EVALUATION OF ALTERNATIVE FUTURE SCENARIOS OF SASKATOON'S NORTHEAST SWALE TO DEVELOP AND ADVANCE AN ECOSYSTEM SERVICES-BASED SEA FRAMEWORK

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Abstract

Rapid urbanization gives rise to development pressures on natural areas, posing threats to urban ecosystems and ecosystem services. The relationship between development pressures and ecosystem services is challenging to realize quantitatively, as urban land use plans rarely integrate the intrinsic values of ecosystem services or consider the implications of development actions on ecosystem services. Ecosystem services-based environmental assessment and urban planning are receiving increased attention, but there remains a need for future-oriented and scenario-based approaches to the consideration of ecosystem services in urban land use planning, with the demonstrated application. This research advanced an ecosystem services-based strategic environmental assessment framework and applied the framework to evaluate the ecosystem services of an urban natural area under current and future land-use scenarios.

The study area is Saskatoon's Northeast Swale, a 26-kilometer-long ecological corridor that provides important ecosystem services like biodiversity, stormwater storage, recreational and educational opportunities, and scenic amenities. Currently, the Northeast Swale is subject to the cumulative stress of a growing city, including residential expansion, stormwater drainage, habitat fragmentation, and a freeway, many of which do not trigger any regulatory impact assessment. The research methods included a review of planning documents, interviews with stakeholders to identify priority ecosystem services, and a survey-based choice experiment to evaluate ecosystem services under alternative land use scenarios. Four swale attributes were used as ecosystem service proxies to estimate the value of those attributes under alternative future land use scenarios and to identify a preferred future based on residents' values for ecosystem services.

The key findings suggest that the swale's ecosystem services are important to local residents and residents are concerned about the negative impacts of current and future development actions on the Northeast Swale. As a result, the land use attributes hold considerable monetary value and residents prefer a future upholding robust protection of ecosystem services of the Northeast Swale, including conserving wetland area, minimizing use disturbance, and restricting new residential development. The monetary estimates of ecosystem services derived from this research will help in making informed decisions on the conservation of the Northeast Swale. For city planners, conservation authorities, and land developers, this research provides an important baseline for assessing impacts of development actions on ecosystems and environmental amenities, for making informed decisions on land-use trade-offs and future planning priorities, and for identifying viable mitigation options.

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Dedication

To Abbu, Ammu and Shohag

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List of Acronyms and Abbreviations

AONB	Area of Outstanding Natural Beauty
CBD	Convention on Biological Diversity
CCME	Canadian Council of Ministers of the Environment
CL	Conditional Logit
CREATE	Collaborative Research and Training Experience
CS	Compensating Surplus
DAC	Development Assistance Committee
defra	Department for Environment, Food & Rural Affairs
EA	Environmental Assessment
EBA	Ecosystem Based Approach
EIA	Environmental Impact Assessment
ES	Ecosystem Services
ESP	Ecosystem Services Partnership
GIS	Geographic Information System
IA	Impact Assessment
IAIA	International Association for Impact Assessment
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
LC	Latent Class
LIFE VIVA Grass	Integrated planning tool to ensure viability of grasslands
MaxEnt	Maximum Entropy modelling software
MEA	Millennium Ecosystem Assessment
ML	Mixed Logit
MVA	Meewasin Valley Authority
MWTP	Marginal Willingness To Pay
NE	Northeast
NGO	Non-government Organization
NSERC	Natural Sciences and Engineering Research Council

NSW	Northeast Swale Watchers
OECD	Organization for Economic Co-operation and Development
PPP	Policy, Plan and Program
RSEA	Regional Strategic Environmental Assessment
RUM	Random Utility Maximization
SEA	Strategic Environmental Assessment
SEEA	System of Environmental-Economic Accounting
SSRL	Social Science Research Lab
STATA	Software for Statistics and Data Science
TEEB	The Economics of Ecosystems and Biodiversity
UK	United Kingdom
UK-NEA	UK National Ecosystem Assessment
UN	United Nations
VOXCO	Survey Software & Online Tools for Data Collection

Chapter 1: Introduction

Approximately 30% of the world's population lived in urban areas in 1930, increasing to 54.4% in 2015, with a projection of 66.4% by 2050 (United Nations, Department of Economic and Social Affairs, Population Division, 2015). This rapid rate of urbanization poses potential changes in urban land-use and can pose unprecedented threats to ecosystems and ecosystem services (Bezák and Lyytimäki, 2011; Chan et al., 2006; Dupras and Alam, 2014; Foley et al., 2005; Slootweg et al., 2010). Ecosystem services (ES) are the benefits obtained from healthy, functioning ecosystems (MEA, 2005). The global community is discerning the importance of the conservation of ES for more than a decade from the UN Millennium Development Goals (MDG) to the 2030 Agenda for Sustainable Development. The emerging agenda of true integration of environment into development ambitions from the MDG (United Nations, 2015) became more specific in Goal 15 of the 2030 Agenda for Sustainable Development, stipulating the conservation of biodiversity and ecosystems (Sustainable Development Goals, n.d.). MEA (2005) and TEEB (2010) have complemented this global concern through identifying the extensive trend of ES exploitation over the past 50 years and mainstreaming the value of ES into decision-making respectively. Subsequently, several global communities i.e. CBD (https://www.cbd.int/), ESP (https://www.es-partnership.org/), IPBES (https://ipbes.net/), UK-NEA (http://uknea.unep-wcmc.org/Default.aspx) and research initiatives i.e. Natural Capital Project (https://naturalcapitalproject.stanford.edu/), SEEA (https://seea.un.org/) are upholding and enhancing the ES concept for conservation and sustainable development. Canada is concurring to this global agenda through the 2020 Biodiversity Goals and Targets for Canada (https://biodivcanada.chm-cbd.net/).

Though studies have shown that urban land-uses adversely affect ES, managing the relationship between urban land-use pressures and ecosystems remains a challenge for planners and policy makers (Dupras and Alam, 2014; Gómez-Baggethun et al., 2013). The relationship between urban land-use pressure and ES is intriguing as land-use trade-offs are decided based largely on economic indicators, and the value of ES are often ignored because of not having any direct market value (Costanza et al., 1997; Dupras and Alam, 2014). The concept of valuation of ES in a global perspective has received widespread attention, largely attributed to the work of Costanza et al. (1997). Though ecosystem valuations have been done in different geographical contexts and scales (Daily et al., 2009; Dupras and Alam, 2014), values for the ES can vary across social and institutional settings (TEEB, 2010). Local ecosystems in particular can have substantial impacts on the quality of life in urban areas (Bezák and Lyytimäki, 2011; Bolund and Hunhammar, 1999; Gómez-Baggethun et al., 2013; Haase et al., 2014; Wurster and Artmann, 2014). The dynamic interaction between humans and ecosystems intensifies in urban areas as demands for ES increase (Artmann et al., 2017). Local, and context-specific, quantitative comprehensive assessments of ES are thus of most value to land use policy and planning decisions, but the challenge remains to prove the validity of ES approaches in urban planning (de Groot et al., 2012; Hansen et al., 2015).

Strategic environmental assessment (SEA) is a systematic approach to consider the environment in decision-making at the early stages of land use policy and planning (Dalal-Clayton and Sadler, 2012; Noble, 2015). The integration of ES in SEA has been receiving global attention recently as land use decisions are having increasingly significant impacts on ecosystems. The intensive demand for ES in urban areas accentuates the necessity to manage such services through improved urban land use planning. As many development activities in urban environments do not trigger regulatory assessment, ES-based SEA can be a valuable tool for the future planning of urban ecological regions with better consideration of ES in land use planning and decision-making. However, the pragmatic application of ES-based SEA, especially in urban land use planning contexts, is limited. There are emerging frameworks of ES-based SEA; valuation techniques for ES in land use decision-making for SEA have been proposed in several literature (Geneletti, 2011; Honrado et al., 2013; Slootweg, 2016) and practiced ad-hoc in several countries. However, there are limitations in the selection of ES valuation methods for SEA, engaging stakeholders and beneficiaries in the decision-making process, and future-based assessments.

Planning authorities i.e. city planners, conservation authorities and land developers need baseline information about ES, and some understanding of future changes in ES values as land uses and development pressures change in order to assess and manage potential environmental threats to natural areas in urban environments (Preston and Raudsepp-Hearne, 2017). However, ES values derived from urban ecosystems are poorly understood, and urban land use plans often provide limited baseline information on ES. Moreover, current land use planning processes, particularly urban land use plans, rarely integrate future-based assessments of 'what if' scenarios (Haase et al., 2014; Westbrook and Noble, 2013). As a result, the implications of future land uses on ES values are also poorly understood. Identification and valuation of available ES and considering these values to assess future alternative development scenarios will help planners to adopt viable land use development plans and mitigation strategies that protect ES.

