To construct a dynamic and strategic understanding of these EIs, drivers leading to the adoption of EIs need to be investigated. Within business and management literature, innovations are understood as resulting from the combined action of drivers both internal and external to an organization (Bossle *et al.*, 2016). In the context of SD, firms operate within an "environmental mode" that distinguishes the elaboration of EI from the formation of other kinds of innovations (Jakobsen and Høyvarde Clausen, 2016). In this environmental mode, external drivers such as normative and regulatory frameworks, technological innovations, consumer demand and professional networks act through a process of "push and pull" to foster the adoption of EIs. Normative and regulatory drivers both constrain and incentivize organizations in implementing EIs. Technological innovations make possible the production of EIs and encourage firms to adopt them. Demand for specific goods opens up new possible markets and compels firms to meet the demand. Finally, professional networks facilitate the growth of innovations by providing access to external knowledge and by pressing firms to remain competitive (Bossle *et al.*, 2016).

External drivers define the general scope and direction of EIs, and internal drivers tailor innovations to the unique characteristics of each organization. Internal factors that can be understood as control variables, such as company size and sector of activity of an organization, determine the likelihood of EIs. Large companies are more likely to implement EIs than small companies. Firms in high-polluting sectors are also more likely to adopt EIs rather than those in non-polluting sectors. Other internal factors define the unique nature of EIs. Organizations and firms implement EIs that are less costly and more beneficial to them (Jakobsen and Høyvarde Clausen, 2016). In addition, environmental managerial concern is key to setting priorities and implementing EIs. Finally, human resources restrict the type of EIs developed by an organization (Bossle *et al.*, 2016).

In the context of campus sustainability, some past literature has highlighted the role of external drivers such as international declarations and campus sustainability networks in the promotion of EIs. From the Talloires Declarations to the American College and

University Presidents' Climate Commitment, international declarations have provided structure and guidance for the expansion of campus sustainability innovations (Dyer and Dyer, 2017; Lozano *et al.*, 2015). Campus sustainability networks such as AASHE were created to focalize and foster campus sustainability and innovations. CSAs such as STARS provide benchmarks to help HEIs plan and implement changes (Urbanski and Filho, 2015). They act both as an "instigator" and a driver of "reinforcement" of sustainability practices (Arroyo, 2017). They diffuse and guide innovations by clearly identifying where innovations can add value to HEIs and society alike while illustrating implementations paths (Rohrbeck *et al.*, 2013).

In addition to external drivers that have encouraged and shaped EIs, past literature has also highlighted the role of internal drivers in defining the scope and the nature of innovations. Although internal drivers such as efficient communication, interdisciplinary collaborations, active leadership, financial resources and efficient organizational structure have been identified by the literature (Allen, 1999; Lozano, 2006, Verhulst and Lambrechts, 2015; Arroyo, 2017), most research has concentrated on the role of internal agents of change. In her seminal book on campus sustainability, Keniry (1995) highlights the role of staff and faculty members in initiating and supporting sustainability initiatives on campus. In this perspective, the success of EIs relies almost exclusively on the work of the change agent and rarely endures if the change agent leaves the HEI. More recent work continues to emphasize on the role of change agents in framing and implementing EIs (see for instance Sharp, 2002; Moore, 2005; Brinkhurst *et al.*, 2011). Change agents are positioned at the heart of campus sustainability efforts and act as social entrepreneurs in the formulation and implementation of EIs. They have an in-depth institutional knowledge that allows them to overcome institutional barriers and transform their campuses (Lozano, 2006; Verhulst and Lambrechts, 2015). Because both students and senior administrators do not remain in the HEI for a long time, change agents are generally people in the middle of the hierarchy, faculty and staff, who can guarantee the successful implementation and durability of EIs (Arroyo, 2017).

However, recent work clearly states that EIs need to be understood as a complex construct situated within a specific environmental and social context shaped by multiple internal and external drivers (Arroyo, 2017). It is therefore critical to look beyond the role of the agent of change and to assess how other factors drive the adoption of EIs. In this paper, the authors build on past literature on campus sustainability and broader findings relative to EIs to construct a conceptual model (Figure 1). To move beyond highlighting the general role of external drivers such as international declarations, campus sustainability networks and CSAs, the authors examine how the social and physical surrounding environments of an HEI drive the development of EIs. Importantly, the authors also evaluate how unique internal socio-economic and physical characteristics of HEIs frame EIs to decipher drivers beyond the agent of change.

Methods

Innovations

The authors retrieved data on April 13, 2015, on 454 EIs from the STARS online platform (AASHE, 2017). Data were gathered for 157 HEIs located in the USA and Canada. As per the rules of the CSA, HEIs can report up to four innovations and earn up to 4 credits (out of a total of 100) toward their STARS rating. To earn credits, innovations need to be truly innovative not only for the reporting institution but also within the field of campus sustainability in general. A letter of support from an independent expert must be provided to ensure that the activity is truly innovative. Reported innovations can occur in any area of

