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Author
Hindle, Richard L

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Y02 as Climate Praxis

Richard L. Hindle

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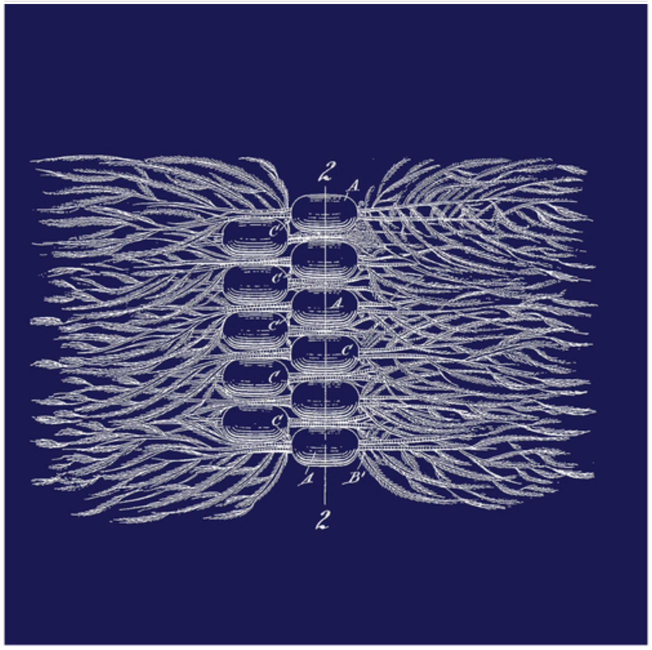
Abstract

This article introduces the recently adopted Y02 patent classification scheme, covering the broader cross-sectoral technologies that "allow adapting to the adverse effects of climate change," and explores the relationship of this global innovation initiative to environmental design and planning praxis. The Y02 classification includes specific subcategories Y02A for "Technologies for Adaptation to Climate Change" and Y02B, "Climate Change Mitigation Technologies Related to Buildings," making it highly relevant to the climate adaptation practices of architecture, landscape architecture, and planning. The YO2A and Y02B classification schemes (a subclass of Y02) were launched in 2018 and are now implemented by patent offices globally to categorize a range of adaptation technologies across sectors such as coastal systems, flood control, building systems, adaptation of existing infrastructure, green infrastructure, human health, and technologies for mapping and sensing the environment. Tagging and organizing patent innovations in this broad sector consolidates information on the subject, allows for the rapid diffusion of innovation, and builds adaptive capacity by creating a knowledge infrastructure and anticipatory framework for future technological trends. The fast pace of innovation in these sectors and the wealth of readily available information present the allied fields of environmental design and planning a distinct opportunity to integrate Y02A and Y02B into climate praxis. This article explores how innovation in these sectors may inform practices of scenario building in planning and design through discourse on probable, plausible, pluralistic, and performative futures. It elucidates the potential of these newly established patent classifications as an anticipatory framework for technological innovation in the built environment.

Keywords: Patents Climate Adaptation and Mitigation Anticipatory Governance Knowledge Infrastructure Built Environment

Opening Image. Early biomorphic, or ecological, coastal infrastructure from the patent archive. Today similar and related technologies are organized by the Y02 patent classification scheme to aid in climate adaptation and mitigation. U.S. Patent 1,129,719 "Jetty Construction" Figure #1. Inventor Richard A. Parrott. Granted February 23rd, 1915 (Public Domain image. Modified by Richard L. Hindle. Source: European Patent office www.epo.org)



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Origins of the Y02 Scheme

The Y02 classification scheme was born out of the need to understand trends in emergent climate technologies. In 2009/2010, the European Patent Office created a novel computer algorithm to automatically identify, track, and organize all low-carbon technologies in a searchable database accessible to patent examiners as a reference for emergent technologies (Calel 2020). The algorithm created real-time technical dossiers and provided insights regarding emerging low-carbon and climate change mitigation technologies (CCMTs). In this manner, the algorithm helped build responsive and predictive capacities within the patent office, targeting a specific sector of environmental technologies while tracking trends and assisting the office in keeping pace with rapidly developing technology. The Y02 scheme evolved from this nascent internal research tool, helping to build a reference dossier for patent examiners and establishing an anticipatory framework for technological evolution in climate adaptation sectors—thus linking technological innovation to global policy initiatives.