1.1. Purpose and objectives

The purpose of this research is to advance a strategic environmental assessment framework for the evaluation of ES under current (baseline) and future land use scenarios. The context for this research will be Saskatoon's Northeast (NE) Swale, which is a 26 km long ecologically rich corridor connecting native prairie uplands, riparian and wetlands in a rapidly growing urban environment (Gersher et al., 2016). The NE Swale is home to federally and provincially listed rare and endangered species (Grilz, 2016). The NE Swale is also under increasing pressure due to the cumulative impacts associated with past, present, and planned residential expansion, stormwater drainage, habitat fragmentation, and the construction of a north commuter parkway and provincial perimeter highway (Gersher et al., 2016). Many of these physical activities do not trigger any federal or provincial regulatory assessment (Sizo et al., 2016a; Westbrook and Noble, 2013).

The objectives of this study are as follows:

i. To identify and classify existing ES of the NE Swale.

ii. To determine baseline non-market values of ES.

iii. To assess the implications of alternative development scenarios on ES values.

This research is a part of a broader research project advancing an ES-based SEA framework. This research provides the methodological description of the ES-based SEA framework application, baseline information, assessment of data, and the information to support land use decision-making.

1.2 Thesis organization

This thesis is presented in six chapters including the Introduction chapter. Chapter 2 presents the background literature on ES, consideration of ES in urban land use planning, the role of SEA as an ES-based planning tool, and the gaps in existing ES-based literature and practices. Chapter 3 provides a brief description of the study area followed by a detailed description of the methods used for the identification and valuation of ES along with the methodological limitations of this approach. Chapter 4 presents the empirical results of the ES-based SEA application along with the futures assessments. Chapter 5 discusses the results of this research along with the implications of adopting an ES-based framework for SEA in urban contexts. Chapter 6 presents the conclusion, key research contributions, limitations of this research, and future research directions.

Chapter 2: Literature Review

To understand the current approaches of ES-based planning and decision-making in urban contexts, a review of the existing literature is presented in this chapter. This chapter will first present a brief description of definitions, classification systems, and the importance of ES followed by the process and context of consideration of ES in urban land use planning. Then, the viability of using ES-based environmental assessment in urban planning is introduced along with the gaps in current research and understanding.

2.1 Ecosystem services

The concept of ES has gained considerable attention since the 1990s. Chronological evolution of the widely adopted definitions of ES are collated in Table 2.1. All these definitions tend to emphasize the anthropogenic nature of ES - i.e. ecosystem processes, functions or goods can be termed as services only if there are humans to benefit from them. The definition of ES presented by the MEA (2005) now perhaps the most widely accepted definition, and adopted in subsequent literature; Fisher et al. (2009), for example, draw on the MEA definition and differentiate between services and benefits to facilitate environmental accounting, as followed by TEEB (2010) and Haines-Young and Potschin (2018).

Table 2.1: Chronological advancement of the definitions of ES

Source	*Definition*
Daily (1997)	Ecosystem services are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life.
Costanza et al. (1997)	Ecosystem services represent the benefits human populations derive, directly or indirectly, from ecosystem functions.
MEA (2005)	Ecosystem services are the benefits people obtain from ecosystems.
Boyd and Banzhaf (2007)	Ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being.
Fisher et al. (2009)	Ecosystem services are the aspects of ecosystems utilized (actively or passively) to produce human well-being.
TEEB (2010)	Ecosystem services are the direct and indirect contributions of ecosystems to human well-being.
Haines-Young and Potschin (2018)	Ecosystem services are the contributions that ecosystems make to human well-being, and distinct from the goods and benefits that people subsequently derive from them.

Similar to the definitions of ES, classification systems have also evolved through several works of literature. The classification of ES proposed by MEA (2005) has been used by most subsequent studies (e.g. Bateman et al., 2011; Crossman et al., 2013; Gómez-Baggethun et al., 2013; Haase et al., 2014) (see Table 2.2). MEA (2005) classified ES in four categories: provisioning, regulating, supporting, and cultural. Various adaptations of this classification have since been presented in the literature. Slootweg and van Beukering (2008), for example, suggested two more classes recognized by the scientific community, namely “carrying” services, providing “a substrate or backdrop for human activities”, and “preserving” services, which includes “guarding against uncertainty through the maintenance of diversity”. TEEB (2010) replaced supporting services with habitat services - i.e. maintenance of life cycle and maintenance of genetic diversity. Maynard et al. (2015) adopted three (provisioning, regulating, and cultural services) of the four MEA services to avoid double counting. Haines-Yong and Potschin (2018) removed “supporting services” from this classification system and changed “regulating services” to “regulation and maintenance services,” defined as “all the ways in which living organisms can mediate or moderate the ambient environment that affects human health, safety or comfort.”

Table 2.2: Conventional classification of ES (Source: MEA, 2005)

Category	*Definition*	*Services provided*
Provisioning Services	The material products obtained from ecosystem	Food, raw materials, fresh water, medicinal plants, wood and fiber, fuel.
Regulating services	Benefits obtained from ecosystem functions and processes	Climate regulation, carbon sequestration and storage, air quality, moderation of extreme events, regulation of air temperature, soil quality and fertility, storm water management, flood regulation, waste water treatment, erosion control, pest control, groundwater recharge, disease regulation, water purification.
Supporting services	Services necessary for production of other ecosystem services	Wildlife habitat, maintenance of genetic diversity, biodiversity, pollination, soil formation, photosynthesis, nutrient cycling, primary production.
Cultural services	Non-material, socio-ecological and psychological benefits	Recreation, aesthetic appreciation, spiritual experience, mental and physical health, tourism, public ecological knowledge, inspiration for culture, art and design, sense of place, social cohesion.

Some of the ES incorporated in MEA (2005) are ecosystem processes or functions (e.g. nutrient cycling), and some are final services (e.g. water regulation). In response, Fisher et al. (2009) suggested separation of immediate services (e.g. nutrient cycling), final services (e.g.

water regulation), and benefits (e.g. drinking water) to avoid double counting of ES when undertaking planning or valuation studies. Dias and Belcher (2015) used ecological endpoints for valuation - e.g. width of the riparian zone, change in water quality, etc., as they are more meaningful to individuals and tangible to perceive. The diversity of approaches suggests that the classification of ES needs to be adapted according to the environmental and socio-economic characteristics of the specific type of ecosystem and the decision context at hand (Fisher et al., 2009; Gómez-Baggethun et al., 2013; Haines-Yong and Potschin, 2018; Notte et al., 2017).

2.2 Consideration of ES in urban land use planning

The concept of ES is gaining attention in urban land use planning literature as a heuristic tool and is still evolving to be adapted in practice from literature (Hansen et al., 2015). There is a complex relationship between urbanization and the natural environment; urban residents depend on local biodiversity and ES for supporting health and well-being as urban areas continue to grow, and urban development negatively affects biodiversity and fragments natural habitats (Seto et al., 2013). Urban growth motivates land-use changes, often causing loss of sensitive natural areas and fragmentation of ecosystems which may have negative impacts on the quality and quantity of ES (Dupras and Alam, 2014; Geneletti, 2011; Kepner et al., 2012).

Urban ES are the range of benefits to sustain and improve human livelihood and the quality of life provided by green and blue spaces in urban areas (Gómez-Baggethun et al., 2013; Grêt-Regamey et al., 2013; Haase et al., 2014). The expansion of the physical extent of urban areas encroaching adjacent ecosystems constrains the ability to conserve and protect urban ES (Seto et al., 2013). In this context, the trade-off between urban densification and the natural environment is a growing challenge for urban land use planning (Artmann et al., 2017; Seto et al., 2013). To address this challenge, ES-based approaches are being introduced to integrate ecological knowledge into land use planning practices in urban areas (Niemelä, 1999). Urban planning based on an ES framework can improve understanding of the consequences of planning actions in urban socio-ecological systems (BenDor et al, 2017; Niemelä et al., 2010). While the concept of incorporating ES in urban planning is prevailing, the scholarly works encompass various planning domains – e.g. land use planning (BenDor et al., 2017; Daily et al., 2009), urban planning (Grêt-Regamey et al., 2013; Hansen et al., 2015), and urban ES assessment (Haase et al., 2014; Sieber and Pons, 2015; Wurster and Artmann, 2014). As demand for ES intensifies in urban areas (Elmqvist et al., 2015), the anthropocentric perspective of human dependency on nature is recommended to be embedded in urban planning (Hansen et al., 2015). Elmqvist et al. (2013) therefore emphasized the importance of identifying people's preferences for urban ES, and BenDor et al. (2017) suggested assessing outcomes of plans with and without ES incorporated through quasi-experimental design to improve planning outcomes.

The concept of economic valuation of ecosystems has existed since the 1960s and captured widespread attention in the 1990s to raise public interest in biodiversity conservation (Braat and de Groot, 2012). Valuation of ES, i.e. expressing the value in monetary terms, is an estimate of the benefits of an ES to society that would be lost if the service were to be destroyed (de Groot et al., 2012). As most planning and development decisions are made on economic grounds (Barbier et al., 1997), a challenge to considering ES in the decision-making process is the absence of a conventional marketplace for many ES (Champ et al., 2014; Costanza et al., 1997; Dupras and Alam, 2014). The valuation of ES can still provide the insights necessary to make pragmatic development decisions and cost-effective policy implementation (Broekx et al., 2013). In other words, quantifying the values of ES associated with a specific habitat can be useful in resource management and mitigation of the effects of anthropogenic actions (Grabowski et al., 2012).