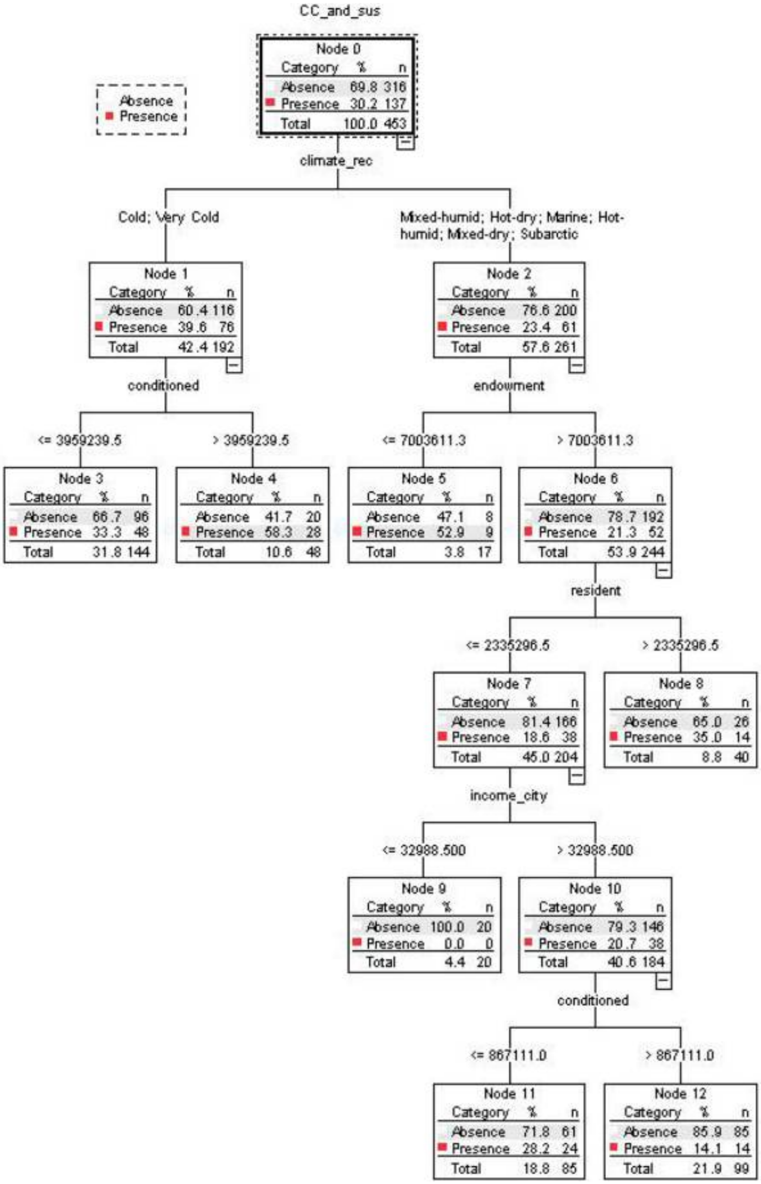

Figure 1.
CART model of climate change and sustainability

campus sustainability. They should not have been reported elsewhere in the STARS report or exceed the highest criterion of an item reported. Innovations must have already been implemented and not be only at the planning stage. Implementation of the innovation needs to be documented. Innovations must have occurred within three years of a given institution's report. Each institution submits a full report every three years on a different submission schedule. Therefore, the data that the authors analyze refer to innovations that occurred between 2010 and 2016.

The authors coded both topics of innovations and modes of implementation following an open coding method (Strauss and Cobon, 1990). The open coding method derives from grounded theory (Glasser and Strauss, 1967) and refers to the process of classifying textual data into categories that emerge from a particular data set. Innovations were coded into seven topics: sustainability and climate change; energy, buildings and sustainable design; waste; landscape, grounds and ecosystems; food and food systems; social and environmental justice; and transportation. Modes of implementations were also coded into six categories: operations, curriculum, co-curriculum, organizational change, research, outreach and partnerships. When applicable, innovations were coded into multiple topics and/or modes of implementations. Number of topics and modes of implementation *per* innovation were recorded. The authors then conducted a systematic analysis of innovations by combining some descriptive statistics illustrated by multiple case studies.

Internal and external drivers of innovations

To assess the significance of internal and external drivers in the adoption of specific EIs, the authors retrieved data reported *via* STARS by HEIs (Table I) (AASHE, 2017). Institutional characteristics and physical and operational characteristics of campuses were selected as internal drivers. "Type of institution" and "endowment" were selected as institutional characteristics. "Total campus area," "gross floor area of building space," "conditioned floor area in acres," "floor area of laboratory space," "floor area of healthcare space," "floor area of other energy-intensive space" and "floor area of residential space" were selected as physical and operational characteristics. Then, variables relative to the social and physical surrounding environments of HEIs were selected as external drivers. Data relative to the HEIs' International Energy Conservation Code (IECC), i.e. climate region, locale, percentage of people living in poverty at the city and state levels and the median income at the city and state levels, were collected.

The authors developed CART models to assess the significance of internal and external factors in driving the implementation of specific innovations. Given the nature of EIs, distinct drivers were selected in different models (Table II). Although most drivers were selected as independent variables in most models, some drivers were selected only in some models to follow past literature on drivers of EIs and improve the performance of the models. Drivers relative to energy use and some spaces on campus were selected for innovations relative to energy or transportation and were not included in models relative to food and environmental justice. On the other hand, drivers relative to social or economic conditions were selected for models relative to food and environmental justice but were not included in models relative to energy and transportation.

CART is a non-parametric technique that can select independent variables that are the most important (from a large number) in determining the dependent variable. CART models (De'ath and Fabricius, 2000) are simple rule-based statistical models that split data within a particular independent variable into two homogenous groups depending on how they interact with the dependent variable and arrange them hierarchically. Many variables can be split and arranged hierarchically. Dependent variables can be categorical (classification) or continuous (regression). Independent variables can be of any type (binary, ordinal, categorical or continuous), and no assumptions about the structure of the data are needed. Several rules are generally applied to determine tree size; these include the proportion in reduction of error needed to create a split and maximum tree size and minimum sample size

Variable	Details	Descriptive statistics
Internal drivers		
Institutional characteristics		
Type of institution[a]	1-associate	3.8%
	2-baccalaureate	25.8%
	3-master	17.2%
	4-doctorate	53.2%
Endowment[a]	in US dollars	Mean 1,273,625,283
		Median 301,000,000
		SD 2,978,421,949
Physical and operational characteristics		
Area[a]	Total campus area in acres	Mean 1,043.3
		Median 549
		SD 1561.58
Floor[a]	Gross floor area of building space (in gross square feet)	Mean 7,071,822
		Median 5,137,104
		SD 6,621,514.8
Conditioned[a]	Conditioned floor area (in gross square feet)	Mean 3,361,899.9
		Median 1,161,851
		SD 5,206,831.4
Lab[a]	Floor area of laboratory space (in gross square feet)	Mean 630,228.3
		Median 193,874
		SD 910,258.2
Health[a]	Floor area of healthcare space (in gross square feet)	Mean 196,605.2
		Median 2,500
		SD 708,130.5
Intensive[a]	Floor area of other energy intensive space (in gross square feet)	Mean 252,596.9
		Median 74,699
		SD 506,689.5
Resident[a]	Floor area of residential space (in gross square feet)	Mean 1,229,341.3
		Median 859,667
		SD 1,203,080.8
External drivers		
Social and physical surrounding environment		
IECC climate region[a]	Hot-humid	4.9%
	Hot-dry	6.8%
	Mixed-humid	29.1%
	Mixed-dry	3.3%
	Marine	12.6%
	Cold	39.3%
	Very cold	3.1%
	Subarctic	0.9%
Locale[a]	Large city	23%
	Urban fringe of large city	10.8%
	Mid-size city	18.5%
	Urban fringe of mid-size city	13.9%
	Large town	12.4%
	Small Town	17%
	Rural	4.4%

(*continued*)

Table I. Attributes of institutions of higher education

Variable	Details	Descriptive statistics
State poverty[b]	Percentage of population living in poverty in the State of university	Mean 14.9 Median 15.8 SD 2.9
City poverty[b]	Percentage of population living in poverty in city of university	Mean 21.2 Median 21.7 SD 11
State income[b]	Median household income for the State (in 2014 dollars), 2010-2014	Mean 57,148.6 Median 57,166 SD 9,194.5
City income[b]	Median household income for city (in 2014 dollars), 2010-2014	Mean 55,056.5 Median 48,120 SD 24,807.3

Table I.

