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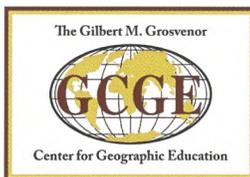
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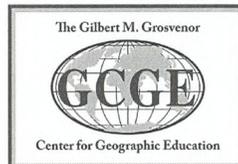
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## Inspiration for Early Career Geographers

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*Accepted October 1, 2020*

### **Abstract**

Multiple paths have charted the future of geography. In the midst of disciplinary uncertainty, what can early career geographers do to stay imaginative? Authored by two early career geographers, this paper outlines some advice and inspiration for geographers to write prolifically, explore placefully, and diversify their reading palettes. It builds upon Peirce Lewis's (1985) challenge to never relinquish "that God-given ability to see and feel and seek to understand the wonders of the earth." Three missions are provided to cultivate imaginative geographers: start a writing group, schedule weekly field dates, and adopt a daily reading routine. These missions frame professional geography into a career path that cultivates joy, curiosity, poetry, and gratitude.

### **Introduction**

Young geographers, remember why you went into the field in the first place and commit yourself accordingly, with zeal. Of course you will make mistakes. Of course you will look foolish now and then; people are sure to giggle as you go about sniffing the world like an adolescent puppy. But those are small risks indeed if you are really serious about understanding the world. Don't let anybody diminish your capacity for *attention*—that God-given ability to see and feel and seek to understand the wonders of the earth (Lewis, 1985, p. 475).

If any lines are worth committing to the geographer's memory, they come from the above quote, which concludes Peirce Lewis's Presidential Address to the American Association of Geographers (AAG). Lewis's 1985 commentary, "Beyond description," continues to enthuse generations of young geographers.

For us, Thomas Larsen and Lisa Tabor, his words played a decisive role in staying or leaving the discipline altogether. He reminded us that it is necessary and proper for geographers to take risks, make mistakes, and pay attention.

Commentaries on the future of geography stress forging multiple futures. Discussion mostly highlights views of tenured and emeritus faculty on institutional restructuring and how to devote intellectual energies of geographers (Bednarz, 2019; Grosvenor Center, 2020; Mitchell, 2020). Lost in the cacophony are the voices of early career geographers, the small-but-significant disciples of geographic research and education. Geography's disciples include traveling teachers pinballing from job to job, struggling to market their geography degrees, and trying to make a meaningful contribution to advance the discipline (Kaplan, 2019; Malloy & Berdahl, 2019). They feel the effects of geography's uncertain future personally.

The present essay avoids enumerating what should be done. That path is already crowded and overtrodden. Rather, this paper offers strategies for early career geographers to recall and cultivate what inspires them about the discipline. Yi Fu Tuan wrote, "If the good inherit Earth, it is because they have the right state of mind—they look and see, hear and understand" (2012, p. 151). Right mindsets can be transformative, but they are not without limits. Tuan followed his statement by saying "most of us are too blinded by ambition, envy, greed and vanity to have what we own" (p. 151). Amid this scrambling, where is the imagination? If "a geographical awareness helps reveal how the segments of our lives fit together" (Sack, 1997, p. 257), then how often do geographers reflect on the joy of seeing, feeling, and seeking to understand Earth's wonders?

Acquiring a graduate degree in geography can open doors, but it also puts graduates at risk of being entrapped by the knowledge they have accumulated (Frige, 2020; Wood, 2019). Intelligent people can acquire a wide vocabulary and library of books but become entrenched in an inflexible mindset that responds inadequately to emerging trends in the job market and scholarly thinking (Epstein, 2019; Robson, 2019). Geographers can learn much from artists like Rainer Maria Rilke (2000), who remarked in *Letters to a young poet* that:

only someone who is ready for everything, who doesn't exclude any experience, even the most incomprehensible, [...] will himself sound the depths of his own being. For if we imagine this being of the individual as a larger or smaller room, it is obvious that most people come to know only one corner of their room, one spot near the window, one narrow strip on which they keep walking back and forth. (p. 90)

Despite the structural problems facing geography, early career scholars have a palatial imagination from which to draw (Lowenthal, 1961). Drawing from our own experience, we devised a series of missions to help early career geographers

unlock the gates to their personal *châteaux*. Specifically, we discuss creative ways to write, explore, and read.

### **We Do Not Have to Open a Vein to Write Well**

What does one get when combining enthusiasm for geography and a gravitation toward sounding smart or provocative? Usually a hodgepodge of technical sentences following lines pulled from our individual manifestos. As scholars who have published multiple manuscripts, we will be the first to say that we are not good writers. We have written more bad sentences than good ones. Part of the academic journey is learning that writing should not be rendered incomprehensible for the sake of sounding intelligent. Taking Steven Pinker's (2014) advice, geographers must be kind to their readers and to themselves.

In personal correspondences with other early career geographers, we notice that writing is a dreaded part of communicating geographic research. We regularly encounter early career geographers who feel fatigued from farming out their dissertations to journal outlets. Writing does not have to be masochistic. The process works best when one is authentic, consistent, and playful. Surly, plainspoken Ernest Hemingway offered sound advice, "I love to write. But it has never gotten any easier to do and you can't expect it to if you keep trying for something better than you can do" (1981, p. 893). When geographers do not enjoy writing, they are less likely to write well and more likely to write less. Integrating play with work and loving to write can catalyze imaginative thinking and overcoming mental barriers to writing (Gilbert, 2015).

Also consider the amount of time involved. There never seems to be enough seconds in the day to check off everything geographers are "supposed" to do. Perhaps they do not wish to put up their ideas to scrutiny by anonymous reviewers or critics. For the most part, peer review and scholarly dialogues can be valuable opportunities for constructive feedback on how to improve one's research or how to better align manuscripts with a journal's expectations. As Rilke (2000, p. 24) penned, writing means "not numbering and counting, but ripening like a tree, which doesn't force its sap, and stands confidently in the storms of spring, not afraid that afterward summer may not come."

Sometimes, critics' comments feel malicious, biased, and unfairly negative. Some colleagues will bypass the original intent of the research to describe that they *think* it should have been or to make *ad hominem* statements toward a scholar's intellectual competence. This behavior proliferates throughout academia and should be met with grace and generosity—not anger and retaliation. Philosopher Martha Nussbaum (2018) wrote that:

people in academic life who love to diss scholars who have criticized them, and who believe this does them some good, have to be focusing only on reputation and status, since it's obvious that injuring someone else's reputation does not make

your own work better than it was before or correct whatever flaws the other person has found in it. (p. 26)

Negative reviews can come off as radioactive, make authors sick to their stomach, and make them want to quit academia and become yoga instructors (or is that just us?). Lashing out or shying away may seem like the optimal route, especially when one's ego feels like it got smashed between the hot irons of a Foreman grill, with one's self-worth dripping into the plastic receptacle at the bottom. As Nussbaum suggested, criticisms can be pathways to improvement when the yearning to preserve status and reputation is replaced with an unyielding curiosity and desire to learn. Nonetheless, the process can be draining when striving to maintain adequate boundaries between work and personal life.

Good ideas disappear with fear and exhaustion. To remain resilient, Thomas Larsen followed horror writer Stephen King's (2000) advice by pinning every rejection letter to the wall (and yes there have been plenty), viewing the collection as a challenge rather than a hindrance. Ideas squeal to a halt when geographers do not take the risk of writing and publishing. Writing may feel like an unnatural act but giving up sends the discipline to its depths (see Bradbury, 1990; Pinker, 2014). Geographers slide open the screen door for students and the public to step out into diverse worlds. Writing likewise assists by directing "the reader's gaze to something in the world" (Pinker, 2014, p. 56).

Pre-writing warms up the imagination, sparks inventive ideas, and arranges thoughts in pursuit of a fully formed work (Mogahed, 2013). Numerous writers overcome creativity blockades by dedicating each morning to journaling at least three pages. According to Julia Cameron (2020):

Morning Pages are three pages of longhand, stream of consciousness writing, done first thing in the morning. There is no wrong way to do Morning Pages—they are not high art. They are about anything and everything that crosses your mind—and they are for your eyes only. (p. 1)

Morning Pages supply writers with the license to jot down whatever comes to mind, even if it is complete nonsense. The practice can also serve as an expression of gratitude (Armenta *et al.*, 2017). Poet Ross Gay (2019, p. xi) once felt "delighted and compelled to both wonder about and share that delight" and decided "that it might feel nice, even useful, to write a daily essay about something delightful." That collection of essayettes became *The Book of Delights*, which was well-received among literary circles. An attitude of gratitude helps set aside toxic feelings to consider which perspectives can motivate and support writing (Armenta *et al.*, 2017).