Valuation of ES can be a projection of the consequences of the choices regarding environmental use and an instrument to provide feedback on the impacts of current or potential land-use decisions and trade-offs on human welfare (Daily et al., 2009; de Groot et al., 2012; Dupras and Alam, 2014; TEEB, 2010). To be more specific, valuation of ES can be used as a tool to simplify and strengthen transparent, rational and engaged decision-making on the implementation of land use interventions, and guiding policymakers to devise informed decisions (Barbier et al., 1997; Daily et al., 2009; Dias and Belcher, 2015; Slootweg and van Beukering, 2008). For urban land use planning, Bolund and Hunhammar (1999) discuss the methodological potential of identification and valuation of ES as an input to cost-benefit analysis. Geneletti (2011), Kumar et al. (2013), Partidário and Gomes (2013), Preston and Raudsepp-Hearne (2017), Ranganathan et al. (2008), Slootweg and van Beukering (2008), and TEEB (2010) have also recommended identification and valuation of ES to enhance decision making at regional policy and plan preparation level. Identification of marginal values of ES is viable in urban contexts, as the supply of ES can be scarce in urban areas (Braat and de Groot, 2012). However, the selection of appropriate methods for the valuation of ES is complex; methods of valuation need to be selected based on finances, data, time, and skill (Gómez-Baggethun et al., 2013; Slootweg and van Beukering, 2008). A combination of different methods i.e. applying both market and non-market based methods is the most practiced way for the valuation of ES (Bateman et al., 2011; de Groot et al., 2012; Dupras and Alam, 2014; Haase et al., 2014; Slootweg and van Beukering, 2008). To improve the economic valuation of ES by incorporating anthropogenic interpretations, TEEB (2010) and Haase et al. (2014) proposed a multidimensional approach to capture socio-cultural perspectives on ES. BenDor et al. (2017) further emphasized using ecological information, stakeholder's participation, and consideration of ES trade-offs as principles of ES frameworks to improve the adaptation of ES valuation in planning practice.

2.3 Role of impact assessment as a tool for integrating ES in urban land use planning

Strategic environmental assessment is a globally recognized systematic approach to integrate environmental considerations into policy, plan, and program (PPP) development and decision-making (Dalal-Clayton and Sadler, 2012; Noble, 2015; Partidário, 1999; Schmidt, et al., 2006; Therivel, 1993). SEA provides a methodological framework for considering the environment in the early stages of PPP development to identify desired future land use outcomes (CCME, 2009; Sizo et al, 2015). Environmental impact assessment, on the other hand, is a regulatory assessment tool usually focused at the project level to identify and mitigate the effects of future consequences of individual development actions prior to the commitment being made (IAIA, 1999). Although SEA is sometimes considered as an upstream version of EIA (Fischer and Onyango, 2012; Partidário, 1999; Noble and Storey, 2001; Therivel, 1993), the context and objectives of SEA are much broader, focused on strategic actions at early stages of planning where substantially different futures or options are still available (Dalal-Clayton and Sadler, 2012; Noble, 2015). SEA is thus a pro-active tool to inform the planning process from the beginning, so future development actions are approached based on SEA outcomes (Slootweg, 2016). SEA is typically envisioned as an integrated future-oriented assessment tool for exploring trade-offs between environmental and socio-economic impacts (Gunn and Noble, 2009; Therivel and Partidário, 1996).

ES-based SEA provides an opportunity to integrate ES in land use planning (Geneletti, 2011; Honrado et al., 2013; Slootweg, 2016). Unforeseen human actions can induce anthropogenic drivers of changes, causing rapid strain on ES and jeopardizing their benefits (Landsberg et al., 2013). The ES approach is thus cogent to enhance current SEA processes and to minimize damage through upfront assessment of both the impacts and dependencies of alternative land use actions on ES (Jacob et al., 2016). The concept of ES could bring added value to SEA processes in urban contexts, through making the process more understandable to stakeholders by focusing on the benefits they derive from healthy and functioning ecosystems, by reinforcing the importance of understanding ES to well-informed strategic decision making for urban land use (Slootweg and van Beukering, 2008; Karjalainen et. al., 2013), and increasing the consideration of socio-economic aspects in impact assessment (Baker et al., 2013; Landsberg et al., 2013; Partidário and Gomes, 2013). These benefits can be ensured, in part, by a participatory, bottom-up approach that considers the ES triggers, drivers of change, and a scenario-based approach (Slootweg, 2016). Carpenter et al. (2006), IPBES (2016), and Geneletti (2011) further emphasized the importance of future scenario analysis in policy support for the conservation of ES.

In the Canadian context, the national cabinet directive for SEA implicitly incorporates ES concepts, but SEA application to regional planning is still not widely practiced (CCME, 2009). While the incorporation of the ES concept in Canadian environmental law is scant, practical application of ES concept in decision-making is highly inadequate (Pastén et al, 2018). Under this circumstance, there is also no national-level assessment framework available for ES protection in urban land use planning. Some regional plans are available for specific areas or sub-regions of some provinces (OECD, 2017), but rarely are ES front and center – the focus is typically on individual environmental components. Thompson et al. (2019) found that explicit use of ES concept is rare in Canadian municipal plans, mostly implicit references of ES-related planning terms. However, ES tools and applications are advancing (Preston and Raudsepp-Hearne, 2017), but methodological guidance on how best to incorporate ES in SEA design is only beginning to emerge. The *Ecosystem Services Toolkit* is a combined federal-provincial-territorial initiative to guide the use of ES assessment in Canada introduced in 2017 (Preston and Raudsepp-Hearne, 2017).

Several researchers have proposed methodological frameworks for considering ES in both EIA and SEA (Table 2.3), emphasizing the identification and prioritization of ES, identification of stakeholders, mapping and valuation of ES, assessment of strategic options, and guidelines for monitoring and follow-up (Partidário and Gomes, 2013; Slootweg, 2016). The OECD DAC SEA guidance recommended consideration of ES if the influenced area provides valued ES and/or the PPP involves direct or indirect drivers of change (Hobbs et al., 2008). However, most of these frameworks are conceptual and lacking demonstrated application. The challenge of transferring the concept to practice at regional or local scales remains (Haase et al., 2014). To understand the implications of ES based SEA frameworks in practice, evidence-based applications are essential. Some case studies are synthesized in Table 2.4 to convey the rationale and the outcomes of different ES based approaches – especially at the strategic level. Review of the case studies vividly renders the scope of an ES-based approach in SEA e.g. plan or policymaking, rather than EIA, and the urgency of a precise methodology to achieve desired objectives. Engaging stakeholders in the SEA procedure has been proven effective in the case studies of Portugal (Baker et al., 2013) and South Africa (eThekwini Municipality, 2011). Geneletti (2013) and Ruskule et al. (2018) also emphasized the necessity to combine trade-offs between different beneficiary groups.

Table 2.3: ES based IA frameworks proposed by different countries/organizations

Concept	*Context*	*Country/Organization*	*Source*
Introduction to the valuation of ecosystem services	Both in EIA and SEA	UK	defra (2007)
Integrating ecosystem services in SEA	SEA	OECD DAC Member Countries	Hobbs et al. (2008)
Valuation of Terrestrial Ecosystem Services	Both in EIA and SEA	Belgium	Fontaine et al. (2013)
Ecosystem Services in Environmental Assessment (ESEA) framework	Both in EIA and SEA	Portugal	Honrado et al. (2013)
Ecosystem Services Review for Impact Assessment (ESR for IA) framework	Environmental and Social Impact Assessments (ESIAs)	World Resources Institute (WRI)	Landsberg et al. (2013)
Methodological framework on ES inclusive SEA	SEA	Portugal	Partidário and Gomes (2013)
Integrating ecosystem services in SEA	SEA	United Nations Environment Programme (UNEP)	Geneletti (2014)
Mainstreaming ecosystem services into SEA	SEA	Comprehensive	Geneletti (2016)
Ecosystem Services Assessment Toolkit	Both in EIA and SEA	Canada	Preston and Raudsepp-Hearne (2017)
Incorporating ES into EIA process	EIA	USAID	USAID (2018)