Essential functions and scope of the Y02 were made public in June 2010 at the United Nations Framework Convention on Climate Change (UNFCC), Subsidiary Bodies Session, in Bonn, Germany. Since then, the initiative has received ongoing support from the UNFCC as a mechanism to link innovation in climate mitigation technologies to global policy and funding initiatives (Veefkind et al. 2012). The ratification of the Paris Agreement in 2015 foregrounded the need for technological solutions to climate change, yet the technological pathways remained poorly understood. The agreement, adopted by 196 Parties at the Conference of the Parties (COP 21) in Paris on December 12, 2015, established clear thresholds for climate change, aiming "to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels." By establishing future benchmarks, the agreement instigated the need for a "politics of anticipation" in which contested choices for climate futures could be "woven into the technical elaboration of alternative pathways" (Beck and Mahony 2017).

Technological innovation features prominently in the Paris Agreement as part of a complex societal response to climate change. According to the United Nations program page,

> The Paris Agreement speaks of the vision of fully realizing technology development and transfer for improving resilience to climate change and reducing GHG emissions. It establishes a technology framework to guide the well-functioning Technology Mechanism. The mechanism accelerates technology development and transfer through its policy and implementation arms.[1]

> This class (Y02) covers selected technologies, which control, reduce or prevent anthropogenic emissions of greenhouse gases [GHG], in the framework of the Kyoto Protocol and the Paris Agreement, and also technologies which allow adapting to the adverse effects of climate change.

Today, the Y02 patent scheme has expanded to include a range of technologies that extend beyond the original low-carbon focus, tagging patents related to climate adaptation, flooding, infrastructure, health, mapping, etc., under a range of subclasses that address the breadth of climate adaptation and mitigation technologies.

Organizationally, this new patent data is organized using the special "Y" designation assigned to monitor new technological developments and to tag cross-sectional technologies that do not fit in a single other section of the International Patent Classification (IPC) and Cooperative Patent Classification (CPC) or have been classified elsewhere. In essence, the Y02 scheme organizes existing and future technologies in broadly related and emerging sectors of climate adaptation to provide insights about existing technological capacities and an anticipatory framework to track future trends. Having emerged from a predictive algorithm to track, organize, and inform the patent office staff about novel areas of technology in which little is known, the Y02 classification scheme establishes the leading edge of technological trends building adaptive capacity in emergent problem spaces—including the cross-sectoral technologies of buildings, the built environment, and the emergent context of coastal adaptation and resilience.

As a mechanism for the diffusion of technical information, the Y02 initiative aims to catalyze innovation through the functions of search and discovery that a publicly accessible database of climate adaptation and mitigation technologies can provide. A recent publication describes the Y02 initiative as a

> dedicated classification scheme for climate change mitigation technologies (CCMTs), where relevant patent publications are "tagged" and classified into a separate scheme fully integrated within the Cooperative Patent Classification (CPC). This tagging allows for non-patent experts to search for climate change-related technologies in a more user-friendly fashion (Angelucci et al. 2018).

Provisions for user-friendly searches mean that technological information can be searched and collated easily, facilitating the diffusion of innovation and helping inventors, governments, and end users to find relevant technologies and their owners. And they are providing technical, legal, and business information to support strategic decision-making in the field of climate change. These advantages are accomplished through efficient and freely accessible searches through the EPO, where users can develop detailed searches, apply filters, and build technical dossiers with limited prior knowledge.[2]

Sectors covered by Y02 are far-reaching. The Y02 designation now includes eight distinct subclasses—Y02A, Y02B, Y02C, Y02D, Y02E, Y02P, Y02P, and Y02W—broadly covering the technologies or climate adaption, including building systems, carbon technologies, information and communication systems, energy, manufacturing, transportation, waste management, and interconnected sectors of environmental systems including water, green infrastructure, etc. (Table 1). Organizing these technological classes under a single classification heading links sociotechnical aspects of patent innovation to the global policy initiatives of the Kyoto Protocol and the Paris Agreement, expanding the technical capacities and knowledge of these initiatives. The patent office contributes information and data to these initiatives by organizing technologies that aim to control, reduce, or prevent anthropogenic emissions of greenhouse gases (GHG) and technologies that allow adapting to the adverse effects of climate change, making this information publicly accessible for use by governments, organizations, and inventors alike.

Table 1. Y-Y02 Classification scheme subject titles.