Writing should interest early career geographers because it represents a form of place-making. That is why naturalist and poet Gary Snyder (2016) takes good care of his Macintosh:

Because whole worlds of writing can be boldly laid out and then highlighted and vanish in a flash at “delete,”  
so it teaches of impermanence and pain;  
And because my computer and me are both brief in this world,  
both foolish, and we have earthy fates,  
Because I have let it move in with my right in the tent,  
And it goes with me out every morning;  
We fill up our baskets, get back home,  
Feel rich, relax,  
I throw it a scrap and it hums. (p. 9)

Writing tools—pencils, notebooks, laptops, the notes app on one’s smartphone, the backs of receipts—are field instruments for the geographic imagination. As a testimony, one of this paper’s authors conceived the idea behind their master’s thesis on a bar napkin! Early career geographers already engage in place-based education, gaining inspiration from the ordinary landscapes they inhabit. Writing accompanies them throughout the day so that they can report back and shed a light on myriad lifeworlds.

### ***Mission: Start a Writing Group***

Reject the myth that writing is an insular, personal endeavor. Writing is a social process, one that is interpersonal, place-based, collaborative, and mutually transforming. Based on research on writing in social spaces (Murray, 2015), the first mission is to seek at least one of the following opportunities:

- Join or start a communal writing group at one’s institution.
- Talk to a friend or colleague about writing-in-progress.
- Converse about writing objectives.
- Organize an off campus writing retreat.

Experiment with different writing groups and approaches, with the goal of finding a supportive outlet or method. These networks take many forms, including virtual outlets (*e.g.*, Zoom, Skype, FaceTime). A newly formed writing group may gather and chat to settle in, bounce around ideas, and establish a comfortable, trusting environment. Maintaining these social relationships and space energizes scholars (Murray, 2015). In our experience, we found ourselves writing more frequently, both together and alone.

### **Take a Regular Dose of Vitamin N**

To sharpen the senses while sniffing about the world “like an adolescent puppy” (Lewis, 1985, p. 475), geographers must be curious enough to travel throughout the rooms of their home as well as they do when on a ramble through the American West or Central Europe (de Botton, 2002). The subspecialty of the

geographer makes no difference. Everyone benefits from spending alone time in nature or within a tranquil state of mind through contemplation (Wicks, 2019).

Every early career geographer needs their Vitamin N (Nature). Geographers are just as susceptible to nature deficit disorder as the rest of the post-industrial world (Louv, 2011). Teaching loads, research projects, and busy homelives hinder the capacity to comprehend places. Humanistic geographers like Edward Relph (1981) emphasize seeing landscapes clearly without imposing any preconceptions, having curiosity to search throughout the world, and developing compassionate intelligence toward places. Break out of the business of teaching and researching from time to time. Find ways to renew the personal, ecological education that life provides (Orr, 2004). Explore, unlearn, and rediscover meaning in being a geographer.

Jewish theologian and philosopher Abraham Heschel said that “as civilization advances, the sense of wonder almost necessarily declines” (qtd. in Orr, 2004, p. 139). Humans relate to nature in various ways, bound themselves to distinctive places, and differ in their levels of connection. What humans have in common is that they all come to love the familiar (Orr, 2004). A daily dose of Vitamin N helps geographers reconnect with their selves in relation to place. Forest bathing, going off-grid, or having a cocktail on a bar patio has transformative implications for early career geographers (see Wicks, 2019). As Orr (2004) writes:

Finally, we can attempt to teach the things that one might imagine the earth would teach us: silence, humility, holiness, connectedness, courtesy, beauty, celebration, giving, restoration, obligation, and wildness. (p. 52)

Meditating on each of these words opens a portal to rewilding the early career geographer. Exploration of the self in relation to geography generates personal mandalas of beauty, celebration, silence, restoration, and obligation.

### ***Mission: Schedule Weekly Field Dates***

Salter (2001, p. 108) wrote that “the reason that there is no bad landscape is that lessons weave through every scene.” Inspired by nature essayists, poets, and humanistic geographers, we suggest devoting time to view, document, and experience ordinary landscapes. We like to call this practice a field date. This practice relates to Julia Cameron’s (2020, p. 1) notion of an artist’s date, “a once-weekly, festive, solo expedition to explore something that interests you. The Artist Date need not be overtly ‘artistic’ – think mischief more than mastery.”

Formal field work, in the traditional sense, requires long, structured stretches of time collecting and analyzing data (Hart, 2001). In the personal search for meaning, life 24/7 can be viewed as a field trip, an opportunity to untether from the desk and experience in a deeper sense the ongoing conversation with places (Tuan, 2001). Most geographers cannot wander aimlessly every day

like Thoreau, nor can they always engage in meticulously planned, research-driven field work. Instead, engage with ordinary situations in a placeful manner, such as drinking coffee on a rainy morning with no digital devices in sight. Other examples include:

- Take an afternoon walk across campus and listening to the wind rustle through the trees (or through the tunnels underneath frostbitten campuses in the Great White North) over the familiar hustle and bustle of academic life (see Gumprecht, 2007).
- Follow local field guides, natural history essays, and travel and adventure accounts to encounter the ghostly footprints of historical landscapes, “all there to show the way if we just see it” (Harlan, 2010, p. 3). Consider:
  - Thomas Lyon’s (1989) *This Incomperable Lande: A book of American Nature Writing*;
  - William Wyckoff’s (2014) *How to Read the American West: A Field Guide*;
  - Hal Jackson’s (2012) *Boone’s Lick Road: A Brief History and Guide to a Missouri Treasure*;
  - James Shortridge’s *Kaw Valley Landscapes: A Traveler’s Guide to Northeastern Kansas* (1988), *The Middle West: Its Meaning in American Culture* (1989), and *Cities on the Plains: The Evolution of Urban Kansas* (2004).
- Going on an unplanned drift (*dérive*) through a nearby area and identifying at least ten new things gone unnoticed (see Bassett, 2004; Souzis, 2015).

Creativity depends upon integrating various modes of exploration. Going on a field date differs from precise and planned field work with an end goal in mind. Such exploration may even be bedridden, simply breathing deeply and watching rain outside a bedroom window—a delightful diversion from feeling dogged tired or anxious about accumulating email notifications. Every ordinary moment is an invitation to become more intimately connected with the environment (Orr, 2004).

### **Turn Literature into Leisure**

Research and teaching in geography represent exercises in *constructivism*, the idea that knowledge is accumulated and nested hierarchically through time. Rarely do fresh ideas materialize out of nowhere like deciphering coffee grounds at the bottom of a mug. Inspiration comes from constantly consuming new information. Geographers are the product of the five closest people around them (Antonopoulos, 2016; Rohn, 1991), and the same goes with what and whom they read.

Reading poetry, especially lean, simple poems, prompts geographers to be receptive to different ways of thinking about their subject. According to Ray Bradbury (1990, p. 39), creative people should read poetry every day “because it flexes muscles you don’t use often enough. Poetry expands the senses and keeps them in prime condition.” Poems also offer bite-sized breaks from the rigid scholarly writing that geographers produce and consume. Some may not enjoy poetry or were scarred from high school course in language arts. Poetry diversifies one’s reading intake and adds more creative channels.