Table 2.4: Case studies on ES based environmental assessment

Case Study	*Country*	*Context*	*Objective*	*Rationale of ES use*	*Method*	*Remarks*	*Source*
Birmingham City Council non statutory Green Living Spaces Plan (2014)	Birmingham, England	Spatial planning	To develop an approach for green infrastructure strategy.	To consider health, well-being and global climate change in city's network of green and blue infrastructures.	National Ecosystem Assessment (2011) methodology used including GIS mapping for ES assessment of green infrastructures.	Barriers include individual and institutional inertia.	Birmingham City Council (2013)
Cotswolds AONB Management Plan (2018-2023)	Cotswolds, UK	SEA	To enhance natural beauty, enjoyment and socio-economic well-being of local community.	ES is included as a crosscutting policy theme of the SEA.	Policy compatibility and consistency matrix is developed by professional judgement and tested the proposed and 'do nothing' scenario.	Little information was presented on water, air quality and climate change.	Craggatak Consulting (2018)
eThekwini Municipality SEA methodology Development (2009-2011)	Durban, South Africa	SEA	Spatial development plans (SDPs) strengthening sustainability considerations.	Using ES for more than 10 years in environmental reporting and monitoring support system.	Multi-criteria approach based on quantitative and qualitative valuation of ES by stakeholders or expert judgement.	The approach was accepted positively being broad sustainability-based SEA.	eThekwini Municipality (2011)
Flood Risk Management Strategies (2016-2021)	Scotland, UK	SEA	To identify and evaluate the effects of flood risk management strategies and their alternatives.	To take account of the human dependency on ES as management actions will affect provision of ES.	Identified and classified potential effects of non-structural actions on ES with mitigation measures.	The relationship between SEA topics and ES was not clearly defined and the assessment was based on expert judgement.	Scottish Environmental Protection Agency (2015)

Flood Management Plan of Napa River	California, USA	Conservation Planning	Reduction of flood damage and watershed management with environmental restoration.	Identified as an alternative plan to eliminate damaging effects on environment, loss of habitats and degradation of water quality.	A civic group, involving all the stakeholders and residents, formulated the plan to sustain river ecosystem with flood protection.	The plan was highly appreciated because of comprehensive approaches and stakeholder's participation.	Almack (2010)
Great Western Development Strategy (GWDS)	China	SEA	Boosting development of the western area and narrowing the economic gap between the western and eastern parts of China.	To explore both direct and indirect environmental impacts from the key development plans and activities.	Composed of an assessment matrix, incorporation of expert judgment and trend analysis.	Constructing a ground rule for participation of all stakeholders at the beginning is critical. SEA capacity below the provincial level was weak.	Li et al. (2012)
Heysham to M6 link road	Lancashire, UK	EIA	EIA of a trunk road development project using ecosystem-based approach (EBA).	To identify robust decisions promoting conservation and sustainable use of special protection area.	The study followed the EBA guidelines of CBD (2012).	The study concluded that EBA should be a planning framework rather than assessment technique.	Ashworth et al. (2007)
Integrated Coastal Zone Management (ICZM)	Portugal	SEA	Planning and management of the maritime space and conservation of marine and coastal biodiversity.	Value of biodiversity and ES were relevant for the policy objectives.	Comparison of ES related policy options through key policy stakeholders rather than detailed analysis and assessment of existing ES.	The approach was considered helpful and effective in policy development and identification of alternative management options and strategies.	Partidário (2010)

Kamehameha Schools Land use plan	Hawai`I, USA	Land use planning	To design and implement a plan that balance environmental, economic, cultural, educational, and community values.	Used as an innovative approach to fulfill their mission and to comply with the sustainable development initiatives.	Used InVEST software to evaluate impacts of alternative futures of agricultural lands.	Cultural services were not assessed quantitatively in this analysis, thus was not considered directly.	Goldstein et al. (2010)
Land-use zoning policy	Araucanía region, Southern Chile	SEA	Exploring effects of implementation of alternative land-use zoning policies on future provision of ES.	For practical integration of ES in spatial planning and decision-making.	Method includes construction of land use scenarios in GIS, InVEST and MaxEnt for modelling ES and development of metrics for scenario comparison.	The study concluded that a conceptual framework combining socio-economic variable and analysis of trade-offs of different beneficiary groups is needed.	Geneletti (2013)
LIFE Viva Grass Project	Baltic countries	Integrated planning	To develop an integrated planning tool to provide spatially explicit decision support for landscape, spatial planning, and sustainable grassland management.	To support the maintenance of biodiversity and ES provided by grasslands and economically viable grassland management.	Base map of land use and supporting natural conditions, look-up table (matrix) of ES assessment and resulting spatial visualization of ES bundles in distribution maps.	One of the challenges was the need to adapt to different planning scenarios and contexts, as well as meeting the needs of different stakeholder groups.	Ruskule et al. (2018)

Metropolitan Glasgow Strategic Drainage Partnership (MGSDP) Implementation Plan (2002)	Glasgow, Scotland	SEA	Planning of sustainable urban drainage system with approach of conveying water in underground pipes and surface.	To enhance the surface water retaining capacity of the landscape and reduce pressure on the underground drainage network, provision of ES is enhanced.	An ES based SEA methodology was used considering impacts on ecosystem functions and ES provision including a green infrastructure master plan and network analysis.	The plan was appreciated for understanding of environmental impacts and effective mitigation and was criticized for lack of assessment of potential effects on climate change and historic issues.	Baker et al. (2013)
Pilot Land Use Strategy (2013-2015)	Scottish Borders and Aberdeenshire	SEA	To produce a practical regional land use framework integrating land management for making best use.	To explore the environmental implications of the land use scenarios, ES is used as SEA topics.	Identified land use opportunities along with baseline mapping for environmental assessment.	Implementation did not include policy requirements; intended to be educative or a guide to assist land use decision makers.	Scottish Borders Council (2014)
Staffordshire Ecosystem Assessment	Staffordshire county, England	Strategic planning	To enable effective partnerships to improve decision-making based on green environment.	To consider economic value of benefits of natural environment in decision-making.	UK National Ecosystem Assessment (UK NEA) framework used.	Challenges include limitations and complexity of method used.	Hölzinger and Everard (2014)
Wareham Managed Re-alignment (UK)	UK	EIA/SEA	Incorporating economic values of ES related to flood and coastal management in traditional environmental assessment practice.	ES relevant to reducing coastal erosion and flood risk was considered to explore natural flood management strategy.	Value transfer method for economic valuation of ES and traditional cost benefit analysis.	Demonstrated limitations in using valuation of ES in decision-making because of unpredictable nature of physical changes and socio-economic context.	defra (2007)

2.4 Research gap in ES-based SEA approach

The impacts of urban development decisions on ecosystems and biodiversity are distinctly noted in diverse studies but integrating this information into strategic-level assessment practice and land-use decision making is inadequate (BenDor et al., 2017). There has been limited empirical application in planning and decision-making processes and fewer tools to support ES consideration at the strategic level of futures-based planning (BenDor et al., 2017; Cortinovis and Geneletti, 2018; Haase et al., 2014; Broekx et al., 2013). There is a substantial gap in the research on providing practical, demonstrated guidance for practitioners on the incorporation of ES in urban planning (Thompson et al., 2019). Slootweg (2016) has identified 'unwillingness', 'silo thinking', and an 'ineffective science-policy interface' as the main causes of limited uptake of ES concept in strategic, futures-based planning. The concept of ES in environmental planning and SEA is still at a rudimentary level and lacking proper guidance and implementation (Honrado et al., 2013).

Another confounding problem is that most frameworks for the ES approach are missing the engagement of stakeholders and social value integration (BenDor et al., 2017; Bezák and Lyytimäki, 2011). Woodruff and BenDor (2016) suggested the engagement of community members in future ES-based planning to understand community preferences, to capture the variation in values, and to display development trade-offs. The widely used monetary valuation techniques are also insubstantial because of the inapplicability of a single valuation tool in all aspects and methodological uncertainties (Pandeya et al., 2016; Schmidt et. al., 2016). The understanding of linkages between landscape and socio-cultural values of ES is under-developed and needs to be incorporated with the monetary valuation in a more pragmatic way (Schmidt et al., 2016; Zoderer et al., 2016). BenDor et al. (2017) thus call for modification of present frameworks or the development of a new framework to examine how planning can better integrate ES information in land-use decision making. What is needed is an integrated and participatory SEA tool for assessing and demonstrating the effects of policies and plans on ES and identifying and weighing the trade-offs between ES under different land use and planning scenarios (Broekx et al., 2013; Pandeya et al., 2016).

Chapter 3: Research Methods

ES should be considered in the early stages of urban land use planning and decision-making. Since ES include benefits to people, it is important to understand the perspectives of urban residents toward ES, the effectiveness of current city planning for protecting ES, awareness about future development plans, and the perceived implications of development plans. This chapter describes the methodology of the ES-based SEA framework along with data collection methods. First, a description of the study area is presented followed by a description of survey design and data collection. Finally, the econometric models for data synthesis and the limitations of the survey design are described.

3.1 Study area description

The Meewasin NE Swale is a 26-kilometer-long ancient post-glacier corridor extending north from Peturrson's Ravine, Saskatoon, to the rural municipality of Aberdeen, encompassing 2,800 hectares of land (Gersher et al., 2016). A 5 kilometer-long section of this greater swale, encompassing 300 hectares of land, falls within Saskatoon's city limits, bordered by the Aspen Ridge neighbourhood to the east, Evergreen, and Silver Spring neighbourhoods in the south, and the South Saskatchewan River to the west (Meewasin, 2018). The study area for this research is comprised of the swale area within the city limits (Figure 3.1). This area is comprised of 44% wetlands, 39% grasslands, 6% woodlands, and 2% croplands (Read and McPhedran, 2019).