Sources: [a]AASHE, STARS; [b]For US HEIs: US Census Bureau (www.census.gov/quickfacts/table/). For Canadian HEIs: www.statcan.gc.ca

Dependent variable	Independent variables
Sustainability and climate change	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, conditioned floor area, floor area of health-care space, floor area of other energy-intensive space, floor area of residential space, percentage of population living in poverty in the state, percentage of population living in poverty in city, median household income for the state, median household income for the city
Energy, buildings and sustainable design	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, conditioned floor area, floor area of health-care space, floor area of other energy-intensive space, floor area of residential space
Waste	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, conditioned floor area, floor area of healthcare space, floor area of other energy-intensive space, floor area of residential space, percentage of population living in poverty in the state, percentage of population living in poverty in city, median household income for the state, median household income for the city
Landscape, grounds and ecosystems	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, floor area of residential space
Food and food systems	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, floor area of residential space, percentage of population living in poverty in the state, percentage of population living in poverty in city, median household income for the state, median household income for the city
Social and environmental justice	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, floor area of residential space, percentage of population living in poverty in the state, percentage of population living in poverty in city, median household income for the state, median household income for the city
Transportation	Type of institutions, endowment, IECC climate zone, locale, total area of campus, gross floor area of building space, conditioned floor area, floor area of healthcare space, floor area of other energy-intensive space, floor area of residential space

Table II.
Details of CART models

of a terminal node. Trees are represented as a graphic with a sample size of each node being reported.

Results

Topics of innovation

EIs pertain to seven topics described below (Table III).

Sustainability and climate change

Of the EIs analyzed, 30.2 per cent engage broadly and in a systemic way with issues of sustainability and adaptation or resilience to climate change. At Babson College (MA, USA), for instance, efforts were made to integrate environmental concerns with economic or equity considerations by hiring a staff member to help students find careers in both the environmental sustainability and social impact fields. At Central Carolina Community College, efforts focused on adaptation to climate change by hosting a conference to explore the adaptation and resilience of local food systems. Ohio State University has implemented a research program to elaborate conceptual models and practical examples of climate-resilient, secure and equitable agricultural food systems. Boston University has conducted an in-depth assessment of its vulnerability to climate change and explored strategies to prepare the campus for a projected sea-level rise.

Energy, buildings and sustainable design

Over a quarter (26.9 per cent) of EIs pertain to energy, buildings efficiency and sustainable design. The University of British Columbia enhanced energy efficiency on campus by replacing its aging steam infrastructure with a more efficient hot water district energy system. To increase its consumption of renewable energy, the State University of New York at Cortland invested in a $3m solar project. At Smith College (MA, USA), efforts were made to develop sustainable design by constructing a Living Building.

Waste

In this data set, 16 per cent of EIs are relative to waste reduction, recycling and composting. Williams College (MA, USA) has adopted a tool to measure pre- and post-consumer food waste and change behaviors on campus. The University of Tennessee at Knoxville concentrated its efforts on recycling by implementing a project to eliminate at least 90 per cent of recyclable waste during athletic events. Students from the University of Minnesota Morris have researched and implemented a cold-weather windrow-based composting system.

Topic of innovation	Frequency per topic (%)
Climate change and sustainability	30.2
Energy, buildings and sustainable design	26.9
Waste	16
Landscape, grounds and ecosystems	14.8
Food and food systems	10.8
Social and environment justice	5.5
Transportation	5.3

Table III.
Frequencies of topics of innovations

Landscape, grounds and ecosystems

In this data set, 14.8 per cent of EIs aim at preserving or restoring local ecosystems and ecosystem functions. For instance, The University of West Georgia has built a 1.6-mile-long pedestrian greenway on its campus. The University of Missouri is working with various partners to restore local wetlands. Finally, the Western Michigan University has earned over $2m of competitive grants to transform its campus into a stormwater neutral campus.

Food and food systems

Slightly over 10 per cent (10.8 per cent) of EIs target food and food system to both increase access to local food and reduce the carbon footprint of food on campus. The University of Kentucky has planned to integrate its teaching, research and extension activities to promote local food on campus and in its region. Knox College (IL, USA) created a 300-ft^2 food-growing structure to be able to extend the growing period of fruits and vegetable into the academic year. Missouri State University started a "Meatless Monday" program in dining halls to reduce their carbon footprint.

Social and environmental justice

A small percentage (5.5 per cent) of EIs have a clear emphasis on social and environmental justice. For instance, the University of Saskatchewan has established a student-managed interdisciplinary wellness project that provides after-hours inter-professional health care and outreach services for the benefit of the local, mostly Aboriginal and low-income population. Faculty at George Washington University are conducting research into implementing policy to support the growth of solar energy in low-income households.

Transportation

Finally, 5.3 per cent of EIs are directed toward decreasing the carbon footprint of transportation on campus. The University of Manitoba has established bike repair stations and promoted winter cycling by conducting research on infrastructure such as bike shelters. Black Hills State University (SD, USA) acquired electric vehicles for trash collection.

Modes of implementation

EIs are developed *via* seven modes of implementation described below (Table IV).

Operations

Less than half (43.7 per cent) of the modes of implementation of EIs relate to campus operations in areas relative to energy, waste and transportation. The University of Washington installed a tower data center to closely monitor energy use and to reduce its

Table IV.
Frequencies of modes of implementation

Modes of implementation	Frequency per mode (%)
Operations	43.7
Co-curriculum	29.9
Organizational change	22.7
Partnerships	18.4
Curriculum	15.9
Research	15.5
Outreach	6.8

carbon footprint. Baylor University (TX, USA) started composting their equine waste to apply on their pasture and reduce emissions during transportation of waste and production of fertilizer. Western Michigan University installed electric vehicle charging stations available for people staying on-campus and the greater local community. A number of EIs operationalize green lab or green computing practices to reduce energy use of high-energy-intensity spaces. The University of Massachusetts in Amherst created the Massachusetts Green High Performance Computing Center, a LEED Platinum data center that uses 25 per cent less energy than typical data centers.