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Y02A & Y02B—Knowledge Infrastructure for Climate Adaptation and Mitigation in the Built Environment

The European Patent Office launched the Y02A and Y02B subclasses in April 2018. They were rolled out internationally over the next few years as patent offices worldwide integrated specifics of the classification scheme into their systems. Together they provide vital knowledge infrastructure for climate adaptation and mitigation in the built environment, helping to map technological capacity in the sectors and provide insights about future trends. Although related to the broader themes of climate and the built environment, they cover a range of technologies with specific applications and scales ranging from façade materials and HVAC to urban water systems and green infrastructure (Tables 2 and 3).

Table 2. Y02A Category titles.

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Table 3. Y02B Category titles.

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Y02A is unique among the eight subclasses of the Y02 for its focus on environmental and urban systems, infrastructure, human health, and riverine and coastal systems, making it highly relevant to a wide range of adaptation efforts in coastal zones, urbanized watersheds, and the broader built environment. The categories cover coastal and riverine systems technologies, water management, infrastructure adaptation, agriculture, human health, mapping, forecasting, and sensing technologies. The breadth of the initiative is astounding, with 702,210 patents covered by the classification and 394,99 new patents tagged under them since January 1, 2018. This current snapshot provides a glimpse of innovation across the six subsections covered by Y02A. To date, the top eight contributors of Y02A patents include China (568,601), United States (124,377), Japan (114,923), Korea (60,269), International WO (50,940), European Patent (48,948), (34,270), and Canada (28,915). Subcategories of Y02A are interesting to consider from the perspective of urban systems thinking, as they include a range of interconnected technologies for infrastructure, water, and ecological systems such as Y02A 20/402 River Restoration, Y02A 20/404 Saltwater Intrusion Barriers, Y02a 20/406 Aquifer Recharge, Y02a 20/144 Wave Energy, Y02a 30/254 Roof Garden Systems, Y02a 20/131 Reverse-Osmosis, Y02A 30/60 Planning or Developing Urban Green Infrastructure, Y02A 90/40 Monitoring or Fighting Invasive Species, and Y02A 90/10 Information and Communication Technologies (ICT) Supporting Adaptation to Climate Change through Weather Forecasting or Climate Simulation (Tables 4–9).

Table 4. Y02A/10 Technologies for adaptation to climate change at coastal zones and river basins.

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Table 5. Y02A 20/00 Water conservation; efficient water supply; efficient water use.

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Table 6. Y02A 30/00 Adapting or protecting infrastructure or their operation.

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Table 7. Y02A 40/00 Adaptation technologies in agriculture, forestry, livestock, or agroalimentary production.

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Table 8. Y02A 50/00 In human health protection, e.g., against extreme weather.

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Table 9. Y02A 90/00 Technologies having an indirect contribution to adaptation to climate change.

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The Y02B subclass primarily covers "Climate Change Mitigation Technologies Related to Buildings, e.g., Housing, House Appliances or Related End-User Applications," with specific subcategories addressing energy efficiency, building materials, and intelligent grid systems. Although narrower in scope than Y02A, Y02B offers organized information related to advances in building technology, facilitating easy searches and analysis within these interrelated building sectors. The Y02B class now includes 477,257 patents across its eight subcategories. They filter through these search results, revealing that 319,263 originate in China, with 67,148 from the United States and 60,680 from Japan. Subcategories of Y02B include a range of interconnected technologies for building systems integrated with solar arrays, green roofs, and geothermal heating systems, including Y02B90/20 Smart Grids, Y02B30/17 District Heating, and Y02B10/50 Hydropower in Dwellings, to name a few (Tables 10–16).

Table 10. Y02B10/00 Integration of renewable energy sources in buildings.

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Table 11. Y02B20/00 Energy efficient lighting technologies, e.g., halogen lamps or gas discharge lamps.

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Table 12. Y02B30/00 Energy efficient heating, ventilation or air conditioning (HVAC).

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Table 13. Y02B40/00 Technologies aiming at improving the efficiency of home appliances, e.g., induction cooking or efficient technologies for refrigerators, freezers, or dish washers.

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Table 14. Y02B50/00 Energy efficient technologies in elevators, escalators, and moving walkways, e.g., energy saving or recuperation technologies.

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Table 15. Y02B70/00 Technologies for an efficient end-user side electric power management and consumption.

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Table 16. Y02B90/00 Enabling technologies or technologies with a potential or indirect contribution to GHG emissions mitigation.