The NE Swale is a combination of steep rocky ridges, rolling prairie, lush valleys, treed areas, and ephemeral wetlands accommodating over 200 documented plant species, 103 avian species, and 18 mammals, 3 amphibians, 2 reptiles and 20 insects including federally or provincially designated species at risk (Jones, 2013; Canada North Environmental Services, 2016). This unique native prairie riparian area provides significant ES with intrinsic values as a natural system, and urban ecological infrastructure (Gersher et al., 2016; Baijius, 2019). The NE Swale carries several historic and archaeological values of Saskatchewan as well (Meewasin Northeast Swale, n.d.). The jurisdiction of the NE Swale aligns with the strategic plans of both the Meewasin Valley Authority (MVA) - a conservation authority, and the City of Saskatoon (Gersher and Akins, 2015). The Northeast Swale Watchers (NSW), a non-profit group comprised of concerned citizens and organizations, are working on conservation and preservation initiatives and awareness of the NE Swale (Brady et al., 2016). Because of the diversity of ecological amenities present in the NE Swale, MVA has identified this region as the highest priority for protection (Jones, 2013).

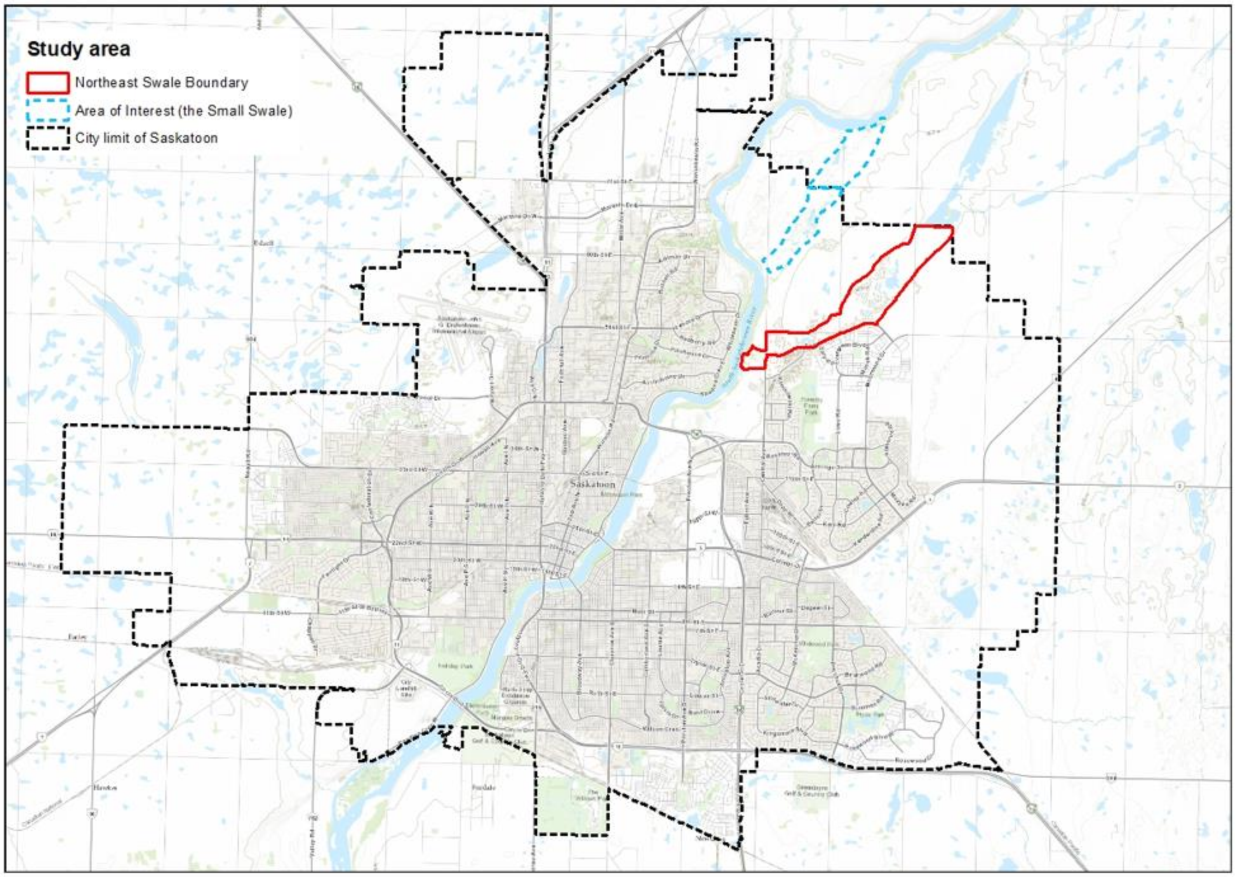


Figure 3.1: The location of the Northeast Swale within Saskatoon's city limits

Urban development in the northeast region of the city of Saskatoon has been encroaching the NE Swale since the mid-1990s ("Urban Planning", 2015) (Figure 3.2). There are three residential communities (Silverspring, Evergreen, and Aspen Ridge) bordering the NE Swale and a new residential development (University Heights 3), including stormwater drainage systems, was proposed in 2007 but still in the planning process (City of Saskatoon, 2013). Additionally, there are four roads (Agra Road, Range Road 3050, Range Road 3045, and McOrmond Drive) crossing the swale, and two roads (Central Avenue and Fedoruk Road) bordering the NE Swale. Since 2015, multiple transportation development projects under the name of 'North Commuter Parkway' project have been implemented by the City of Saskatoon. The distinguished North Commuter Parkway project includes construction, improvement, and extension of several roads and bridges including Chief Mistawasis Bridge, the extension of Marquis Drive, McOrmond

Drive, and Central Avenue, and construction of pedestrian and cyclist facilities (Major Projects, n.d.). Since 2019, a new transportation corridor (Freeway/Provincial Perimeter Highway) through the NE Swale is being planned by the Government of Saskatchewan, which is currently in the functional planning process (https://saskatoonfreeway.org/) (Table 3.1).

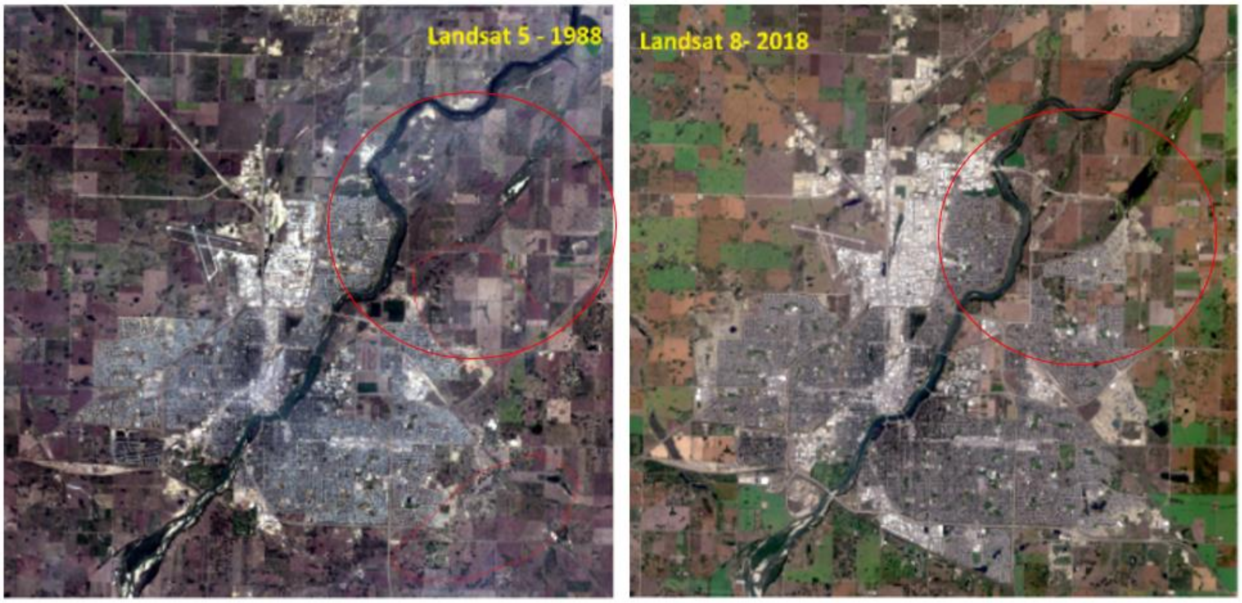


Figure 3.2: Aerial Images in 1988 (left) and 2018 (right) showing the increase in residential developments adjacent the Northeast Swale