High impact research and teaching depend on high impact literature. Success also depends upon consuming an array of literature to conjure new ideas and links among ideas. Keeping up with the scholarly and informal literature involves the imperfect process of perfecting the daily routine. Here is the daily reading ritual for Thomas Larsen:

- *Morning* – Walk the dog while listening to *The Writer’s Almanac* and *The Economist Intelligence* podcasts before sitting down to write and research scholarship for the latest paper. Take a break and listen to an audiobook, such as comedian Tom Papa’s (2020) *You’re Doing Great! And other reasons to stay alive*.
- *Afternoon* – Scan the American Geographical Society (AGS) *DailyGeo*, the American Association of Geographers (AAG) *SmartBrief*, and the American Association for the Advancement of Science (AAAS) *Daily News* and *First Release Notifications*.
- *Evening* – Read at least five pages from five non-geography books. The latest selection of prose, poetry, and non-fiction includes: Ted Kooser’s (2004) Pulitzer Prize-winning poems in *Delights and Shadows*; Mary Oliver’s (2014) collection of nature essays in *Upstream*; Andrea Wulf’s (2015) biography of Alexander von Humboldt; Robert J. Wicks’s (2019) *The Tao of Ordinarity: Humility and simplicity in a narcissistic age*; and poems from the great Sufi master Hafiz (Ladinsky, 1999).

The weekly reading ritual for Lisa Tabor, who demands flexibility in her life, is to:

- *Most mornings* – Read approximately one chapter of a book that benefits her current classes. At the moment, these books include *The Invention of Nature: Alexander von Humboldt’s New World* by Andrea Wulf (2015), which will be integrated into the graduate level course Nature of Geographic Thought, and *The World: A brief introduction* (Haass, 2020), which is being deployed to enhance her large lecture course in World Geography. Before engaging in daily work, she completes *The Sunrise Manifesto: Guided morning journal* (almost never at sunrise) as means for practicing gratitude, setting daily goals, and decluttering the mind (SaltWrap, 2016).

- *Most afternoons* – Review email blasts from various listservs, which include *Science*, the *Proceedings of the National Academy of Science*, AAG’s *SmartBrief*, the *Esri Globe*, the news outlets of *Medium* and *CNN*, and whatever new reads arising from the state Department of Education and university. This time is also ideal to read an article that a colleague, co-author, or old advisor forwarded.
- *Most evenings* – Take a walk and alternate between being one with nature and listening to fun podcasts or audio books. She tends toward podcasts and audiobooks that are not work-related AT ALL, like *The Office Ladies*, *Straight Up with Stassi*, or *Freakonomics*. She always reads before bed -- whatever she feels like reading in that moment!

To be creative, we must read creative work. Several the listed books have less to do with scholarship and more to do with being human (see Ladinsky, 1999; Papa, 2020; Wicks, 2019). Responding to a geography vocation does not end at 5:00 PM. It is part of an individual’s search for meaning (Tuan, 2012). Geography promotes the everlasting self, which, according to poet laureate Tracy K. Smith (2018),

Comes in from a downpour  
Shaking water in every direction—  
A collaborative condition:  
Gathered, shed, spread, then  
Forgotten, reabsorbed. Like love  
From a lifetime ago, and mud  
A dog has tracked on the floor. (p. 71)

Reading good literature is essential to the education of the geographer (Sauer, 1956). Tuan embodies the type of geographer who spent a lifetime reading and making sense of his own place within the cosmos, using geography as a medium for expression, clarity, and conundrum (Tuan, 2001, 2012). Books and poems nurture the geographic imagination (Lowenthal, 1961).

***Mission: Adopt a Daily Reading Routine***

Frequently (and readers may already be thinking this), the day appears too cluttered for reading time. That is why a routine or ritual is so important. Experiment with which reading routine works best:

- Draft of list of required readings and desired readings.
- Integrate a piece or type of reading outside of our normal genres, or perhaps a guilty pleasure that we would scold ourselves for checking out from the library.
- Ask others what they are reading.
- Reflect on how days go when reading is prioritized versus when it is not.

It can be shocking how much reading can fit into daily schedules. The goodness it feels to include these various readings compels us to make the time. Indulging ourselves with full acceptance while mixing in relevant work-related pieces helps us live a more authentic life. David Kelly called it “creative confidence” in his 2012 TED talk, saying that “overcoming fear in one domain subsequently gave people new confidence in other areas of their lives, too” (Walters, 2012, p. 1). And this more authentic life will increase our positivity, our enjoyment of our work, and ultimately our creativity in all that we do.

### Supporting Early Career Geographers

Writing almost four decades ago, Peirce Lewis noted, “All sorts of things are in flux—that only a while ago were thought to be fixed in place: economic conditions, political attitudes, social institutions” (Lewis [1983] 2004, p. 30). Fast-forward to present, early career geographers face new kinds of flux, especially with the renaming and consolidation of geography departments, accelerating global changes, and the recent COVID-19 global pandemic (Dorling, 2020; Frazier and Wikle, 2017; Winkler, 2016). Amid such change and uncertainty, hope exists when geographers embrace emerging situations (see Winkler, 2016). Lewis later stated ([1983] 2004,

Times like these are always unsettling and sometimes downright disagreeable. But—and it’s an important but—such times of change are times of opportunity. If a tougher and leaner geographic profession is alert to those opportunities, the next few years can see unprecedented gains for the profession that we all love so deeply. (p. 30)

We should work to inspire, support, and protect future generations of professional geographers. Sebastian Junger (2016), in his book *Tribe: On homecoming and belonging*, summarizes this sentiment with three conditions for human wellbeing: (1) competence in what they do, (2) authenticity in how they live their lives, and (3) a connection to others. Young geographers have the capability to build creative, authentic careers in communion with other geographers through starting writing groups, scheduling personal field trips that rewild their understandings of ordinary places and the human spirit, and reading high impact scholarship, poetry, and prose to expand their mindsets.

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## **Framing Human-Environment Connections through Waterscapes: A Geographic Lens for Teaching and Learning about Water Resources**

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### **Abstract**

The concept of “waterscapes” is examined, with a focus on applications in secondary schools and the pedagogy for undergraduate geography students. The waterscape emphasis on external flows of capital, political relations, and policy that interact with the physical watershed, as well as the hydrosocial cycle, are particularly well suited to support teacher pedagogical content knowledge because of the flexibility in interpreting and applying concepts using what we have termed “the shallow sustainability approach”. Employing case studies from the Singapore geography curriculum, we explore new pathways for the traditional interpretation of waterscapes that include linking mathematical modelling of hydrologic systems with rich local narratives.

**Keywords:** waterscapes, hydrosocial cycle, socio-hydrology, IWRM, WSUD, water resource management, water resource education

## Introduction

*...the study of water provides a logical link between an understanding of physical and social environments.*

R.J. Chorley and R.W. Kates (1971, p. 3)

Characterizing human-environment interactions is a cornerstone of geographic research and education (Bednarz, 2006; Grindsted, 2013; Turner, 2002; Zimmerer, 2010) and in particular, we note the importance of Pattison's "four traditions of geography", originally published in 1964, and revisited again in 1990 (Pattison, 1990) that addressed the centrality of human-environment interaction in modern geography. Subsequently, the National Geography Standards released under the auspices of the National Council for Geographic Education in the U.S. included "Environment and Society", in which Standard 14 - *How human actions modify the physical environment*, Standard 15 - *How physical systems affect human systems*, and Standard 16 - *The changes that occur in the meaning, use, distribution, and importance of resources* are particularly pertinent to our discussions (Heffron & Downs, 2012). While the human-environment interaction is a central theme of geography, it is reflected using different philosophical and technical approaches as diverse as neoliberalism and Marxism, qualitative ethnographies and quantitative geospatial analysis and big data (e.g., Bakker, 2010; Castree, 2002; 2010; Church, 2010; DeLyser & Sui, 2014; Yang *et al.*, 2015;). Water is essential for life and as such provides a rich context by which to explore human-environment relations, per our opening quote.

The objective of this paper is to discuss and expand the concept of waterscapes as a pedagogical approach to facilitate a deeper understanding of the human-water environment interaction related to water resource assessment and management. Using case examples from secondary and undergraduate geography courses in Singapore to integrate aspects of content and Shulman's ideas regarding pedagogical content knowledge (PCK) (1986), we illustrate the value and relevance of waterscapes as a new lens to explore water resource issues within a geography curriculum. In essence, we see waterscapes as a new way of thinking about how we assess, manage, and teach about water resources that more explicitly incorporates the centrality of human-environment interaction and is distinctly geographical. However, we also conclude that there is a need to consider alternative interpretations and expand the concepts of waterscapes, thereby enhancing the utility of the concept within the pedagogical toolbox. In this, we suggest some pathways forward.