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Together, Y02A and Y02B create a novel form of knowledge infrastructure, managing the exchange of technical information in complex social-ecological-technical systems (SETS) that make up the contemporary city. Paul Edwards defines knowledge infrastructure as "robust networks of people, artifacts, and institutions that generate, share, and maintain specific knowledge about the human and natural worlds" (Edwards 2010). Knowledge infrastructures are complex networks intertwined with social, technical, and environmental systems and, therefore, have radical implications for how society perceives and manages the world. As the word "infrastructure" implies, knowledge systems serve as substructures supporting other systems and are entangled with society, economy, energy, material use, politics, and the management of complex environmental systems. Therefore, knowledge infrastructures are also linked to planetary processes and the evolution of the Technosphere, contributing to "large-scale, long-term, anthropogenic environmental change," making them integral to future planetary management (Edwards 2017). The establishment of the Y02 classification scheme leverages the innovation knowledge infrastructure of the patent systems in service of climate adaptation and mitigation, building technological capacity and strategic foresight, premised on the assumption that technology will play a role in responses to climate change.

Evidence of these capacities is gained in literature and through strategic government initiatives. For example, in the United Kingdom, the recently published national "Ten Point Plan for a Green Revolution" sets out the approach the government will take to "build back better" by supporting green jobs and accelerating the path to net zero through renewable energy, sustainable buildings, and the protection of nature. The plan's commitments to the protection of nature include specific language and financial earmarks for flood protection, stating, "We will invest £5.2 billion in a six-year program for flood and coastal defenses including new innovative approaches to work with the power of nature to not only reduce flood risk, but deliver benefits for the environment, nature, and communities," thus outlining the need to assess technological pathways for realization of the initiative.[3] With the plan, the UK Intellectual Property Office published a report on flood and coastal defense sector patent activity using the Y02A classification to analyze trends in flood adaptive technologies. The report notes an uptick in patent activity in this area, with most patented technologies developed in China and less activity domestically within the UK, leading to recommendations for domestic technological capacity in this sector.[4]

Anticipatory Governance: Strategies for the Design and Planning of Probable, Plausible, Pluralistic, and Performative Futures

Climate change necessitates planning for an uncertain future. Over the past decade, anticipatory governance has emerged as a framework to comprehend and manage acceleration and complexity in systems and develop foresight in areas ranging from politics and defense to technology and climate change. In essence, it refers to the process of governing in the present to adapt to or shape uncertain futures. A

> a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible. It motivates activities designed to build capacities in foresight, engagement, and integration—as well as through their production ensemble (Guston 2014).

Given the focus on future trends, anticipatory governance builds capacities in foresight, engagement, and integration within institutions, government, and society, making it particularly useful when conceptualizing approaches to problems such as climate change.

Anticipatory governance challenges notions of planning as a fixed linear process and instead integrates complexity and change into possible future scenarios. The framework for anticipation is, therefore, proving valuable in sectors planning for climate change. A recent survey article states:

> It is becoming evident that the traditional planning paradigm that I [the author] term "predict and plan" will not be adequate to address the highly complex and uncertain issue of climate change. Uncertainty and the extended planning horizon that climate change calls for will likely still exist when governance decisions are required. In response to this problem, a new approach is emerging in literature and practice. Anticipatory governance, a new model of decision-making under high uncertainty based on concepts of foresight and flexibility, uses a wide range of possible futures to anticipate adaptation strategies, and then monitors the change and uses these strategies to guide decision-making (Quay 2010).

Reflecting momentarily on the Paris Agreement and the "politics of anticipation" resulting its climate benchmarks, it is evident that the Y02 initiative not only creates vital knowledge infrastructure but also provides technological insights, and foresight, that may inform decision making at local and planetary scales. This information is particularly useful in environmental design and planning, as it may report the practices of these disciplines and ultimately contribute to climate mitigation and adaptation in the built environment.

Although no universal framework exists for anticipatory governance in practice, a recent survey article summarizes the possible approaches that have emerged from research and literature on the subject and relevant examples of how anticipation of the future The authors neatly organize this into four approaches that capture the range of anticipatory governance and the mechanisms through which they may be applied, which they summarize as follows: 1) Probable futures, strategic planning, and risk reduction; 2) Plausible futures, enhanced preparedness, and navigating uncertainty; 3) Pluralistic futures, societal mobilization, and cocreating alternatives; and 4) Performative futures, critical interrogation, and political implications (Muiderman et al. 2020). The range of approaches outlined by the paper provides insight into anticipatory governance practices. It helps comprehend how the approaches to a spectrum of "futures" can become essential components of environmental design and planning praxis. Diving deeper into this range of approaches reveals how technological innovations covered by Y02A and Y02B can contribute to and help conceptualize these urban and environmental futures through design and planning practices.