Table 3.1: List of development plans adjacent the Northeast Swale

Development plan	*Authority*	*Timeline*	*Source*
University Heights 3 Sector Plan	City of Saskatoon	2007-unidentified	City of Saskatoon (2013)
Saskatoon Freeway/ Provincial Perimeter Highway	Government of Saskatchewan	2019-late 2021	Associated Engineering (2017)
North Commuter Parkway	City of Saskatoon	2015-2018	Major Projects (n.d.)
Northeast Swale Master Plan	MVA	2015-unidentified	Gersher and Akins (2015)

All these development pressures and plans adjacent to the NE Swale are examples of the cumulative stress of urban growth on this natural ecosystem (Jones, 2013); however, the potential and realized impacts of most of these development actions have not yet been assessed (Read and McPhedran, 2019). Local conservation groups including the NSW are concerned about the environmental impacts of these development actions, such as habitat fragmentation, introduction of invasive species, and loss of biodiversity and ES (Dove, 2019; Northeast Swale: Saskatoon, SK, n.d.). In response to concerns about the negative impacts of urban land use and developments on the NE Swale, the MVA is implementing a Master Plan, including a greenway around and trail connections within the NE Swale (Tank, 2017). Limiting traffic speed, dark sky compliance, and wildlife-friendly fencing are some of the mitigation measures being considered by the City and MVA (Northeast Swale, n.d.) along with seeking heritage status (Tank, 2019) or 'Environmental Reserve' status to conserve the NE Swale. However, concerned citizens are asking for a holistic environmental impact assessment of the development actions before implementation (Dove, 2019).

3.2 Research design

This research is a part of a larger project, "Ecosystem Services-based Strategic Environmental Assessment Framework Development and Model Application for Saskatoon's Northeast Swale," funded by Environment and Climate Change Canada and NSERC CREATE for Water Security and supported by the Spatial Initiative and the Social Science Research Lab of the University of Saskatchewan. The purpose of this larger project is to advance an ES-based SEA and educational initiatives for the NE Swale. As a part of the broader project, this research has identified and classified the ES of the NE Swale, evaluated the baseline ES values and

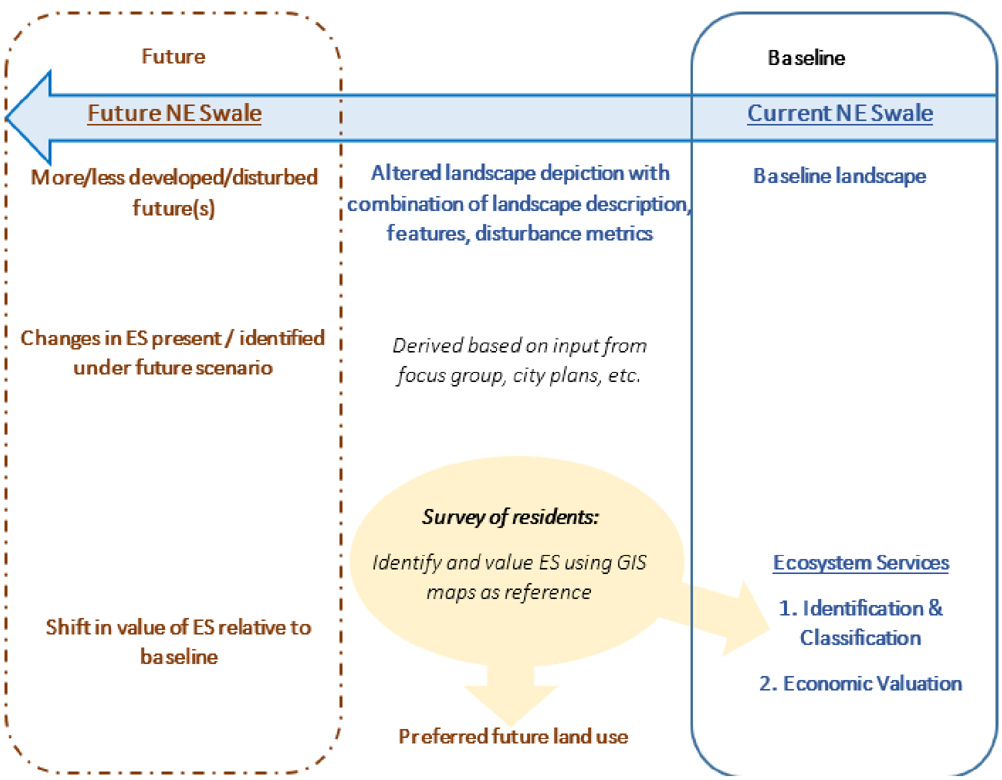


Figure 3.3: Conceptual research design

identified the impacts of ES values on preferences for future land use scenarios ranging from a 'lesser-developed/disturbed' future to a 'more-developed/disturbed' future (Figure 3.3).

Specifically, this research presents an ES-based SEA approach for incorporating the valuation of ES and analysis of alternative future scenarios to identify trade-offs between conservation and development actions. As SEA design requires the identification of desirable outcomes or 'best' options to inform strategic policy and planning decisions (Noble, 2015), a choice experiment was used as the method for comparing alternative future scenarios. The research was conducted in three phases as described below and summarized in Figure 3.4.

3.2.1 Phase 1: Identification and classification of ES

In the first phase, the existing ES of the NE Swale were identified based on a review of available planning documents (see Appendix I). Initially, fourteen ES were identified which were commonly or frequently referenced/identified in the sample of planning documents (see Appendix II). Then, interviews were conducted with a small sample of local stakeholders (n = 10) to identify the most important ES among the fourteen. The identified stakeholders included representatives from the City of Saskatoon, Meewasin Valley Authority, Saskatoon Nature Society, University of Saskatchewan, Saskatoon Land Branch, and a residential land developer. Since Geneletti (2011) and Preston and Raudsepp-Hearne (2017) recommended including a minimum number of ES in the analysis for effective SEA practice, only the ES that will be affected by the plans were identified from stakeholder's ranking. The stakeholders were asked to rank the five most important ES among the fourteen and explain the reasons for choosing that ES in an open-ended question. The five most important (prioritized) ES were identified from the weighted average of the ranks assigned by the stakeholders and the societal benefits of the ES were identified from the answers of the open-ended question. Then, the prioritized ES were classified based on the classification of MEA (2005) to understand the best method of valuation and avoiding double counting. Finally, a conceptual diagram of the relationship between priority ES and their societal benefits were drawn from an analysis of the responses of the stakeholders.

3.2.2 Phase 2: Survey design and map preparation

In the second phase, a baseline map of the study area was developed using the web-GIS platform by the U of S Spatial Initiative (Shen et al., 2019). In this phase, a choice experiment was selected as a tool for data collection and the survey questionnaire was designed accordingly. Choice experiment is a survey technique, used to ask individuals to make choices between alternative bundles of attributes with different levels of ES at different prices to reveal their willingness to pay for those services (Adamowicz et al., 1998; Bateman et al, 2011; Hanley et al., 1998). The designing of the choice experiment survey was completed following the recommendations of Johnston et al. (2017).