We begin this paper by providing a brief outline of three different conceptual approaches to water resource assessment and management, integrated water resources management (IWRM), socio-hydrology, and waterscapes. We

follow this with a brief overview of pedagogical content knowledge (PCK) which is used to frame the discussion of the nexus between water resource management principles and PCK, as presented in the third section of the paper. Finally, a case study approach is used to explore how waterscapes can provide new ways of looking at water resource issues within a geography curriculum.

### **Current principles, practices, and paradigms of water resource assessment and management**

In this section we discuss three different approaches to water resource assessment and management, namely, IWRM, socio-hydrology, and waterscapes. IWRM has been applied throughout the world (Borchardt *et al.*, 2016; Charnay, 2011; Giordano & Shah, 2014; Mekong River Commission, 2016) and the management framework is explored explicitly in university curricula, but generally at the graduate level and more as a planning and management topic with distinctly technical underpinnings (Bourget, 2006; Jonker, 2005; Powell & Larsen, 2013). Individual components of IWRM (e.g., water source and catchment conservation; valuing water resources economically and socially) are found within secondary school and undergraduate curricula (Hirsch & Lloyd, 2005; Irvine *et al.*, 2015a; Shah & Treby, 2006). The waterscape concept was first formally outlined by Swyngedouw (1999) and more recently, the field of socio-hydrology has begun to evolve (e.g., Di Baldassarre *et al.*, 2015; Loucks, 2015; Sivapalan *et al.*, 2014; Troy *et al.*, 2015).

### **Principles of Integrated Water Resource Management (IWRM)**

Irvine *et al.* (2010) summarized the modern development of IWRM and its eight guiding principles. The eight guiding principles are as follows:

- 1) Water source and catchment conservation and protection are vital.
- 2) There should be agreement between stakeholders on water allocation within a national framework.
- 3) Management must be addressed and implemented at the lowest appropriate level.
- 4) Capacity building is essential to sustainable development and management of water resources.
- 5) Stakeholders from all sectors must be involved in a participatory process of developing inclusive water resource management policy.
- 6) Efficient water use is essential and can be considered an important 'source' in itself.
- 7) Water provides essential ecosystem services that should be appropriately valued.
- 8) Striking a gender balance is essential.

Although widely applied, there also has been considerable debate and criticism of IWRM. A common criticism, one that echoes earlier criticisms of sustainable development concepts, is that the definition of IWRM is too broad to be meaningful (Biswas, 2008; Jewitt, 2002; Medema *et al.*, 2008). On the other hand, Anderson *et al.* (2008) argued that while different definitions of IWRM exist, there is a common understanding of its fundamental principles and approaches and that there should be a shift away from debates on definitions but rather towards identifying implementation mechanisms. Giordano and Shah (2014) concluded that "...the current monopoly of IWRM in global water management discourse is shutting out alternative thinking on pragmatic solutions to existing water problems." Cohen and Davidson (2011) suggested that with IWRM "...the conceptual jump from technical tool to governance unit was made without an attendant focus on the broader components of water governance.," while Garcia (2008) identified a number of questions and challenges faced by practitioners in moving from IWRM theory to real world application.

### **Principles of Socio-hydrology**

The socio-hydrology literature tends to be dominated by the engineering and earth system science community who are exploring new approaches to managing water by linking complex system theory, demographics, and to a lesser extent, socio-economics. The social theory components, including geographical aspects of human-environment interactions in the socio-hydrology literature, are still not well-developed (e.g., Di Baldassarre *et al.*, 2015; Loucks, 2015; Sivapalan *et al.*, 2014; Troy *et al.*, 2015; Wesselink *et al.*, 2017).

As Wesselink *et al.* (2017) noted:

The ontological aspiration of scholars in socio-hydrology is to capture the full range of human behavior in the interaction with the natural systems. However, in the methodological implementation of these ideas both the natural and the human dimensions are reduced to fit in a quantitative model. (p. 3)

Di Baldassarre *et al.* (2015), for example, developed an interesting approach that considered a peak-over-threshold time series of high-water levels and property damage to represent floods that were linked to three differential equations representing the temporal change of demography, technology, and society in response to flood conditions. It was concluded that the models successfully captured some of the general societal attributes, but Vogel *et al.* (2015) noted quantitative descriptions of stakeholder and societal behavior remain a great challenge.

## Principles of Waterscapes

Perrault *et al.* (2012) succinctly summarized the principles of waterscapes:

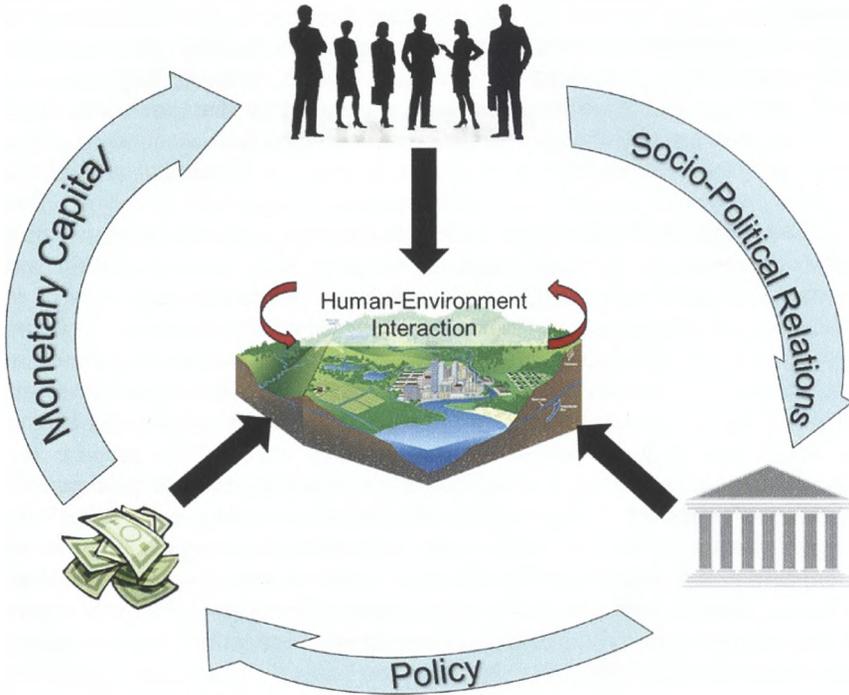
Waterscapes explore the ways in which flows of water, power, and capital converge to produce uneven socio-ecological arrangements over space and time, the particular characteristics of which reflect the power relations that shaped their production (p. 486)

Importantly, a waterscape extends beyond the physical boundaries of a watershed (Figure 1). In some ways, as noted by Swyngedouw (1999) and reviewed by Irvine *et al.* (2016), waterscapes theory can be linked to concepts of political ecology. Swyngedouw (2009) also observed that "...interventions in the organization of the hydrologic cycle are always political in nature and therefore contested and contestable." Furthermore, our contention is that an important element of the waterscapes framework should be the hydrosocial cycle. Linton and Budds (2014) likely would disagree as they stated, "We propose the hydrosocial cycle as an analytical tool for investigating hydrosocial relations and as a broader framework for undertaking critical political ecologies of water." As we will discuss later, we believe the waterscapes concept to be more encompassing and elegant and therefore, we prefer to consider the hydrosocial cycle as an element within the waterscapes concept. The hydrosocial cycle begins to place a greater emphasis on the role of human involvement with the hydrologic cycle. As noted by Linton (2014):

The hydrosocial cycle borrows somewhat from the concept of the hydrologic cycle, but modifies it in important ways. While the hydrologic cycle has the analytical effect of separating water from its social context, the hydrosocial cycle represents water as a hydrosocial fact, thus putting people and politics at the center of all water issues. (p. 114)

As such, the hydrosocial cycle addresses Swyngedouw's (1999) concern regarding the dualism of nature and society whereby the inseparable connection between nature and society is not adequately addressed.

**Figure 1**  
*The Waterscape Concept*



*Note.* Human-environment interactions within the physical boundaries of the watershed remain central. However, there are policy, monetary, and socio-political currents that interact outside of the watershed boundaries, but which also flow into, and directly impact, the human-environment interactions within the watershed.