Co-curriculum

Over a quarter (29.9 per cent) of modes of implementation of EIs pertain to co-curriculum initiatives and promote career development, green funds, conferences or green competitions. For instance, the University of North Carolina at Chapel Hill has supported a series of initiatives to develop entrepreneurial sustainable approaches to global challenges, including venture capital competitions. The University of Tennessee at Knoxville has implemented a Green Revolving Fund that operates with a $100,000 budget to conduct energy retrofits and efficiency projects on campus. The American University (Washington DC, USA) regularly organizes ECOllaborative Colloquiums to bring together members of their community who are working on environmental and sustainability-related issues. Stanford University (CA, USA) orchestrated a Solar Decathlon in partnership with the US Department of Energy to challenge students from 20 collegiate teams all around the world to design, build and operate solar-powered net-zero homes.

Organizational change

Of the EIs analyzed, 22.7 per cent of modes of implementation result in significant organizational changes that deeply modify how HEIs function as a result of strategic planning initiatives or changes in governance. For instance, the Appalachian State University (NC, USA) has defined a strategic plan focused around the objective to "envision a just and sustainable future". The Northern Arizona University has established a coordinating committee for campus sustainability to facilitate inter-departmental sustainability initiatives and bring together decision makers from across campus. Rice University (TX, USA) has created a Center for Energy and Environmental Research in the Human Sciences to explicitly sponsor research on the energy/environment nexus across the arts, humanities and social sciences. A few EIs are dedicated to green impactful investment or fossil fuel divestment initiatives. The University of New Hampshire took part in the billion-dollar Green Challenge and joined 32 other colleges and universities to launch a national challenge to invest in revolving funds that finance energy efficiency upgrades on campus.

Partnerships

Less than 20 per cent (18.4 per cent) of modes of implementation of EIs rely on strong partnerships with other HEIs, cities, businesses and industries, or Federal agencies. For instance, American University partnered with George Washington University (Washington DC, USA) and the George Washington University Hospital to build a 52-MW solar photovoltaic power system. The University of New Hampshire has partnered with the town of Durham to adopt an integrated watershed management plan and an integrated permit approach for wastewater and stormwater management to reduce capital investment and operating costs. The University of Wisconsin-Stevens Point partnered with Chevrolet to enhance clean energy and energy efficiency on campus. The University of California, Santa

Barbara has partnered with the EPA, the local water districts and the other UCs to implement a water action plan to improve water conservation and efficiency.

Curriculum

Slightly over 15 per cent (15.9 per cent) of modes of implementation of EIs modify the curriculum by implementing new departments, majors or minors, degree requirements, courses or learning experiences. For instance, the University of North Carolina at Greensboro created the first sustainable tourism and hospitality program in 2013. Tulane University (LA, USA) created a Public Service Graduation Requirement after Hurricane Katrina that includes service learning sustainability courses. Chatham University (PA, USA) has initiated an interdisciplinary study abroad program in Costa Rica.

Research

In this data set, 15.5 per cent of modes of implementation of EIs pertain to research-related activities and concentrate on funding opportunities for faculty research, student research, internships or scholarships. For instance, as part of its climate action plan, Emory University (GA, USA) has implemented support to encourage the involvement of faculty in campus sustainability. Penn State's Reinvention Fund is an internal competitive grant program designed to support interdisciplinary teams that pursue political solutions to sustainability challenges. Middlebury College (VT, USA) has established a FoodWorks Internship Program to provide students with a consulting opportunity around issues of food and sustainability.

Outreach

A small percentage (6.8 per cent) of EIs concentrate on community outreach. For instance, the Greater Carlisle Project initiated by Dickinson College (PA, USA), along with local partners aimed at enhancing local SD Richland Community College, has generated teaching materials for grades K-12 to be used in local schools and beyond.

Number of topics of innovations and modes of implementation

Some EIs span multiple topics of innovations and/or modes of implementation. Indeed, 9.5 per cent of EIs stretch over two topics, whereas 0.7 per cent cover three topics. For instance, Clarkson University (NY, USA) created a research, education and operation agroforestry carbon offsets program in Uganda and explicitly integrated considerations relative to energy, ecosystems and environmental justice and development in the Global South. A number of innovations extend beyond one mode of implementation; 33 per cent of innovations operationalize two modes of implementation, 5.3 per cent of innovations mobilize three modes of implementation and 2.1 per cent of innovations involve more than three modes of implementation. For instance, Colgate University (NY, USA) integrated its campus operation, research and curriculum to establish strong partnerships to enhance forest carbon sequestration and ecological restoration on campus and in Patagonia (Argentina).

Classification and regression tree models

CART models explore relationships between topics of innovations (dependent variable) and internal and external drivers of innovations (independent variables). Each tree shows how relevant splits in the data explain the relationships between the dependent and independent variables. The most significant splits are made first and arranged at the top of the tree.

Subsequently, less important splits are made afterward and arranged lower in the tree. Lower branches of the tree specify which variables condition the adoption of given EIs and are arranged from the most to the least influential. Each branch splits the data in two groups, namely, HEIs that adopted the innovation and others.

Climate change and sustainability

The analysis of innovations relative to climate change and sustainability produced a CART model with 12 nodes, 3 of them relative to the presence of the innovation (Figure 1). *EICC climate regions* was the first discriminator, with HEIs in "cold" and "very cold" zones being more likely to adopt this kind of EI. The second and last separation were driven by the *floor area of air-conditioned space*, with HEIs less than 3,959,239 gross ft^2 of air-conditioned space being more likely to adopt such innovations.

Energy, buildings and sustainable design

Innovations relative to energy produced a CART model with 12 nodes, 5 of them relative to the presence of innovation (Figure 2). The largest separation occurred at the level of the variable *floor area of healthcare space*, with HEIs with more than 2,450 gross ft^2 being more likely to adopt such innovations. The second largest separation was driven by the *floor area of laboratory space*, with HEIs with more than 32,826.5 ft^2 of laboratory area being more likely to innovate. *EICC climate regions* was the next discriminator, with HEIs in "mixed-humid", "cold" and "very cold" zones being more likely to adopt energy-related innovations. Finally, *total area of campus* and the *floor area of laboratory space* are the last two discriminators with larger campus (more than 238 acres), with HEIs with more laboratory space (more than 117,549 ft^2) being more likely to implement such innovations.

Waste

The analysis of innovations relative to waste produced a CART model with two nodes (Figure 3). The unique separation occurred at the level of the variable *total area of campus*, with larger campuses (more than 61.5 acres) being more likely to develop innovations relative to waste.