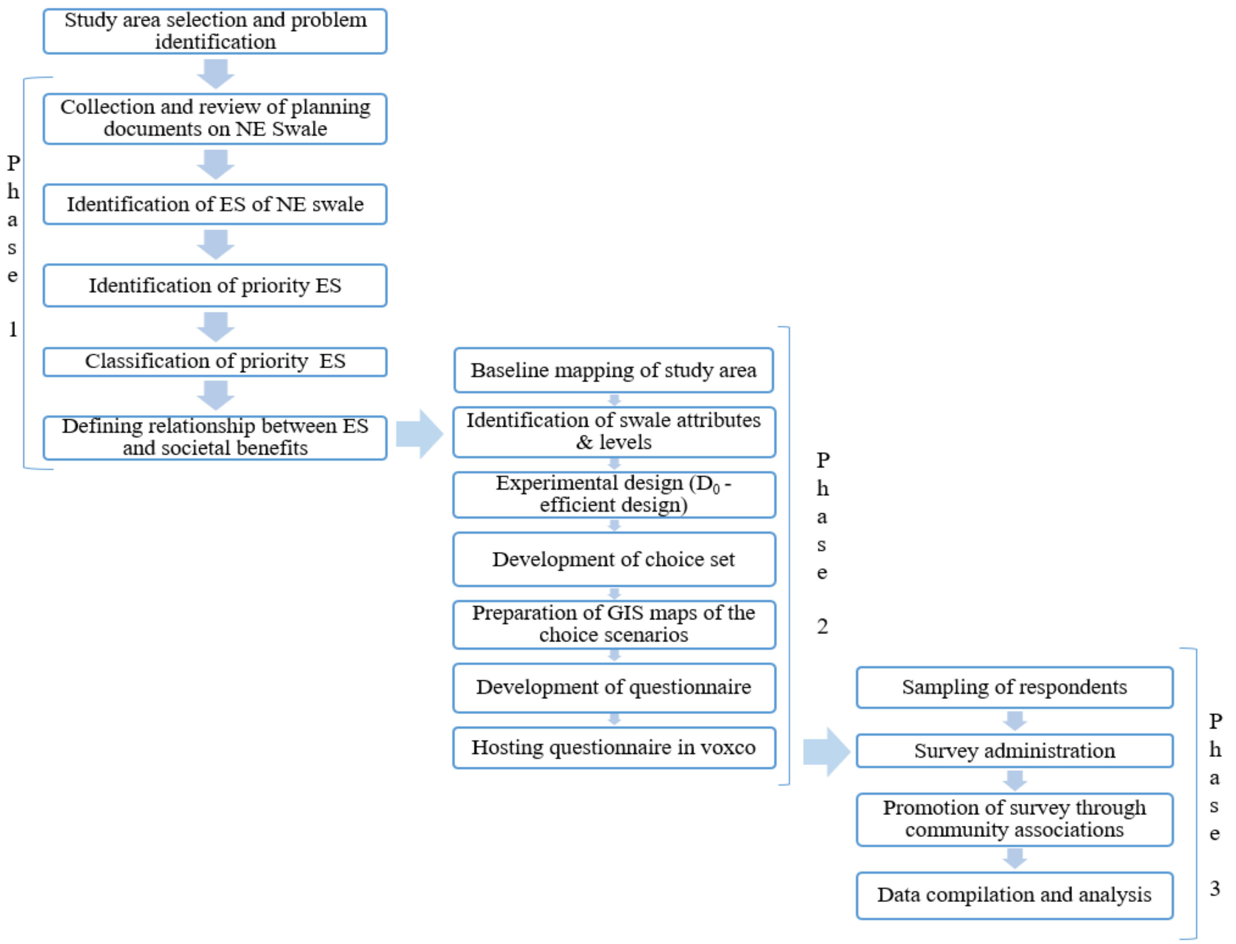


Figure 3.4: Flow diagram of research methods

3.2.2.1 Design of attributes and levels

The conceptual diagram of relationships between priority ES and their societal benefits were used to identify ES proxies for valuation, referred to as “swale attributes". These swale attributes are features that are easily identified or recognized by residents, and thus more tangible to weigh and assess versus more abstract ES. Four swale attributes (new neighbourhood, green corridor, wetland areas, and recreational trails), characterized by different levels of change or spatial extent) were identified from the five priority ES (Table 3.2). An annual increase in property tax was selected as the payment vehicle for measuring the tradeoffs between those attributes.

Table 3.2: Attributes and levels used in choice experiment set

Attributes	*Description*	*Levels*
Neighborhood	Development of new neighborhood around the NE Swale	No change; New Neighborhood
Green Corridor	Green way/corridor around NE Swale	0m; 20m; 60m
Wetlands	Total wet area within the NE Swale	No change; 50% Increase; 50% Decrease
Recreation	Recreational trails developed within the NE Swale	No Change; Crushed gravel (many); Natural Grass (some)
Property Tax	Increase in property tax per year because of improvement	$0; $50; $100; $250; $500

The swale attributes and levels were as follows:

Neighbourhood: Neighbourhood was used as a swale attribute to represent the societal benefits of the lands available for urban development. Urban development of adjacent natural areas affects the environmental quality and flow of ES (Bezák and Lyytimäki, 2011; Dupras and Alam, 2014). Two levels of neighbourhood development were considered in the assessment:

- No new neighbourhoods are developed – the landscape will remain the same as the current situation.
- A new residential neighbourhood is developed adjacent to the NE Swale.

Green Corridor: Green corridor is a vegetated buffer around the NE Swale to minimize the impacts of adjacent development. As described in the Master Plan of the NE Swale, the function of the green corridor is to protect it from the impacts of adjacent developments. Green corridors provide the societal benefit of the opportunity to access nature (Matsuoka and Kaplan, 2008) relating to ES like biodiversity, scenic amenities, educational and scientific benefits, and recreations. Three levels of the green corridor were considered:

- There is no green corridor – the landscape will remain the same as the current situation, with development right to the edge of the NE Swale.
- Establishment of 20-meter green corridor, providing limited protection to the NE Swale from adjacent development.
- Establishment of a 60-meter green corridor to provide enhanced protection for the NE Swale from adjacent development.

Wetlands: Wetlands was represented as a proxy of wetland ES, representing the total surface area of water bodies in the NE Swale (Nielsen et al., 2012; Sizo et al., 2016b), which sustains wetland biodiversity (Birol et al., 2006). Wetlands provide the societal benefit of reducing damage from flooding (MEA, 2005; Pattison-Williams et al., 2018) and recreational benefits (MEA, 2005). Three levels of wetland area were considered:

- No change in wet area - the landscape will remain the same as the current condition.
- Total wet area increases by 50% compared to the current condition, as a proxy for potentially more stormwater storage capacity.
- Total wet area decreases by 50% compared to the current condition, as a proxy for potentially less stormwater storage capacity.

Recreation: Recreation was used as a swale attribute to represent the societal benefits of the opportunity to access nature (Boll et al., 2014). As described in the Master Plan of the NE Swale, the trails may improve human experience with nature by providing ES like recreational benefits and educational benefits. Three levels of recreation were considered:

- No new trails are developed for recreation –the landscape will remain the same as the current situation.
- Some new trails are developed for recreation – all from natural grass–to provide passive recreation in a less developed, more natural setting.
- Many new trails are developed for recreation – made from crushed rock or gravel – to provide passive recreation in a more developed, less natural setting.

Property tax: Property tax was determined from the annual tax to provide services payable by property owners. Property tax increases annually in the City. In this research, an additional increase beyond the normal annual increase was used as a payment measure to capture the value of changes in swale attributes under different land use scenarios. The payment was set to range from $0 (where annual property tax does not increase beyond the normal annual increase) to $500 (where annual property tax increases significantly beyond the normal annual increase).

3.2.2.2 Experimental Design

Using the five attributes with varying levels, numerous unique choice scenarios can be constructed by full factorial design (i.e. 2×3×3×3×5=270 alternatives). To reduce the number of possible combinations of scenarios to a manageable set for mapping, comparison, and evaluation, D-efficient design was developed using the STATA Dcreate command (Hole, 2016), resulting in 20 pairs of alternative future scenarios of the NE Swale. As no prior information on preferences for the swale attributes was available, d_0 design was developed, which means β values were set to zero (see Appendix III for the full STATA command of efficient design). Using those 20 pairs, 10 choice experiment sets were developed with two alternative future scenarios and a status quo or “opt-out” scenario of the NE Swale. The status quo or “opt-out” scenario was included in every choice set to create real-world choice situations giving the option not to choose from a set of competing alternatives (Champ et al., 2014).

3.2.2.3 Questionnaire design

The U of S Spatial Initiative developed visualization maps of the 20 scenarios generated from experimental design using web-GIS. A questionnaire was designed to explore the preferences and perspectives for alternative scenarios of the NE Swale among City of Saskatoon residents living adjacent to the NE Swale (see Appendix IV for the survey questionnaire). Ten choice experiment sets were developed pairing the 20 scenarios along with a status quo scenario in each set depicting no changes in swale attributes and no annual tax increment. Visualization maps were included in the choice sets along with a description of the swale attributes in a tabular format (see Table 3.3 for a sample choice set).

Choice experiments are typically presented with verbal comparisons (e.g. Birol et al, 2006; Carlsson et al., 2003; Grammatikopoulou et al., 2012; Mao et al., 2019) or with hypothetical pictorial presentation (e.g. Brahic and Rambonilaza; 2015; Chen et al., 2017; Chen and Chen, 2019; Ja-Choon et al., 2013; Hassan, 2017; Maldonado et al., 2019; Shoyama et al., 2013). Chen et al. (2017) utilized visualization of attributes to minimize the cognitive burden for respondents and to facilitate the understanding of the choice task. Bateman et al. (2009) showed that virtual reality treatments could significantly improve non-market valuation techniques. Multiple web-based ES assessment tools use visualization maps of ES, however, challenges like data scarcity and complex techniques limited their use in practice (Pandeya et al., 2016). The GIS maps included in this choice experiment depicted a representation of the future conditions of the NE Swale to the respondents which acted as a visualization tool to help with making choices. Instead of depicting the ES, a land-use map of the area depicted various future scenarios.

The survey questionnaire consisted of three parts. The first part of the questionnaire outlined the purpose of the research and asked for the informed consent of participants. Then, the choice experiment sets (10 sets) were included followed by several questions to debrief the choices participants made in the previous part. The questionnaire then proceeded to questions on attitudes and perspectives towards the NE Swale and the future development plans, followed by some basic socio-demographic questions about the participants.

3.2.3 Phase 2: Sampling and survey administration

The number of respondents required for a questionnaire including 10 choice sets with three alternatives was calculated as at least 83 using the equation presented in Orme (2010). All of the 10 choice sets and other questions were compiled in an online survey platform (VOXCO). Residents of the three neighbourhoods bordering the NE Swale - Aspen Ridge, Evergreen, and Silverspring - were selected as potential survey participants. A systematic random sampling of the residents of these three communities was conducted by SSRL. A total of 1,029 telephone numbers that correspond with residents in the three neighbourhoods were purchased from ASDE Survey Sampler (http://surveysampler.com/). As mobile phones do not have postal codes assigned, mobile phone numbers were not purchased.