We see waterscapes as being characterized by two key changes in the way scientists examine water resources management:

- 1) The frame of reference has expanded to encompass the “human” aspect of the hydrological cycle, or the hydrosocial cycle, which emphasizes the geographical lens of human-environment interactions and provides us with a new way of thinking about the “what” we are studying. This informs the thinking about “how” we should investigate the hydrosocial cycle and creates a shift into new methods of knowing – surveys and observations will become as important as streamflow measurements or modelling.

- 2) The scale of analysis is dynamic. It is not fixed at the catchment level but scales up or down according to what needs to be examined, which represents a shift in terms of the way we do things.

### **Pedagogical Content Knowledge**

The paradigm of pedagogical content knowledge (PCK) emerged from issues related to educational quality and the desire for reform in U.S. schools beginning in the early 1980's (Carlsen, 1999; Gess-Newsome, 1999). To address some of these concerns, Shulman (1986, 1987) began a line of research that identified signature characteristics of the teaching profession. Shulman (1986) initially outlined three categories of teacher knowledge: 1) content knowledge; 2) curricular knowledge; and 3) pedagogical content knowledge. Content knowledge pertains to what a teacher may have learned in formal (or informal) settings, such as through the courses in their major at university, while curricular knowledge refers to the tools (e.g., technology) and understanding of how to teach (e.g., teaching strategies for different learners). Pedagogical content knowledge refers to the teacher's ability to translate difficult content material so that it is understandable for the student. It is not sufficient to simply understand the content of the discipline; the teacher also must understand pre-conceptions that students of a particular age may have about a topic and have a range of strategies to address these pre-conceptions. We emphasize that these skills are equally pertinent to the high school teacher and the university professor.

As applied to science education reform, PCK follows a constructivist approach that is inquiry-oriented and student-centered. As such, teachers must "...select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students" (Park *et al.*, 2011). Under these conditions, teachers with more sophisticated PCK skills may have a greater ability to implement educational reforms and the "deep sustainability" approach to the hydrosocial cycle described in the next section may present challenges for teachers to translate into pedagogy (see also Seow *et al.*, 2019a, 2019b). The question for this paper then becomes whether the waterscapes framework can be helpful in explaining the complex social and physical interactions of the hydrosphere.

### **Water Resource Management Frameworks and Implications for Pedagogy**

Waterscapes, socio-hydrology, and IWRM have some similarities, but also a number of important differences. Wesselink *et al.* (2017) delivered an extensive and thoughtful comparison of the hydrosocial cycle and socio-hydrology and here we hope not to reiterate their very good summary, but rather offer some additional insights.

Linton and Budds (2014) provided a very detailed discussion of the

properties of the hydrosocial cycle:

We employ a relational-dialectical approach to conceptualize the hydrosocial cycle as a socio-natural process by which water and society make and remake each other over space and time....

In the hydrosocial cycle, things like water, society and social power retain their positive identities but are understood to relate internally, whereby they are neither considered as already-existing entities, nor ones that can maintain independent identities following interaction with each other....

This, in practice, implies that we need to think differently about water... One starting point, as suggested above, is to question the meaning of water(s) in any given situation. This will entail asking what different waters, knowledges, and meanings are articulated and how these might internalize vested interests and power structures.... (p. 175)

This clearly non-neoliberalist approach asks us to think in a new way about water, where we have a virtual molecular “watersociety” with internal bonding; the chemistry analogy being a water molecule (H<sub>2</sub>O). Socio-hydrology and IWRM, on the other hand, lend themselves to a more neoliberalist political interpretation and might be written Society + Hydrology (or as an ion group, H<sup>+</sup> and OH<sup>-</sup>), which are separate, but connected entities (consistent with Chorley’s opening quote). In our experience, working with line agencies and community groups in applied water projects in North America and Southeast Asia, this proposed new way of thinking about water (i.e. “watersociety”) may present conceptual barriers (see also, Garcia, 2008). Similarly, this new way of thinking about water may present PCK challenges for teachers. As such, we suggest a “shallow sustainability” approach in applying the waterscapes (and hydrosocial cycle) concept, as opposed to the “deep sustainability” approach described by Linton and Budds (2014). Shallow sustainability focuses on the means we use to accomplish an end, favoring efficiency and substitution, while deep sustainability addresses the ends themselves through a more holistic approach. Shallow sustainability would address transportation issues by producing more efficient cars and alternative fuels, while a deep sustainability approach would focus on creating a quality of life in which one would work locally and eliminate the necessity for automobile transportation. If we extend this analogy to water, a shallow sustainability approach would pursue the construction of a raingarden to manage pluvial flooding whereas a deep sustainability approach would ask what is water and how do the social needs of all community members shape the oneness with the resource.

Water resource management typically is applied at the watershed scale. The watershed might be thought of as the fundamental hydrologic and geomorphologic unit because the physical boundaries facilitate the determination of water, sediment, and chemical mass balances, which are useful in supporting water resources management decision-making. While this physical boundary approach is helpful in quantifying mass balances, it also tends to focus attention on the local drivers and processes within the watershed and de-emphasizes external forcing factors (the issues of climate change notwithstanding). This is underscored by the IWRM principle that management must be addressed and implemented at the lowest appropriate level. In part we might see this as a scale issue, and as noted above, the waterscapes framework can support a dynamic scaling approach. Furthermore, while IWRM retains a certain technical pragmatism that is attractive to on-the-ground application, we believe that waterscapes, with its geographical focus on spatial and temporal relations and human-environment interactions, can serve to fill the conceptual shortcomings of IWRM (cf. Cohen & Davidson, 2011) and provide a deeper appreciation for the complexities of water resource management. We would further contend that the richness of geographical community narratives gives a “face” to the daily negotiations of water accessibility and resiliency that cannot be entirely captured in mathematical abstraction (cf. Vogel *et al.*, 2015).

As sound water management continues to be an important theme globally, education is essential to ensure that the next generations will learn about innovative and sustainable approaches to management. What are the implications of such a shift in relation to geographic and water resources management pedagogy? In addition to the way curricula can be developed and what issues in water resources management and geography can be taught, it will also change the way we think about how the topics are taught. Let us consider case studies from Singapore to explore the implications of waterscapes for pedagogy.

### **Framing PCK and Waterscapes – the Singapore Curriculum Context**

Because of its small catchment area and dense population, water is a matter of national security in Singapore (Tortajada, 2006) and the closed-loop water management approach in this island-state has evolved to become one of the most sophisticated and resilient systems in the world (Irvine *et al.*, 2014; Luan, 2010). Appropriately, water is a focal point in the Singapore geography curriculum, which has a rich modern history that has been traced by Irvine *et al.* (2015a), while Chang (2012) provides a detailed and critical review of geography education at all levels in Singapore.

Adapted from Roberts (2013), the 2014 syllabus (and retained through the 2021 revised syllabus), Geographical Inquiry, has been used as a key guide for pedagogy in the 2014 and 2021 school geography syllabus in Singapore. A related signature pedagogy in the geography curriculum is the required

Geographical Investigation (GI) at each grade level. The GIs typically are fieldwork-based and require the students to plan their research, gather and analyze data, and construct their geographical interpretations, as well as evaluate and communicate their findings. The intent of the GI is to reinforce classroom learning through fieldwork by giving the students an appreciation for real-world applications of geographical knowledge and skills.

Teacher preparation in Singapore currently follows two primary paths - a Bachelor of Arts or Science in Education, or the Postgraduate Diploma in Education (PGDE). All student teacher preparation in Singapore is done at the National Institute of Education (NIE), Nanyang Technological University. The four-year BA program, in the case of geography, requires students to complete both a full complement of physical and human geography courses (culminating in a required overseas field experience for their final year project) and pedagogy. Students enrolled in the 16-month PGDE program already have obtained an undergraduate degree, and apart from a small amount of content upgrade, focus entirely on pedagogy classes. Fieldwork for both the BA and the PGDE programs is an essential element of geographic education and prepares students to implement the GIs of the geography curriculum.

We now turn to a series of case studies to illustrate how waterscapes can clarify content within a curriculum in a way that supports PCK. For this, we focus on examples from the geography curriculum in Singapore. Examples could be equally drawn from geography curriculum throughout the world.

