Introduction

The aim of the Master of Geographic Information Systems (MGIS) for Sustainability Management program at the University of Washington is to teach people how to create a more sustainable world—not an uncommon aim in higher education. But what makes this online graduate degree program unique is that it focuses specifically on how to design a sustainable world by combining the power of problem-solving approaches like geodesign, with the power of problem-solving technology like geographic information systems (GIS).

The MGIS for Sustainability Management program is a part-time, two-year program designed for early and mid-career professionals. The program focuses on how to use GIS to develop sustainable solutions for a variety of complex problems ranging from land use and affordable housing development to transportation and water quality improvements.

Program Director Tim Nyerges teaches GIS and Problem Solving, the first of nine courses in the program. In class, he often asks rhetorical questions, such as: How do we measure what we value?

The same question can be asked through the lens of sustainability. It is clear we value the world through setting goals for sustainability. But how do we measure our performance when it comes to sustainable management of the Earth on local, regional, and global scales? The answer to this important question requires data.

Digital data of various kinds, including geospatial data, is abundant today and continues to grow exponentially. But data in itself is not actionable knowledge. Data has to be analyzed to become information, and GIS can be used to analyze data based on its geographic location. But that information has to be evaluated in a broader context to become actionable knowledge for sustainability management. GIS can offer powerful capabilities to evaluate information in the context of spatial interrelationships between the biophysical, social, and economic dimensions of a social-ecological system, more generally thought of as sustainable systems.

The Need for Sustainability Information Science

For more than a decade, Nyerges has been leading an effort to try to understand how large groups of people use geographic information technology to evaluate complex geospatial problems and then act to improve future well-being. In particular, he has focused on decision-making situations in which a large amount of public funds are allocated for land use, transportation, and water resource management.

One of the dilemmas in using information technology to support these kinds of public decision-making situations is the inclination to provide too much information. Too much information, no matter how well-intentioned, can sometimes do more harm than good, drowning people in a sea of information. This challenge led researchers like Nobel Laureate Herbert Simon to call for a science of information processing. Similarly, Nyerges sees the need for integrating sustainability science and sustainability management with what he calls a sustainability information science. “Sustainability information science is the bridge building between findings in sustainability science and the (best) practice of sustainability management to move findings to actionable knowledge,” he asserts within an article about sustainable systems information representation.1
Sustainability involves describing, assessing, and managing existing situations such that they meet the needs of current generations while not compromising the ability of future generations to meet their own needs.

Figure 1. The three knowledge domains of sustainability

Three Knowledge Domains of Sustainability

The curriculum of the MGIS for Sustainability Management program integrates three knowledge domains—sustainability science, sustainability information science, and sustainability management (see Figure 1). Although an individual student’s pathway through these three knowledge domains may be somewhat unique, the MGIS program requires each student to integrate in their coursework sustainability science concepts, sustainability information science methods, and sustainability management substantive case studies.

As students learn about sustainability science, they demonstrate their mastery of sustainability science concepts like ecosystem services, common pool resources, and the resilience of social-ecological systems. As students learn sustainability information methods, they demonstrate their mastery of various units and topics in the Geographic Information Science and Technology (GIS&T) Body of Knowledge. As students learn to become sustainability management practitioners in a rapidly growing geospatial industry, they demonstrate their mastery of all of the domains within an organizational setting, including integrating geospatial industry-specific competencies with their personal effectiveness and professional workplace competencies as elaborated in the Department of Labor’s Geospatial Technology Competency Model and Geospatial Management Competency Model.

A Geodesign Approach to Sustainability

As Simon has said, anyone who designs aims at changing an existing situation into a more preferable one. Most people can probably imagine a more preferable situation when they think about what they value or what they need from their biophysical and human-built environment. However, sustainability involves describing, assessing, and managing existing situations such that they meet the needs of current generations while not compromising the ability of future generations to meet their own needs.

The MGIS program has adopted a geodesign approach as a problem-solving framework for using GIS in sustainability management. The term geodesign emerged in part to highlight how geographic science comes together with design when situations span large geographic areas, from the size of a neighborhood to the size of entire urban growth landscapes and river basins. In fact, instructors in the MGIS for Sustainability Management program often take their case study examples from the Puget Sound region, considering the biophysical region itself as well as the massive network of people and organizations within it as an enormous field laboratory with which to show students how to approach problem solving and analysis using GIS.