Landscape, grounds and ecosystems

The analysis of innovations relative to campus landscape, grounds and ecosystems created a CART model with 18 nodes, 4 of them relative to the presence of the innovation. *EICC climate regions* was the first discriminator, with HEIs in "mixed-humid", "cold", "marine", "mixed-dry" and "very cold" being more likely to innovate in that area than HEIs in "hot-dry", "hot-humid" or "sub-arctic" zones. *Locale* was the next discriminator, with HEIs in "large towns", "urban fringe of large city", "urban fringe of mid-size city" and "rural" areas being more likely to foster innovations relative to their landscape and grounds. Next, HEIs with an *endowment* of more than $4.8bn but a *total floor area* of less than 12,952,783.5 ft^2 were more likely to introduce such innovations Figure 4.

Food and food systems

The analysis of innovations relative to food and food systems produced a CART model with 24 nodes, 5 of them relative to the presence of the innovation (Figure 5). The largest separation occurred at the level of the variable *total floor area*, with HEIs with a build area of more than 152,538 ft^2 being more likely to foster such innovations. *Median household income at the state level* was the next discriminator, with HEIs located in a

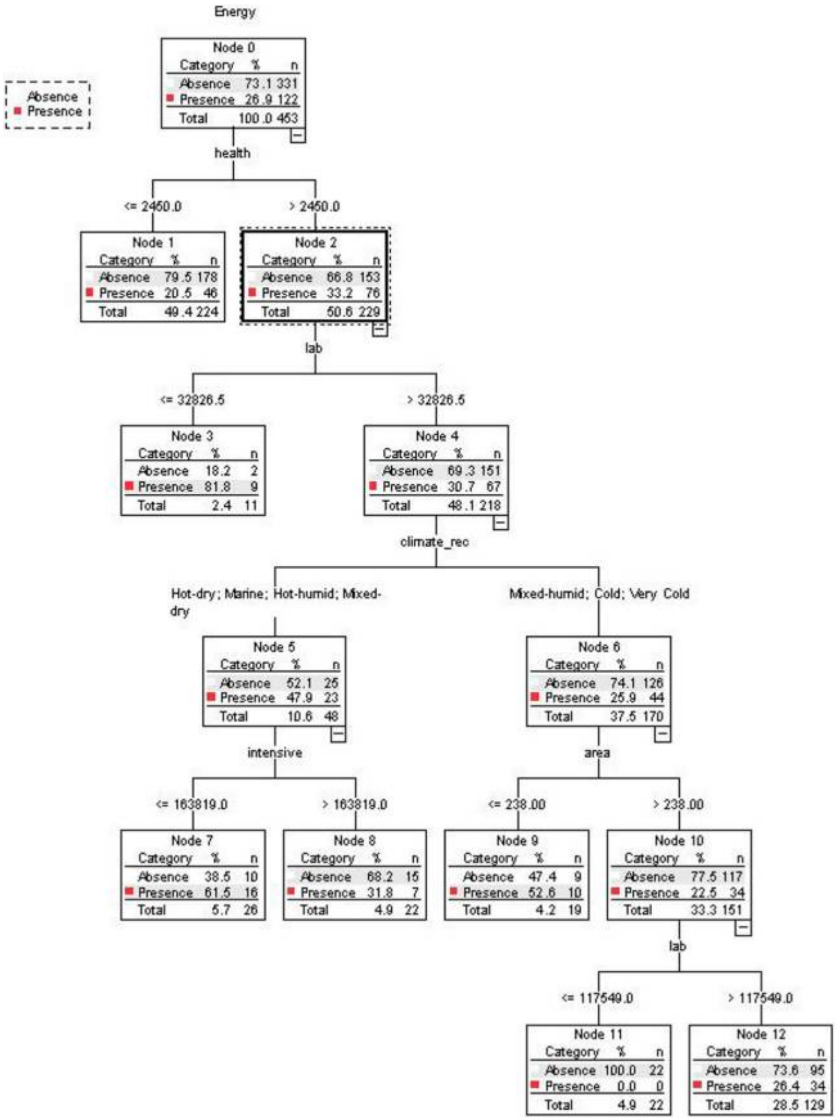

Figure 2.
CART model of energy, buildings and sustainable design

state with a median annual income superior to \$44,066 being more likely to innovate. Next, *total floor area* was again a discriminator, with HEIs with a built area of more than 1,212,462 ft^2 more likely to introduce such innovations. Finally, the *percentage of population living in poverty in the city* of the HEIs along with *the total area of resident space* were significant discriminators, as HEIs with less than 18 per cent of their population living in poverty and with more than 499,463 ft^2 of residential space were more likely to pioneer such EIs.

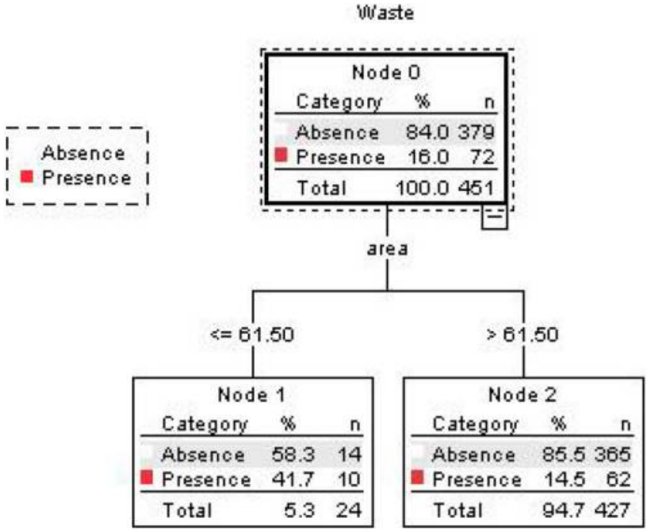

Figure 3. CART model of waste

Social and environmental justice

The analysis of innovations relative to environmental justice produced a CART model with 20 nodes, 4 of them relative to the presence of the innovation (Figure 6). *Median household income at the state level* served as the first two discriminators, as HEIs located in a state with median income of more than $47,488 but less than $77,450 were more likely to develop such innovations. HEIs located in "*large cities*" were slightly more likely to adopt innovations relative to environmental justice than others. Finally, HEIs located in "mixed-humid" and "sub-arctic" areas and those with an *endowment* of less than $3.7bn were more likely to launch such innovations.