### **Waterscapes as a new pedagogical framework for Water Resource Education**

#### **Case study – the hydrosocial cycle and water management in Singapore**

The senior author is a hydrologist who focuses on urban hydrology and was skeptical of the need to include the explicit designation of “social” as part of the discussion on the hydrologic cycle. It seemed to him that there would be no value-added in the modified term since human interactions and impacts are an integral component in all his research. However, because Singapore’s geography curriculum has an in-depth focus on water issues, as do the BA and PGDE programs at NIE, we decided in some way to explore the need for specifically designating the “social” part of the hydrologic cycle. To address this question, we projected a diagram of the hydrologic cycle that included representations of a city, waterbodies (Lake Washington and Puget Sound, U.S.A.), farmland, and forest (i.e., differing land uses, including human activity) at the start of four different NIE classes. The students simply were instructed to “Describe What is Going on in this Diagram.” No other explanation was provided, and the students were given five minutes to complete the task. The characteristics of the four classes are summarized in Table 1. The classes represent a range of levels and experience in geography but were selected by convenience as they were being taught by various

of the co-authors. The total sample size across all classes was 43.

**Table 1**

*Classes participating in the hydro-social cycle Description Experiment*

| <b>Class</b>   | <b>Academic Level</b>           | <b>Class Size</b> | <b>Comments</b>  |
|--|---------------------------------|-------------------|--|
| AAG10A,<br><i>Elements of Physical Geography</i>     | Year 1, BA program              | 9                 | A mix of students having geography as a primary or secondary focus                       |
| AAG40D,<br><i>Geographical Methods and Fieldwork</i> | Year 4, BA program              | 13                | All students having a primary focus in geography and conducting their final year project |
| QCG52C,<br><i>Teaching Outside the Classroom</i>     | PGDE program                    | 8                 | Not all students had a Geography bachelor's degree                                       |
| MAS944,<br><i>Global Cities</i>                      | Masters in Humanities Education | 13                | All were graduate students but only 2 were teaching Geography                            |

A simple word cloud was constructed based on the narratives that each student provided and is shown in Figure 2. A few trends could be identified from this exercise and are apparent in the word cloud. First, in general, the students provided excellent process-oriented narratives and clearly described water movement through the hydrologic cycle. However, only 7 of 43 students (16%) made any meaningful statements regarding human interaction with the hydrologic cycle, with an additional 4 students referring to Puget Sound or Lake Washington by name. The PGDE class provided the least detail in the description of the hydrologic cycle and had the second lowest percentage (12%) of participants noting a human influence. Perhaps this result is related to the lack of a geographic background (not all PGDE students have a Geography degree). They may be only starting to transition from expert student to novice teacher, without the more extensive content-pedagogy connections of the BA program. Interestingly, the MA class had the highest percentage (38%) of participants noting a human influence, but only 2 in the class were geography teachers. Since the MA class represented older students than the PGDE class, this result may reflect the importance of what Morine-Dershimer and Kent (1999) call personal pedagogical knowledge, or the knowledge obtained through personal, practical experience.

**Figure 2**  
*Word Cloud*



*Note:* Word cloud constructed from Singapore student descriptions of the hydrologic cycle diagram.

There is no doubt that we might have conducted a more rigorous and extensive evaluation, for example, using concept mapping. However, let us accept for now that there seems to be some evidence, at least in the context of the Singapore education system, that the majority of students do not explicitly identify the interaction between society and the hydrosphere. The question then becomes, how might the concept of waterscapes and hydrosocial cycle be implemented? Here, we turn to another case study in Singapore. Water Sensitive Urban Design.

**Water Sensitive Urban Design and raingardens to illustrate the connections between the hydrosocial cycle and PCK**

Water Sensitive Urban Design (WSUD) has been aggressively pursued in Singapore as a means of minimizing localized flooding, but maximizing the release of runoff to drinking water reservoirs and improving runoff quality (e.g., Irvine *et al.*, 2014; Lim & Lu, 2016). The objective of WSUD is to mimic a site's pre-development hydrology utilizing design techniques that infiltrate, filter, store,

evaporate, and detain runoff close to its source. WSUD is de-centralized and works with nature to reduce flooding and improve runoff quality. WSUD technologies include raingardens, cleansing biotopes, green roofs, grassed swales, pervious pavement, constructed and floating wetlands, rain barrels, and conservation of trees.

WSUD is of particular relevance to the Singapore Secondary 1 and junior college geography curricula, with their focus on approaches to managing urban flooding. Indeed, the Public Utilities Board (PUB, Singapore's water agency) has implemented a raingarden program with schools, while the Housing Development Board (HDB, the statutory board responsible for Singapore's public housing) has now included WSUD in all new HDB estate designs (Loc *et al.*, 2020).

PUB, in partnership with NIE, AECOM, and Green Earth Consultants, collaboratively constructed a demonstration raingarden at NIE, details of which are discussed by Chang *et al.* (2018). The raingarden is instrumented with an Internet of Things (IoT) meteorological station (Figure 3a) and provides numerous learning opportunities including determination of simple water budgets, measuring infiltration rates (Figure 3b), and understanding how raingardens (as an example of WSUD) can be both a water management technology and make a city more liveable through enhancing greenspace. Urban liveability is a theme in the lower secondary geography curriculum.

Frequently, however, our NIE team is asked by teachers what they can do with a raingarden. The opportunities are boundless with respect to water management, liveability, and even climate change, but it requires us to help teachers bridge from established PUB policies and programs to the geography curriculum. How might waterscapes and the hydrosocial cycle help with this? To begin, fieldwork explicitly supports Geographic Investigations (GIs) as a signature pedagogy in Singapore schools. Infiltration measurement (Figure 3b) is an example of a specific GI undertaken at the Junior College level. The IoT meteorological station (Figure 3a) supports the Singapore Upper Secondary Geography 21st century competency goal of developing confident learners who can communicate effectively through the use of ICT (including big data).

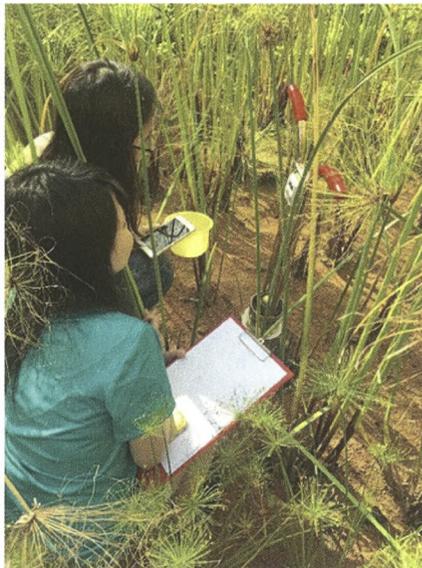
As such, several geography classes at NIE use the meteorological data in assignments. Selected final year project research has focused on sampling and evaluating the efficacy of the raingarden in improving runoff water quality (nutrients and total suspended solids). Water quality assessment is a Lower Secondary GI. These various topics and experiences are linked throughout the undergraduate program by content and pedagogy lecture material on pluvial water management, WSUD, and urban liveability.