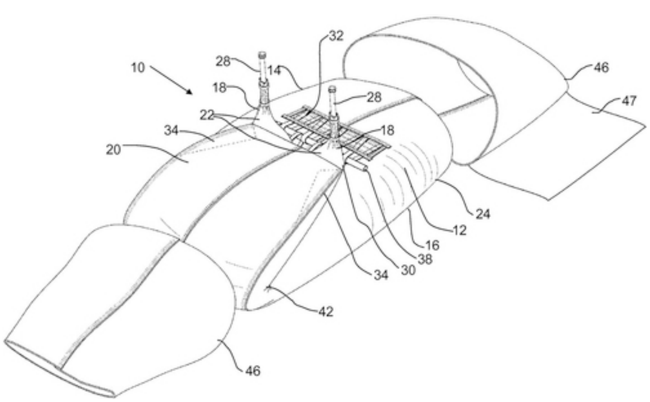
Probable futures are considered a starting point that "futures are scientifically uncertain and complex, but still assessable in terms of probable and improbable future risks." In assessing probable futures, the anticipation is to evaluate these risks and inform strategic policy trajectories on minimizing future risks. This process often involves cost/pricing scenarios, forward-looking information services, economic modeling, technological forecasting, analysis of climate statistics, environmental impact assessments, etc. Governments and other agencies are regularly involved in everyday planning and forecasting as they consider approaches to city management, project planning, and other practical challenges associated with climate change, such as adaptation of coastal infrastructure or revision of building codes.

Practical projects, such as budgeting for a seawall replacement, developing technical specifications for building façades, or issues related to predictable design and planning requirements, are all part of a probable future and can be understood through technology. Take, for example, the processes of coastal seawall and breakwater upgrades occurring globally to improve biodiversity and coastal defense. Technological innovation can inform new material and design standards, helping to align advanced technologies with the pragmatics of local planning. Novel concrete mixtures like ecological concrete, By Econcrete Tech Ltd. (US9538732B2 and AU2014217435B2 Methods and matrices for promoting fauna and flora growth) are engineered to meet international construction standards. They can integrate into marine construction projects. Importantly, by tracking innovation in ecological concrete or a range of other applicable technologies, planners and designers can develop an understanding of leading-edge systems that can serve as an anticipatory framework for probable futures. This innovation is true across the range of systems covered by Y02A and Y02B.

Plausible futures consider that “the future contains irreducible uncertainties and multiple plausible future trajectories are feasible.” In this approach, anticipation becomes a mechanism for deliberation, thus building adaptive capacities and preparedness that allow for uncertain futures as their trajectories unfold. This approach involves a range of options built on shared knowledge between experts and other constituencies. Comprehending plausible futures may be accomplished by mapping, participatory modeling, and other actions involving exchanging information based on local and subject-area expertise. Initiatives to promote the exchange of technical knowledge are common in planning and design professions. For example, the 100 Resilient Cities initiative, partly supported by the Rockefeller Foundation and partners, aimed to build urban resilience through social and technical pathways. The network of 100 cities spans continents, aiming to link urban resilience networks and catalyze innovation. The project’s statement on technology looks at urban centers to develop resilience technology and the end user, focusing primarily on digital technology for smart cities, analytics, and mapping.[5] Importantly, these smart city recommendations made as part of the 100 Resilient Cities Initiative, concluded in 2019, can now be coordinated by Y02A 90/10 classification, covering Information and Communication Technologies (ICT) supporting adaptation to climate change through weather forecasting or climate simulation” and other smart cities innovations.

The value of planning for technological pathways for plausible futures is evident across design and planning activities. For example, planning for plausible futures is widespread within the discrete domains of climate adaptation and resilience in coastal zones. We can look towards sustained long-term planning conferences, such as the State of the Coast conference in Louisiana, that aims to create an “interdisciplinary forum to exchange timely and relevant information on the dynamic conditions of Louisiana’s coastal communities, environment, and economy and to apply that information to existing and future coastal restoration and protection efforts, policies, and decision-making.” In addition to the plenary session and keynote lecture, a robust list of donors and exhibitors showcase new technologies that address the audiences and practical elements of initiating Louisiana’s coastal master plan. Technologies exhibited at the conference help communicate various technological options that address the plausible futures discussed. Exhibitors such as Tetratech, Louisiana State University, and ORA have intellectual property covered by Y02 and achieve knowledge transfer through this process. Briefly consider the water-filled flood control structures US9297133B2 “Fluid fillable structure” manufactured by Aqua Dams Gulf Coast (Gulf Coast AquaDams in Abbeville, LA.). Their rapidly deployed coffer dams, exhibited at the State of the Coast conference in 2014, inform end users in subsided and flood-prone lands how to protect their property using the system (Figure 1). These entrepreneurial approaches to addressing plausible coastal futures integrate technology into practice through community engagement and knowledge exchange as part of regionally specific conferences.