Transportation

The analysis of innovations relative to transportation issues produced a CART model with four nodes (Figure 7). The *total area of floor space* served as the sole discriminator predicting the presence of such innovation. HEIs with a total floor area of less than 16,479,775 ft^2 were more likely to institute innovations relative to transportation.

Discussion

Our analysis shows that for EIs reported in STARS, drivers beyond international declarations, campus sustainability networks and internal agent of change incentivize and provide a favorable context for the implementation of given EIs. External drivers such as climatic zones, local income and poverty rate drive the development of several EIs. For instance, HEIs located in "cold" and "very cold" climate regions are more likely to develop EIs relative to energy efficiency and renewable energy. Because they use an abundant amount of energy to heat their buildings, they are faced with strong economic and environmental incentives to innovate. HEIs in average socio-economic contexts, where income levels and poverty rates are close to the mean, are more likely to adopt EIs relative to food and environmental justice. This result does not reflect past literature on food and environmental justice EIs that highlights how HEIs located in low-income areas respond to

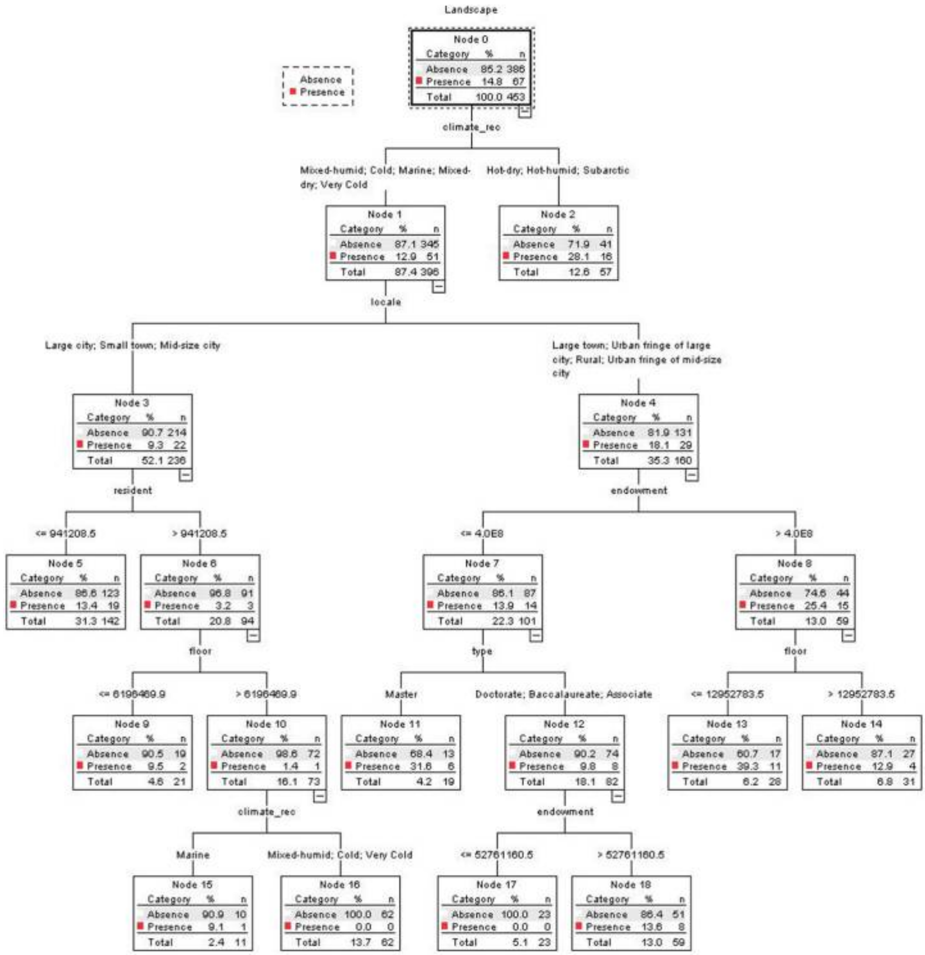

Figure 4.
CART model of landscape, grounds and ecosystems

their socio-economic environment by shaping their campus sustainability efforts (Orr and Cohen, 2013). Additional research should be conducted to elucidate the drivers of food and environmental justice EIs and weigh the respective role of agents of change versus local socio-economic contexts. Internal drivers relative to the size of various spaces on campuses and the endowment of HEIs significantly impact the implementation of EIs. In both cases, HEIs with relatively large physical spaces and endowments appear to be more likely to innovate. Possible explanations for these findings may include the fact that large physical space and endowments often correlate with and may reflect broader institutional capacities to develop and report EIs.

In addition, the authors investigated how “traditional” topics of innovations and modes of implementation shape campus sustainability. The term “traditional” refers to what Mazmanian and Kraft (2009) analyze as the first (1970-1990) and second (1980-2000s) epochs of US environmental policies. During the first epoch of environmental policies, policy makers at the federal level led the regulation of pollution and waste issues, whereas in the