The geodesign approach incrementally adds more complexity, and more information, into
In a sustainable systems map, we are interested in imagining, based on best available evidence.

Adopting a geodesign problem-solving approach for sustainability management presents a unique opportunity and challenge: It means assessing not only whether changing an existing situation to a more preferable situation will satisfy present needs, but also whether changing that situation may compromise the ability of future generations to meet their own needs as well. In other words, one can use a geodesign problem-solving approach to change an existing situation to a more preferable one, but unless that geodesign approach takes into consideration the principles of sustainability, there is no guarantee that changing the situation will meet both sets of current and future needs equitably.

Sustainable Systems Mapping

Instructors and students in the MGIS for Sustainability Management program have been designing and testing a new map type they call the "sustainable systems map," as one of several innovations in sustainability information science.

In GIS-based cartography, most everyone is familiar with classical thematic mapping techniques like the cartogram, choropleth map, dot density map, isarithmic map, flow map, and the proportional point symbol map. Each of these mapping techniques uses color, size, or shape, among other characteristics, to display the quantitative attributes of spatial units, e.g., a U.S. county map where red colors indicate a greater population density and green colors indicate a lesser population density. In a thematic map, we think about relations between the quantitative attributes of spatial units other than how they are related in coordinate space, and thus a sustainable systems map attempts to make these relations more explicit.

In a sustainable systems map, we are interested in imagining, based on best available evidence, relations between the properties of elements that are believed to indicate something about the character or state of a larger social-ecological system. A sustainable systems map—as Figure 2 illustrates—shows that when the

Figure 2. A student’s sustainable systems map for salmon recovery in the Puget Sound region implemented as a web app.
properties of one element at one scale change (e.g., due to a disturbance or external driver of change), the properties of other elements at another scale change. As a result of such disturbances and changes, the character or state of a system as a whole can be fundamentally altered, and perhaps will never recover. Fundamental alterations to the state of a system can impact the common pool resources and the ecosystem services valued by affected parties, including future generations.

A sustainable systems map works with a geodesign approach as a representational model capturing incrementally more complex relationships between and among the elements of a social-ecological system. A sustainable systems map can encode simulation models or basic spatial thinking and systems thinking into a map representation that others can then use for problem solving. (See Figure 2 for example.) Of course, if the spatial thinking and systems thinking is flawed, then the sustainable systems map is flawed as well.

Thus, another way that sustainable systems mapping can help organizations is by revealing some of the unknown, unanticipated, or unintended consequences of proposed management interventions. Graduate program advisor Robert Aguirre teaches the mapping course. He explains, “One of the unintended consequences of sustainability management is that when you try to optimize for one thing, like one kind of ecosystem service, you might very well end up creating a less than optimal situation when it comes to other ecosystem services that are just as valued.” In other words, sustainability management is often about managing zero-sum circumstances.

Aguirre believes that practitioners will be able to expose the flaws in systems thinking about sustainability management problems by creating a sustainable systems map. He explains, “People can use sustainable systems mapping techniques to spread out their simplifying assumptions on a realistic geographic stage. If done well, everyone can see if it really makes sense or not before considering any management interventions.”

**Sustainability Information Services**

Another important emphasis among instructors and students in the program is to think beyond just learning how to use powerful desktop GIS. Students learn the importance of having programming skills to create their own tools and applications based on sustainability management needs. Man Wang, who teaches Python Programming and GIS for Decision Support, explains, “For the Python Programming course, most students start the course with Python experience ‘only in the zoo.’” She notes that while one course does not automatically make students programmers, it does enable them to use programming skills to automate and/or customize certain tasks, making them more efficient and effective at work.

Darren Kavanagh, the program’s senior computer specialist, often consults with instructors and students about how they might implement sustainability science concepts with the latest open technology and standards. With Darren’s help, students and instructors work together to design, test, and implement data management, map creation and geospatial analysis services. These information services are designed to not only perform a vital role within an organization’s sustainability management work, but also to be shared over the web through fast, open, and interoperable platforms.

Information services are computing activities performed by a server, e.g., a data server, on behalf of a client, often in the form of a web browser. An open and interoperable platform refers to a collection of data, software, and hardware working through an interface or set of interfaces (also known as application programming interfaces or APIs) that provide access to map, database, and/or analytic services, often independent of any one particular software or hardware vendor. Professor Nyerges is moving the program toward implementing an open and interoperable sustainability information services platform because “cloud computing and geodesign come together into sustainable system services for complex sustainability problem-solving topics.”