Figure 1. US Patent 9,297,133 “Fluid fillable structure.” Invented by James Andrew Mills and Gregory Allan Parrent. Granted March 29, 2016. The patent describes a flood control device that can be rapidly deployed utilizing fluid-filled chambers to construct a temporary ‘levee’ wall as marketed by AquaDam. This type of flood control barrier is now covered by several sections of the Y02A classification scheme that address issues of adaptation to flooding.



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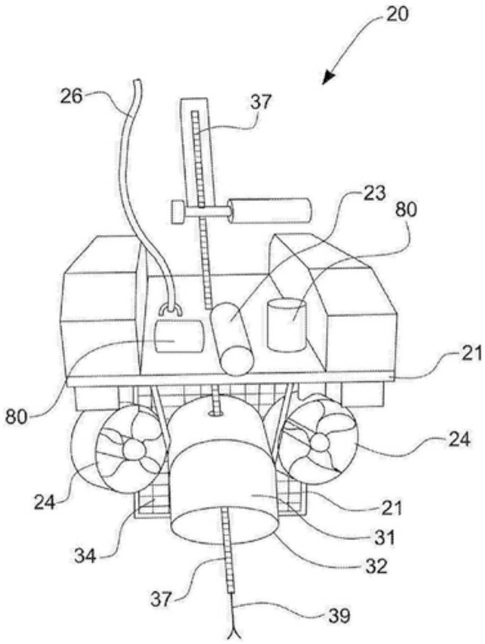
Pluralistic futures consider “embedding multiple future worlds, shaped by interaction, and dependent on diverse interpretations of the world.” This pluralism is achieved by mobilizing diverse societal actors that may collectively develop actionable pathways for change. This type of cocreating enables the conceptualization of new and transformed futures. As a form of future scenario building, it involves the workshops that integrate futures into present-day environments or design competitions that help mobilize collective action towards a desired state. This type of envisioning is expected in the professional practices of architecture, landscape architecture, and urban planning, which embrace future projections as change agents. The Y02A and Y02B classification schemes may inform these processes, helping to comprehend existing technological capacities. For example, the annual Land Art Generator Competition, which aims to accelerate the transition to postcarbon economies by providing models of renewable energy infrastructure, tests design strategies for renewables in public spaces.[6] This process is directly informed by innovations covered by the Y02B scheme, as many of the systems promoted by the competition are at the leading edge of geothermal, solar, and wind energy generation (Tables 10–16).

Pluralistic futures are also central to design and planning pedagogy and can foreground innovation and patent research as a main theme. For example, in the summer of 2016, the author (Hindle) and Neeraj Bhatia (CCA) led a workshop as part of DredgeFest California, focused on sedimentation and earthworks in the California Delta. During the weeklong workshop, participants and workshop leaders were asked by the DredgeFest organizers to develop responses to a series of scenarios that covered the pluralistic futures in the delta. After a short initial exercise exploring existing technologies from the patent archive and extrapolating their territorial impact, the team created four new technologies under the pseudonym Bureau of Territorial Technologies (Hindle and Bhatia 2016). Each invention addressed issues ranging from subsidence and accretion of sediment to aquifer recharge and levee reinforcement. By developing a specific technology and understanding how it would alter the broader landscape, they allowed designers to quickly understand the implications of their design proposals, moving back and forth between technological invention and pluralistic regional transformation, ultimately facilitating design experimentation at the scale of the territory and the detailed scale of a specific technology developed by the designer.