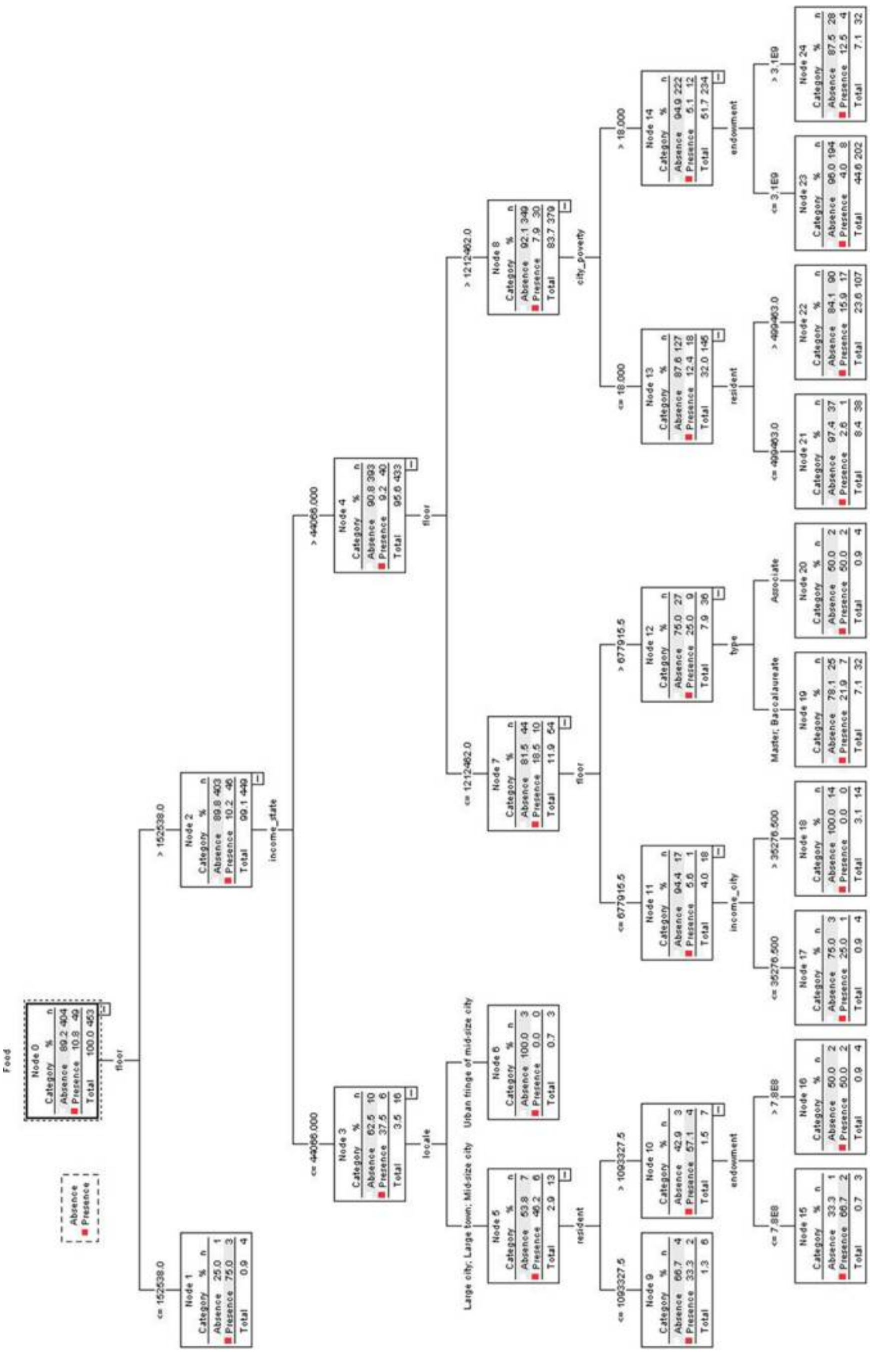

Figure 5.
CART model of food and food systems

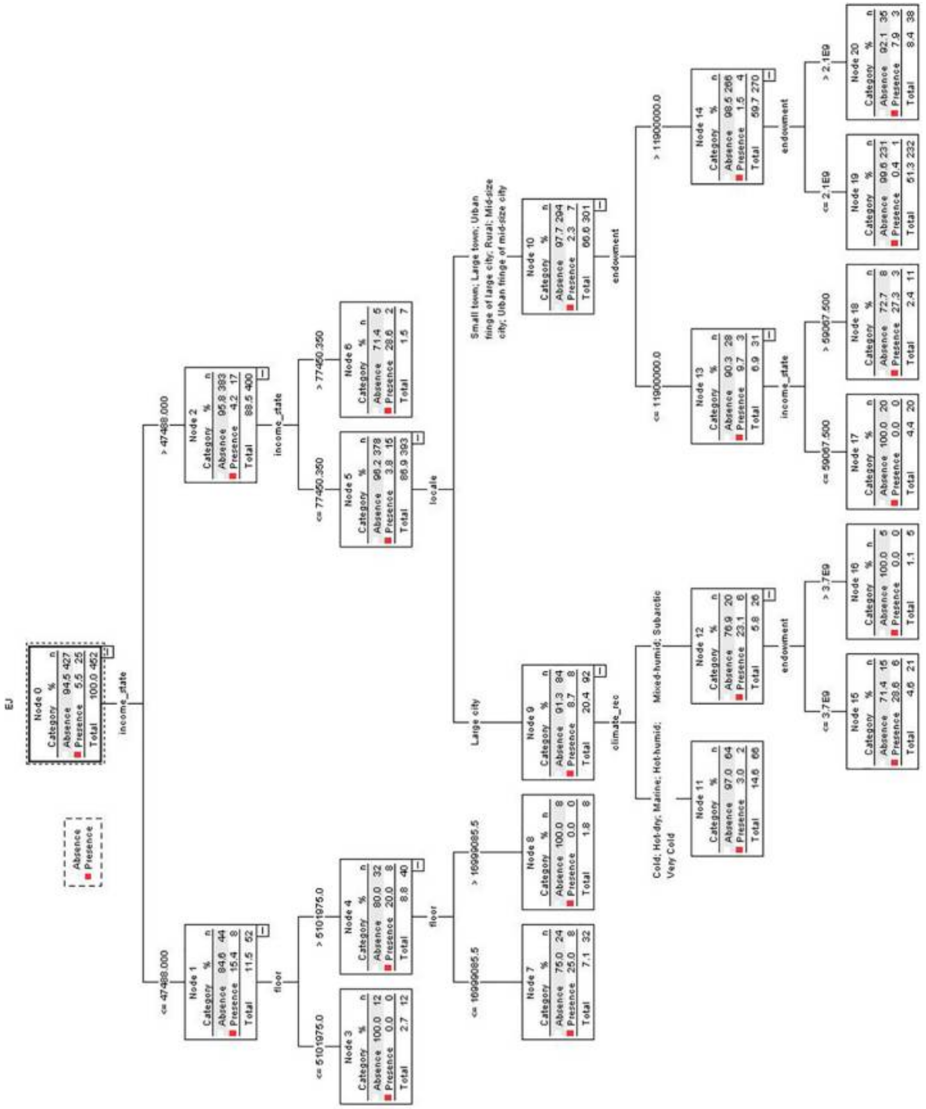

Figure 6.
CART model of social and environmental justice

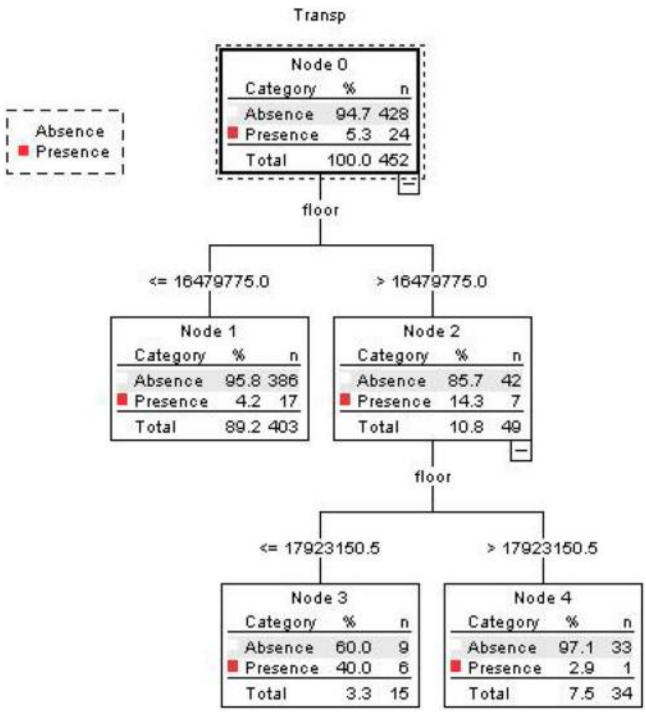

Figure 7.
CART model of transportation

second epoch, a larger variety of policies were initiated to enhance flexibility and efficiency. We argue that "traditional" EIs have followed a similar path with an initial focus on environmental topics and compartmentalized modes of implementation (Washington-Ottombre, 2017). Half of the innovations reported by HEIs concentrated on innovations relative to mitigation initiatives applied to energy, landscape management, waste and transportation. It is interesting to note that although such EIs focus on traditional topics of campus sustainability, efforts are often made to integrate multiple modes of innovation to use the campus as a laboratory. For instance, at California State University at Channel Islands, students have worked in collaboration with staff from facilities to design and implement a bioswale to mitigate water runoff on their campus. The combination of multiple traditional topics and modes of innovation ensures the durability and effectiveness of an EI by rooting it more deeply into the HEI.

The other half of EIs encompass "emerging" types of innovations that have broadened the traditional scope of campus sustainability to create new dynamics of innovation that often echo and reinforce the culture of an HEI. The term "emerging" refers to the third epoch of environmental policies in which actors adopt a holistic approach for creating sustainable communities (Mazmanian and Kraft, 2009). Contrary to what has been highlighted by past studies (Lid and Stone, 2015; Lozano *et al.*, 2015), our results indicate that EIs frequently adopt a holistic approach to sustainability. Those innovations explicitly integrate social and economic aspects of sustainability with environmental concerns. Our analysis indicates that sustainability and climate change, along with social and environmental justice, have become an important focus of EIs. HEIs are enlarging the scope of campus sustainability to implement change more durably and mirror campus culture beyond sustainability. For instance, the University of Kentucky organized a sustainability fair that they reported had limited impact. They then learned from this experience and initiated an ambitious sustainability challenge grant program to fund and implement interdisciplinary proposals that will help advance ecological integrality while promoting local economic vitality and social justice. By doing so, they capitalized on their strong research expertise and meshed sustainability into the broader campus culture.

This more holistic interpretation of campus sustainability results in new innovation dynamics where topics and modes of implementation are more diverse and integrated to create a unique campus sustainability "brand". Current sustainability efforts seem to be moving beyond compartmentalized initiatives (Lorenzo *et al.*, 2015) toward a wider breadth of innovations. EIs often address environmental issues from various angles. They target multiple environmental topics and modes of implementation. New curricular and research initiatives are more diverse and extend beyond the natural and social sciences toward the humanities, as illustrated by the new Center for Energy and Environmental Research in the Human Sciences created at Rice University. Modes of implementation of EIs are more integrated and spread across the physical, educational and institutional dimensions of campus sustainability. Integration reinforces the impact of EIs by durably changing or reinforcing the culture of an HEI. For instance, Sterling College (VT, USA) has built on its enduring commitment toward local and sustainable food systems by creating and leading the Vermont Higher Education Food System Consortium to share and promote courses, internships, research and an annual symposium on all aspects related to food and agriculture with other HEIs in Vermont.