**Figure 3**

*A Demonstration Raingarden at NIE*

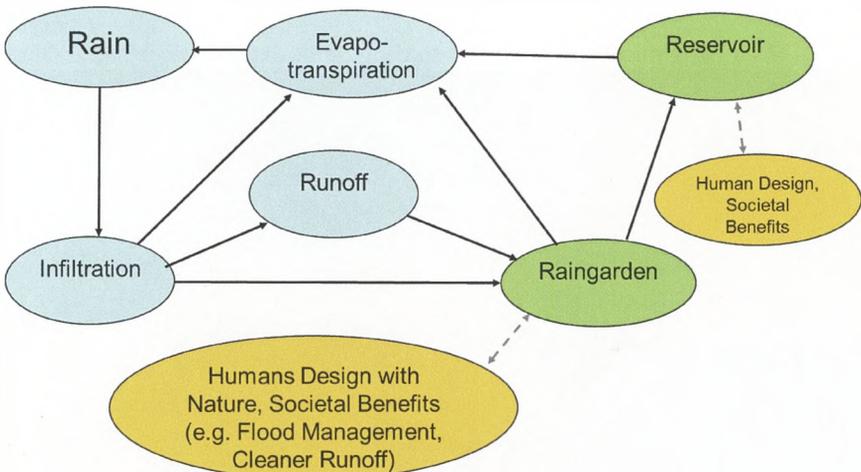


**3a. (above)** NIE raingarden with IoT meteorological station in the foreground.  
**3b. (below)** NIE students conducting infiltration experiments in the NIE raingarden. (Photo by authors)



As noted above, the hydrosocial cycle includes the human element explicitly as part of the hydrologic cycle. Teachers and student teachers in Singapore are well versed in the operation of the hydrologic cycle (Figure 2), but the standard hydrologic cycle might be modified, as in Figure 4, to represent the hydrosocial cycle for the raingarden. This type of hydrosocial cycle modification could be done for any WSUD, or water management structure, such as a reservoir. We acknowledge that our WSUD interpretation of the hydrosocial cycle is decidedly a “shallow sustainability” approach. It does not consider water and society as one, but as being separate and intimately linked.

**Figure 4**  
*Modified Hydrologic Cycle*



*Note.* Components of the traditional hydrologic cycle (blue ovals) with some type of water resource management structure (e.g., raingarden or reservoir, green ovals), and the social interaction with the hydrologic cycle (tan ovals).

Components of the content, fieldwork, and lecture material noted above were incorporated into a Year 3 ecohydrology and catchment management course. It culminated in an assignment that applied PCSWMM, a deterministic, mathematical model, to deepen the understanding of WSUD benefits and connections to localized flood and water quality management. The first two individual assignments in the class (measuring infiltration rates in the raingarden and estimating evapotranspiration rates from the raingarden using the IoT data) provided input to the final assignment that applied PCSWMM to explore different design and runoff scenarios. PCSWMM, which is based on the U.S. EPA SWMM

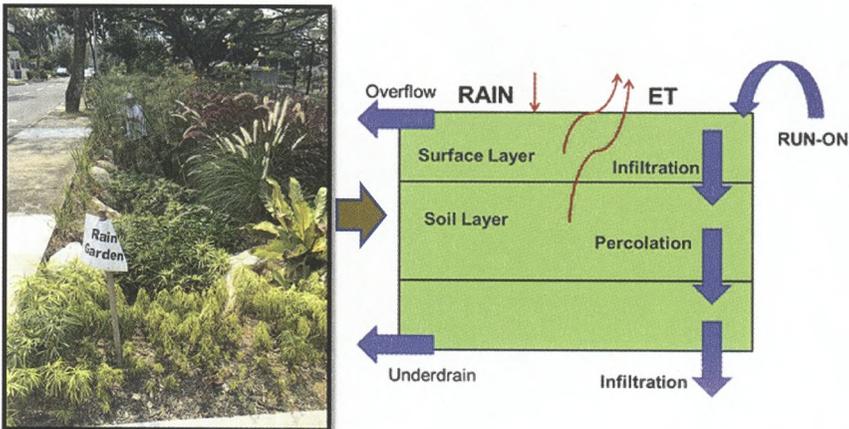
model, is a dynamic, deterministic water quantity and quality model that has been applied extensively around the world (e.g. Ho *et al.*, 2015; Huber *et al.*, 2005; Shrestha *et al.*, 2014). As such, application of PCSWMM within a class assignment provided the students with an authentic learning experience. Model theory and hands on training were provided in the class. The assignment explored different development scenarios:

- 1) What would the runoff from the NIE raingarden catchment area look like prior to construction of the raingarden, when it was only a grassed area?
- 2) What would the runoff from the NIE raingarden catchment area look like after the construction of the raingarden?
- 3) What would the runoff from the NIE raingarden area look like if the raingarden was turned into a parking lot?

This assignment provided the students with experience in visualizing how a mathematical model represents the physical landscape to explore design options (Figure 5), which is most important as it links familiar visual perceptions with the technical aspects of mathematical modelling. In this way we hope to promote a multidisciplinary bridge akin to the classic human-environment investigations in the traditional geography curriculum.

**Figure 5**

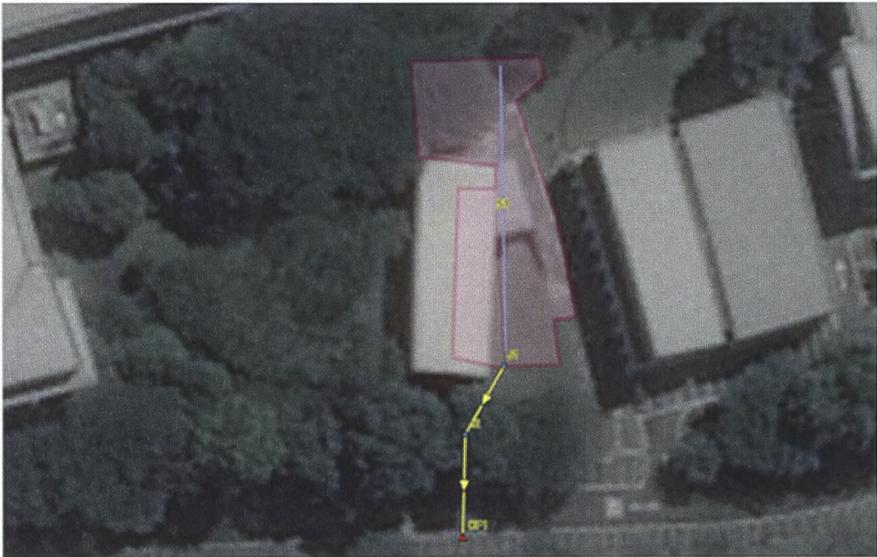
*Faber Park Raingarden and it's Substrates*



*Note.* Faber Park Raingarden, Singapore (left) as it appears visually at street level (photo by authors) and how the raingarden substrates (three layers in this example) and associated hydrologic processes are represented schematically in the PCSWMM model (right).

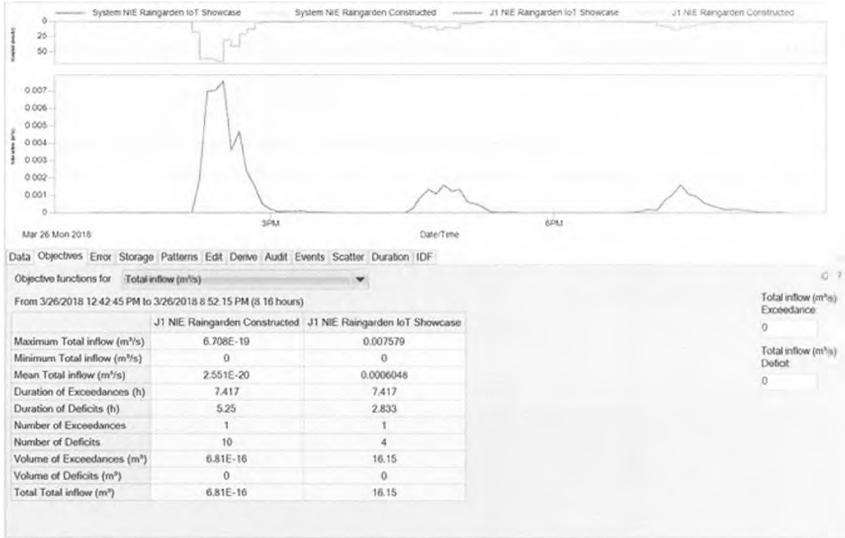
PCSWMM model results for a 40 mm rain event having a peak intensity of 66 mm/hr, as measured at the IoT meteorological station on March 26, 2018, are shown in Figures 6 and 7. To conclude this section, we have connected mathematical modelling with water resources management using the hydrosocial cycle as a theoretical underpinning (Figure 4). If we consider the waterscapes framework in this case study, we see that the general closed loop management and green infrastructure philosophy presented by PUB is implemented at a local scale (NIE campus). This process included flow of capital, policy, and even socio-political relations from outside of the NIE campus. Let us examine a final, larger scale example of waterscape theory in the next section to underscore some of the ideas initiated in this section.