Performative futures engage the future through “fabrications, or sociotechnical imaginaries that are speculative, but still performative in calling into being certain privileged visions of the future.” Their capacity for speculation allows alternate readings and potential to emerge and for their political implications and material consequences to be investigated. Methods such as narrative image-making serve as heuristics, enabling diverse futures to be explored and analyzed for their political and social implications by opening discourse and framing new potential. Performative futures are often central to realizing environmental scenarios and new ecologies and are tracked through technological innovations in Y02A and Y02B. Take, for example, the debate around invasive species in which new environmental scenarios for managing wildness and autonomy are conceived (Cantrell et al. 2017). Theorists in this space look towards technologies such as the RangerBot, designed by scientists in Queensland, Australia, to attack invasive starfish. These are examples of integrated robotics and computation employed in managing invasive species—evoking a novel form of Anthropocene wilderness. A specific patent subclass Y02A 90/40 covers “Monitoring or fighting invasive species,” which includes a range of related technologies such as rovers to collect invasive lionfish or devices for filtering algae blooms (Figure 2).

Figure 2. UK Patent 2,567,452 “Method apparatus and system for controlling fish.” Currently assigned to Atlantic Lionshare Ltd. Granted July 08, 2020. The invention covers a robotic device to cull lionfish. It is one of the numerous autonomous vehicles designed to hunt invasive species and is now covered by Y02A90/40 for technologies “Monitoring or fighting invasive species.”



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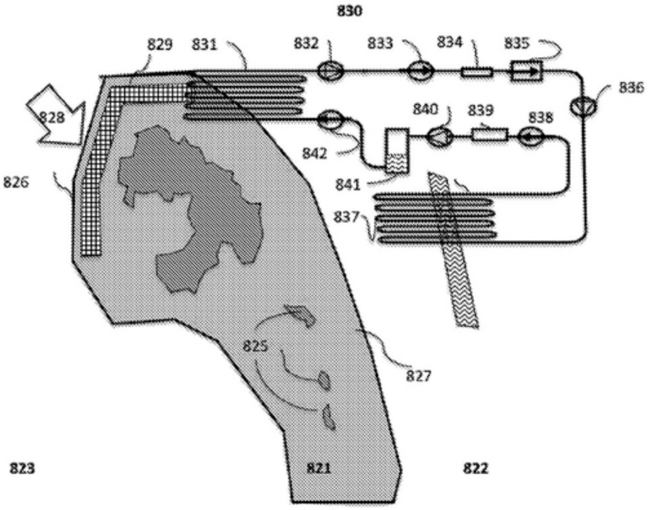
Given technology's projective nature and the patent system's anticipatory capacities, performative futures weave a distinct thread through the Y02 classification. Patent trends offer insights into future environmental scenarios while revealing the patent system's role in adaptive governance and new knowledge infrastructures. Knowledge and anticipation of these trajectories have planetary implications, as evident in evolving geoengineering discourse and debate. In the emerging geoengineering sector, few laws or government entities are in place to manage developments given the extraterritorial nature of the proposals and global impact, making foresight of future trends significant. According to a recent paper on the subject, "In the absence of a governance framework for climate engineering technologies such as solar radiation management (SRM), the practices of scientific research and intellectual property acquisition can de facto shape the development of the field" (Oldham et al. 2014). In this speculative technological space, new frameworks of patent law are also being proposed, including patent pools that ensure the unrestricted use and diffusion of technologies to "save the planet" (Chavez 2015). Irrespective of the validity of existing geoengineering technology, it is interesting to take note, just in case these projections of future climate solutions take shape. We can see this debate taking shape in real time with the advent of geoengineering technology for marine environments that aim to save coral reef habitats. For example, WO2022091107A1—"System and method for reducing the temperature of water in coral reef and adjacent ocean"—requires the existence of global technologies and political actors capable of altering marine environments and atmospheric systems—calling into question not only the validity of the technology but the politics of the performative future it represents (Figure 3).

Figure 3. World Intellectual Property Organization (WIPO) Patent WO2022091107A1 "System and method for reducing water temperature in coral reef and adjacent ocean." Invented by Sunit Tyagi. Published May 5, 2022, by the WIPO. The invention relates to cooling ocean surface temperatures to protect coral reefs. It is an example of geoengineering technology and reef restoration methods now covered by broad categories of the Y02 classification scheme. fighting invasive species."



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Discussion

Given the reciprocity between innovation and the built environment outlined by the Y02A and Y02B scheme, the allied environmental design professions have a distinct opportunity to translate this knowledge infrastructure and anticipatory capacity into climate praxis. Tracking innovation within the Y02A and Y02B classifications can help national governments, architects, landscape architects, planners, and communities make informed decisions about the environment's future and technology. The classifications also build networks of inventors and facilitate the diffusion of innovation, linking the sociotechnical aspects of innovation to global policy initiatives and local projects. Together, this framework for climate praxis addresses the scale and scope of climate adaptation and resilience with design, architecture, and planning, operationalizing innovation through tangible real-world projects and conceptualizing probable, plausible, pluralistic, and performative futures.