Finally, HEIs act as innovators and promoters of social change within a specific bioregion (Orr, 2005). Modes of implementation of EIs extend beyond the boundaries of campus and rely on strong partnerships with other local or non-local actors. Campus sustainability is moving beyond the gates of the campus and reaching different levels of action across biophysical, social and economic boundaries (Hoover and Harder, 2015). For instance, the University of New Hampshire has led the development of an integrated watershed plan in collaboration with the neighboring town. In this way, HEIs are stepping out of the boundaries of the campus to respond to an urgent environmental need and enact significant change relative to stormwater and wastewater management. In this example and beyond, both the development and the implementation of EIs appear to be motivated by unique conditions of the social-ecological system surrounding the HEIs.

Therefore, even though the role previously highlighted by the literature of internal agents of change as main drivers of EIs must not be underestimated, they do not solely define the nature and scope of EIs. The agent of change catalyzes local sustainability needs with the culture and institutional capacity of an HEI to implement durable change. The agent of change does not wear blinders but is receptive to dynamics external and internal to the HEIs that will facilitate and guarantee the success of EIs. Because EIs are integrated into the culture of the HEI, their success extends beyond the mission of the agent of change toward durable organizational change.

Conclusion

To define strategies and policies to efficiently promote campus sustainability, this paper offers the first systematic understanding of campus sustainability innovations and has begun unpacking the complex drivers behind the elaboration of specific EIs. More precisely, the authors asked and provided responses to two fundamental questions: *What are the topics and modes of implementation of campus sustainability innovations? What are the* *external and internal factors that drive the development of specific innovations?* The authors arrived at these answers by coding and analyzing 454 innovations reported within STARS. The authors then used descriptive statistics and illustrations to assess the state of EIs within STARS. Furthermore, the authors produced CART models to more distinctly evaluate the role of internal and external drivers in shaping EIs. This study shows that external and internal factors provide an incentive and a favorable context for the implementation of given EIs. In contrast with recent literature, this research also reveals that EIs often broaden the traditional scope and scale of campus sustainability. EIs create new dynamics of innovation that echo and reinforce the culture of an HEI.

This work provides the first aggregated picture of EIs in the USA and Canada. It produces a new and integrated understanding of the dynamics of campus sustainability. Beyond the image of the agent of change innovating in a *vacuum*, this work paints a picture suggesting that agents of change catalyze synergies driven by multiple, identifiable and quantifiable factors both internal and external to the HEI. Successful and durable innovations that emerge out of this process are holistic by nature and deeply rooted in the culture of a given HEI. Therefore, campus sustainability staff members and allies should not be wholly opportunistic or disperse their efforts but develop their own "brand" of campus sustainability. Even though blueprints toward sustainability seem ill-suited to the unique nature of each HEI, CSAs such as STARS should concentrate more heavily on diffusing successful paths to holistic EIs to promote durable organizational change.

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