**Figure 6**  
*PCSWMM Model*



*Note:* Plan view of raingarden and catchment area (pink polygon) with underdrain (yellow line) leading to a larger surface drain as represented in PCSWMM.

**Figure 7**  
*PCSWMM Results*



*Note:* PCSWMM results for storm event of March 26, 2018. Rainfall hyetograph from IoT station used as model input is shown in the top graph. Runoff from the area before the raingarden was constructed is shown as the blue line. Runoff leaving the raingarden, after raingarden construction, is shown in the tan line and essentially is not visible compared to the pre-raingarden construction scenario due to raingarden storage.

### Loss of Wetlands, Phnom Penh, Cambodia

In this section we more fully connect the umbrella waterscape concept, including the hydrosocial cycle, within a larger and international spatial scale. This wetland example explicitly underscores the 21<sup>st</sup> century competency focus in the Singapore geography curriculum with respect to data acquisition and interpretation. The 21<sup>st</sup> century competencies of being a concerned citizen who appreciates the interdependency and fragility of the local and global environment and who has a sense of responsibility toward the Earth and its ecosystem also are addressed. This case study has been regularly featured in the AAG40B, Geographies of Sustainability class at NIE.

Phnom Penh, Cambodia does not have a traditional wastewater treatment plant to treat municipal waste. Instead, it relies on a system of naturally-occurring wetlands located in peri-urban regions. A combination of sampling and modelling conducted in the largest of Phnom Penh’s wetlands, Boeng Cheung Ek, over the

past decade has shown that it effectively treats wastewater quality (Irvine *et al.*, 2006; Sovann *et al.*, 2015; Visoth *et al.*, 2010). Boeng Cheung Ek, which traditionally ranges in size from 1,300 ha in the dry season to 2,000 ha in the rainy season, provides a source of food and livelihood for the peri-urban community living on its shores (Ro *et al.*, 2020; Figure 8).

**Figure 8**  
*Wetland Farmers*



*Note:* Wetland farmers offload water spinach for local markets, with their wetland “fields” in the background and the encroaching city in the far background (photo by author, circa 2007)

After emerging from the tragic Khmer Rouge period during which the city was nearly entirely abandoned, development of Phnom Penh has flourished, with the population increasing from 999,800 in 1998 to 1.731 million in 2015. As the city has developed, it has begun to fill in the wetlands that provide wastewater treatment and flood protection services (Loc *et al.*, 2020; Ro *et al.*, 2020). The infilling of Boeng Kak (a smaller wetland in north Phnom Penh) has been highly contested due to the displacement of marginalized communities and the apparent increase of localized flooding from a reduction in storage capacity (e.g., Schneider, 2011). Boeng Cheung Ek appears to be following the course of Boeng Kak. A recently completed 2-lane motorway has longitudinally dissected the wetland and water spinach production areas closest to Phnom Penh are rapidly being displaced by modern housing. Through their modelling efforts Irvine *et al.*

(2015b) were able to show that the motorway construction would negatively impact the wastewater treatment capacity of the wetland, but that it would still function. Further plans for infilling, however, make the future of the wetland uncertain and the question is, development for whom? The large, modern homes certainly are not for the young girl in Figure 9. In many ways, then, this issue underscores the waterscape emphasis on flows of capital (especially foreign investment) from outside of the watershed. It also emphasizes the dynamic nature of the rural-urban continuum and how socio-political relations and policy can impact local community.

**Figure 9**  
*Young Girl Displaced*



*Note:* A young girl from a water spinach farming family examines the infilling sand that recently had displaced her family’s house (photo by author, circa 2011).

Most certainly the situation in Phnom Penh illustrates well Swyngedouw’s (2009) observation that “...interventions in the organization of the hydrologic cycle are always political in nature and therefore contested and contestable.” But it is important in this contestation to consider the entire picture, from water quality to housing; from urban to peri-urban, and how mathematical models might be used to help make informed management decisions. The waterscapes lens encourages this type of inclusive investigative approach.

## Conclusion

The key elements of a waterscape, that it extends beyond the physical boundaries of a watershed to consider the external flows of capital, political relations, and policy that interact with the physical watershed, together with the hydrosocial cycle, can be useful in focusing discussions on human-environment relationships. Certainly, Richard Chorley's observation that the study of water provides a logical link between an understanding of physical and social environments is pertinent to the concept of waterscapes. We have illustrated how PCK within the geography curriculum of Singapore might utilize the concept of waterscapes and the hydrosocial cycle to facilitate an understanding of complex water resource management dynamics. Waterscapes is a concept that is well-suited to teaching and learning about water because it is integrative, offers multiple perspectives, and meets the needs of a robust curriculum on sustainable management of water. Seow *et al.* (2019a) have argued that fieldwork is a type of signature pedagogy for learning geography because it met all the components of a signature pedagogy: (1) the concrete, operational teaching and learning practices employed by teachers; (2) the deep structural understandings they have about knowledge in their subjects; and (3) the professional values, beliefs, and attitudes they have about their craft. Collectively, these dimensions shape the discipline's habits of the "mind" (subject matter) and habits of the "heart" (values) such that when teachers use waterscapes as an organizational concept in class and in the field, they are teaching in a way that is distinctively geographical, considering the human-environment lens (e.g., in the last case study, development for whom?). This human-environment relationship is more easily overlooked in the technically oriented IWRM framework.

Although some may argue that the hydrosocial cycle, in and of itself, should be the framework focus, we believe the overarching idea of waterscapes provides both a broader investigative scope and a more appealing recognition touchstone. We also believe the approach of socio-hydrology, at this point, in trying to mathematically model societal responses deterministically, will be difficult. However, while the waterscapes concept is attractive, certainly in its geographic focus and the possible flexibility in facilitating development of PCK using our proposed "shallow sustainability" approach, it does not seem to have had a particular impact on the broader water resources community. Possibly, the waterscapes concept has not gained traction because frequently a qualitative case study approach has been used in association with a variety of social theories. The case studies are chosen to support the contentions of the researchers and without quantification are not reproducible and can reflect an overt bias towards the "human" side of the argument. In this sense it is analogous to the critical question "this is political ecology but where's the ecology?" (e.g., Walker, 2005). We have shown that mathematical modelling of the physical system and detailed physical and social data collection and analysis can be incorporated into the waterscapes

approach which may be more appealing to hydrologic scientists and engineers, while at the same time addressing social concerns. Botkin and Keller (1998) noted that “When we confuse what we would like to believe with what we have the evidence to believe, we have a weak basis for making critical environmental decisions.” We believe the evidence should include quantification, which is consistent with the 21st century education competencies, but also must be informed and enhanced through the geographic tradition of rich local narratives. As such, we suggest a possible way forward is to take an approach similar to climate change studies. Detailed mathematical modelling is conducted to characterize the physical system, but a more qualitative scenario or ensemble case study approach might be taken to become familiar with societal needs and thereby inform the modelling via an interactive, spiraling investigative approach.

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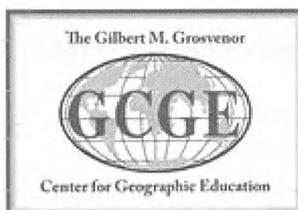
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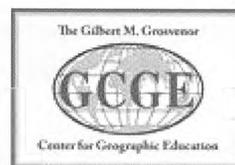
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## The Gilbert M. Grosvenor Center for Geographic Education

*Texas State University*



The Gilbert M. Grosvenor Center for Geographic Education has been established to provide leadership in the movement to increase the quality of geographic education in America's schools, at all levels. This will be accomplished by innovative activities related to how students and the general public learn geography. Through these efforts, changes in public policy will be manifested that will elevate the importance of geography in American society, as well as the educational system.

The name of the Grosvenor Center is designed to honor the vast contributions that Gil Grosvenor and the National Geographic Society have made in advancing the national reform movement in geography. As Grosvenor points out: *As the world grows smaller and more interdependent daily, our country's future absolutely depends on our ability to see the connections between ourselves and our global neighbors.*

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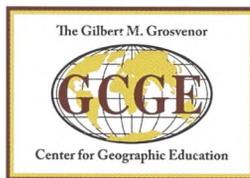
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