Opportunities also exist to coordinate design, planning, and architecture practices with global green initiatives through the Y02 scheme. Engaging Y02A and Y02B as a framework for climate innovation can expand the allied disciplines' technological capacities and lead to new research opportunities. Evidence of this is emerging nationally with implications for pedagogy and praxis. For example, in the United States, a nationwide effort for landscape architecture to be designated a STEM (science, technology, engineering, and math) discipline is afoot. STEM set programs are academic programs that fall under at least one approved category from the United States Department of Homeland Security (DHS). The American Society of Landscape Architects (ASLA) has pursued STEM designations through advocacy with DHS to support this effort. DHS uses one criterion to evaluate STEM: innovation, research, and the development of patented technology. A recent white paper published by the ASLA and authored by a consultancy aims to link the profession of innovation in climate adaptation technologies through the classifications established by the Y02A patent classification scheme. The authors of the white paper found that "Within Y02A are more detailed categories of technologies to support climate change adaptation.[7] An ASLA analysis of the technologies in Y02A shows that at least 22 relate directly to topics covered in the landscape architecture curricula or have been the subject of research and innovation projects by landscape architecture students and faculty," thus claiming a distinct technological capacity, or scope, for professional education using the Y02 classification scheme. Similar changes are also instigating shifts in professional practice where the legal statutes that define professional licensure in New York State, Ohio, and Missouri now include clauses for patent works.[8]

The global patent system and the Y02 classification scheme provide the precise institutional mechanism for the diffusion of innovation and coordinated technological pathways for climate adaptation. The allied professions of environmental design and planning are central to this global initiative in their capacity to operationalize novel climate technologies through their professional practices and pedagogy. Integration of Y02A and Y02B into climate praxis also builds adaptive capacity through the recursive and iterative processes of innovation linked to the processes of urbanization, building, and planning, creating a timely opportunity to expand disciplinary scope and agency in the context of a changing planet.

A Note on Open Innovation Models

Of course, open-source mechanisms and intellectual property will play a role in adaptation and resilience technology. This fact does not diminish the importance of either. They operate complementarily to each other. In general, an 'open source model' refers to a collaborative mode of production in which innovation is shared more openly. An 'open innovation model' refers to a process in which a firm integrates ideas from inside and outside to innovate (Chesbrough 2003). Preliminary research into the role of such open source methods in climate mitigation technology does outline clear pathways for technology transfer using open innovation and open source methods through licensing agreements of intellectual property rights (IPR) and the creation of general public licenses (GPL) in addition to conventional licensing and sharing of technology through patent pools, patent commons, and alternative structures such as equitable access licensing and clearing houses for eco-technology (Srinivas 2011). Importantly, these modified arrangements are built on models for shared and distributed intellectual property that do not negate the need to manage sequential innovation and inventors' rights, such as those operated by the traditional patent system and YO2. Examples include The Low Carbon Patent Pledge, comprising 597 patents, 14 organizations, and 13 countries—including pledges from Hewlett-Packard, Microsoft, Meta, Amazon, Lenovo, and JP Morgan Chase.[9] The low-carbon participants help accelerate the adoption of low-carbon technologies, foster collaborative innovation, and facilitate sustainable breakthroughs by making critical intellectual property broadly available without charge around the world. This cooperative agreement makes leading-edge technology freely available to anyone and expands the reach of partners in the venture—a model that can be applied across sectors.

Data Statement

The data supporting this study's findings are available from the European Patent Office at https://www.epo.org/en and are free to access. Patent searches, images, and data were derived from the European Patent Office patent search website https://worldwide.espacenet.com/patent/ and are available in the public domain.

Additional information

Notes on contributors

Richard L. Hindle

Richard L. Hindle is an Associate Professor of Landscape Architecture and Environmental Planning at the University of California Berkeley. He researches patent innovation and the built environment, living systems, climate adaptation, and resilience. His published work includes 'Technical Lands' (Jovis 2022) and 'Aesthetics of Contemporary Planting Design' (ORO 2021) and articles in *Journal of the Patent Office Society*, *Journal of Landscape Architecture*, and *Journal of Architectural Education*.

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