**A Competency-Driven Curriculum and a Hybrid Online Format**

To earn the MGIS degree, students complete a minimum of 45 credits. The program is a coursework-only professional degree and no thesis is required. Students begin their studies in late summer and continue to take one course at a time for the next eight quarters. The final course immerses students in a capstone project of their choice in which they work in small teams using GIS to develop a solution to a sustainability issue faced by a real-world client who partners with the MGIS Program during the quarter.

Most of the courses are delivered online. However, each summer students spend three days...
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Each summer students spend three days of intensive study on the UW campus in Seattle, WA. (Figure 3), meeting fellow students to develop project ideas, undertake advanced GIS work, and deliver presentations. This hybrid model combines the flexibility of online learning with the richness of social learning through face-to-face interaction—and, summer in Seattle is wonderful.

The MGIS Program is organized in two parts: core courses during the first year, and concentration courses during the second year. The core courses teach the fundamentals of GIS software technologies and help develop advanced skills in spatial thinking, problem solving, and decision making. Concentration courses in sustainability management provide a background in how sustainability is viewed around the world, with a focus on refining problem-solving skills so students can balance competing priorities among stakeholders.

As noted, to ensure that the knowledge and skills gained in the program are nationally recognized, the program curriculum adheres to competencies outlined in the GIS&T Body of Knowledge, the U.S. Department of Labor’s Geospatial Technology Competency Model and Geospatial Management Competency Model, and various sustainability science bodies of knowledge.

A Capstone Experience

The capstone course, or GIS Workshop, gives students an opportunity to demonstrate and practice skills learned, refined, and mastered within earlier courses in the program and then apply those skills to a sustainability-related project sponsored by a community partner within the Puget Sound region. The capstone experience immerses students in the full range of competencies associated with the use of GIS for sustainability management (Figure 4).

Working in small teams, students define project goals with the partner, perform database design, acquire and analyze data, model sustainable solutions, and recommend a course of action. Students in the workshop often recognize the importance of personal effectiveness and workplace competencies like time management. Students also realize how difficult it is to scope out an organization’s core business process and then design, test, and implement a geospatial information product.

One of the major challenges that workshop project groups confront is that an organization’s geospatial business processes are often fragmented into activities carried out by operational managers from different functional units or departments, with no single person respon-
sible for the performance of the entire process. In addition, public, nonprofit, and private organizations have their own rules and approach their business process workflow in their own particular ways; students often find that partners might be resistant to changing business process workflow.

Yet these same kinds of organizations, with their resources and authority, are tremendous levers, capable of change if a proper business case can be made, which is not an easy thing to do. A business case is a structured proposal for improvement that functions as a decision package for organizational decision makers about the use of GIS for sustainability management. Student working groups often come to realize that much of their work is about deciphering an organization's workflow and understanding what makes things tick. Once that is accomplished, they are in a much better position to make a business case for changing some aspect of that core business process, inspired by the three domains of sustainability: science, information science, and management. Suzanne Davies Withers, who co-teaches the GIS Workshop course with Robert Aguirre, believes the knowledge that students get in the program allows them to move into other lines of work in the same field, often in the same companies. But for others, she says, “They really weren’t aware that they would really be able to be in the driver’s seat when it comes to taking on tasks or research, or making a difference in the various fields. I hope the students take away from this program an understanding of themselves as change makers.”

Sustainability: It’s in Our Nature

When it comes to sustainability, the mantra of the University of Washington (UW) is: Sustainability: It’s in our nature. The good news is that like many college campuses across the United States, at UW the concept of sustainability seems to permeate every aspect of life, from campus operations to the curriculum. Still, there is always the risk that sustainability will be perceived as a buzzword rather than a set of concepts, methods, or substantive problems at work every day.

Many public, nonprofit, and private sector organizations already use GIS and geospatial information to make decisions every day. The goal of the MGIS for Sustainability Management program is that by teaching practitioners how to design databases, maps, analyses, and applications with sustainability concepts as a guide, they can become the internal change makers who through the power of thousands of recommended course corrections will steer decision makers in public agencies and other influential organizations to design more sustainable solutions for our world.

References


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