Then, the potential participants were contacted by telephone and asked to participate in the survey. Specifically, participants were asked to provide an email address by which they would be sent the survey. The recruitment process via telephone launched on June 26 and ran until July 4, 2019. Telephone numbers were scheduled to be called up to five times without a response before the number was discarded. A total of 134 participants were recruited via telephone and were sent invitations to complete the online survey. The survey was also promoted locally using posters in the community and Facebook posts. After the respondents were invited to participate in the online survey, two email reminders were sent on July 15 and 23, and one additional telephone reminder was conducted on August 1, 2019. Overall, 119 participants completed the online survey: 52% were those recruited via telephone, and 48% from other promotional measures. Thirteen responses were removed based on responses of debriefing questions as those respondents were from outside of the predefined communities. The remaining 106 survey responses were recorded in Excel file and choice experiment data were analyzed using STATA 15 software package.

Table 3.3: Sample choice experiment set

Set 1 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A 	Scenario B 	Scenario C 
Neighborhood	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.	No new neighborhoods are developed.
Green corridor	20-meter green corridor to help protect the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	No change in wet area.	Total wet area decreases by 50%.	No change in wet area.
Recreation	No new trails are developed for recreation.	Many new trails are developed for recreation, made from crushed rock or gravel.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $250 per year to support the above uses and activities.	Your property tax increases by $100 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

3.3 Econometric model

Choice experiment is a survey technique, used to ask individuals to make choices between different levels of ecosystem goods and services at different prices to reveal their willingness to pay for those goods/services (Bateman et al, 2011). Choice experiment, i.e. scenario comparison, is considered particularly worthwhile in assessing marginal changes (changes that are relatively small at the scale of analysis) (Braat and de Groot, 2012) and considering marginal changes induce meaningful monetary valuation (Broekx et al., 2013).

In this research, the choice experiment method is used for estimating preference for swale attributes, marginal willingness to pay (MWTP) value, and for scenario comparison. As the choice experiment is consistent with random utility maximization (RUM) theory (Bockstael and McConnell, 2007), preference and MWTP can be estimated using logistic regression models. Logistic regression models are commonly used to analyze discrete choice data to examine an individual's probability of choosing a scenario. According to RUM theory, an individual chooses the alternative that provides the highest utility. It is assumed that the welfare of an individual is comprised of an observed component (V) and an unobserved component (ε) (Train, 2003). According to the Random utility theory, the indirect utility attained by an individual due to choosing scenario *i*,

$$V_i=\beta_{SQ}*SQ+\beta_N*N+\beta_{HC}*HC+\beta_{LC}*LC+\beta_{MW}*MW+\beta_{LW}*LW+\beta_{CGT}*CGT+\beta_{NGT}*NGT+\beta_{TAX}*TAX \quad (3.1)$$

where, β_{SQ} is the coefficient of the status quo variable with SQ = 1 for the status quo scenario and SQ = 0 for all other scenarios; β_N is the coefficient of neighbourhood variable with N = 1 for scenarios with new neighbourhood developed and N = 0 for all other scenarios; β_{HC} is the coefficient of high green corridor variable with HC = 1 for scenarios with 60-meter green corridor and HC = 0 for all other scenarios; β_{LC} is the coefficient of low green corridor variable with LC = 1 for scenarios with 20-meter green corridor and LC = 0 for all other scenarios; β_{MW} is the coefficient of more wetland area variable with MW = 1 for scenarios with an increased wetland area and MW = 0 for all other scenarios; β_{LW} is the coefficient of less wetland area variable with LW = 1 for scenarios with a reduced wetland area and LW = 0 for all other scenarios; β_{CGT} is the coefficient of crushed gravel trails variable with CGT = 1 for scenarios with crushed gravel trails and CGT = 0 for all other scenarios; β_{NGT} is the coefficient of natural grass trails variable with NGT = 1 for scenarios with natural grass trails and NGT = 0 for all other scenarios; and β_{TAX} is the coefficient of cost attribute with TAX = annual tax increment values associated with each scenarios.

The probability of choosing scenario *i* among a choice set,

$$P = \frac{\exp(\mu V_i)}{\Sigma \exp(\mu V_j)} \quad (3.2)$$

where, V_i is the maximum utility attained by an individual by choosing scenario i; V_j is the utility associated with the other scenarios in the choice set; and μ is a scaling parameter.

Three regression models were used to identify the preferences for swale attributes, Conditional Logit (CL) model, Mixed Logit (ML) model, and Latent Class (LC) model. CL model was estimated in this research using STATA 15 "clogit" package. However, the CL model is the best-known model for the discrete choice experiment in social science researches, results of ML model and LC model can present better estimation and additional information (Bockstael and McConnell, 2007). The use of more than one model reveals heterogeneity in preferences among respondents and provides additional information on public preferences (Birol et al., 2006; Häfner et al., 2018). Moreover, the LC model reveals socio-demographic information on the subsets of respondents with heterogeneous preferences (Ehrlich et al., 2017; Kemperman and Timmermans, 2006; Liao et al., 2015; Tu et al, 2016; Veitch et al., 2018). The ML model was estimated in this research using STATA 15 "mixlogit" package (Hole, 2007) and the LC model was estimated using STATA 15 "lclogit" package (Pacifico and Yoo, 2013).

According to Hanemann (1994), the Marginal Willingness to Pay (MWTP) in choice models was calculated as the negative ratio of the coefficient of a non-cost attribute, β_{nc} and the cost-attribute, β_c.

$$MWTP = -\left(\frac{\beta nc}{\beta c}\right) \quad (3.3)$$

Maximization of the likelihood function from Eq. (3.3) gives an estimate of the marginal willingness to pay estimates associated with the swale attributes. MWTP values are the monetary terms of an individual's willingness to pay for a marginal change in the swale attributes. Moreover, compensating surplus (CS) is a closed form of monetary terms for a change from the current situation (Dias and Belcher, 2015). CS allows decision-makers to choose the alternative providing the highest utility. CS is the monetary terms of utility that an individual receives in a choice situation, as illustrated in Eq. (3.4).

$$CS = -\left(\frac{1}{\beta c}\right)(V1 - V2) \quad \ldots\ldots \quad (3.4)$$

where, β_c is the coefficient of cost attribute; V_1 is the value of the indirect utility associated with status quo; and V_2 is the value of the indirect utility associated with specific levels of attributes describing the changed scenario.

3.4 Limitations to the methods/study design

Only residents living adjacent to the NE Swale were surveyed in this research, not the residents across the city. Thus, responses may not be representative of the opinions of all residents of the City of Saskatoon. However, this was the cost-efficient sampling process as the landline numbers were purchased. Second, sampling by telephone was based on landlines and did not include cellular phones. This may have limited the number of potential participants reached. However, posters and media were used to promote the survey and recruit additional participants. Third, in most cases, focus group discussion is recommended for the selection of attributes and levels. However, in this research, attributes and levels were identified indirectly from stakeholder interviews. Fourth, d_0 design was used for choice set design, where one can argue that results from a pilot survey could be fed into the design to create a more efficient design. However, this step was overlooked to keep the process simple. Fifth, a description of the attributes and levels was not presented in the questionnaire; instead, a detailed description is presented in a tabular form along with visualization maps. This approach was adopted to reduce the cognitive complexity of reading heaps of text through visualization maps and simple texts.

Chapter 4: Results

This chapter presents the empirical results from the different phases of the ES-based SEA framework application. First, the priority ES and their societal benefits are described from the input of the stakeholders, followed by the relationship between these ES and the swale attributes presented through the ES conceptual diagram. Then, perceptions of the respondents about the NE Swale, future development plans, and the responsible authorities are delineated as identified from the questionnaire survey in phase 3. Then, the estimated results from the regression models are presented as identified from the choice experiment survey. The preferences for the swale attributes and the marginal willingness to pay for these attributes are estimated followed by an analysis of future scenarios of the NE Swale to identify the desired future.

4.1 Swale ecosystem services

Swale ES are the services that provide direct or indirect societal benefits to the residents living nearby the NE Swale and to the citizens of Saskatoon. Stakeholders ranked five ES provided by the NE Swale from a predefined list of fourteen ES. Five priority ES were identified from weighted average, including regulating services like stormwater runoff storage and carbon sequestration and storage, supporting services such as biodiversity or habitat for plants and animals, and cultural services such as educational and scientific knowledge, scenic amenities, and recreation (Table 4.1). The NE Swale provides habitat for plants and animals including some provincially/federally listed endangered plants and animals, which stakeholders considered the most important ES. Educational and scientific knowledge and stormwater runoff storage both were considered the second most important ES provided by the NE Swale. Stormwater runoff storage provides the benefit of an opportunity for learning about the natural processes of the stormwater cycle. Although stakeholders ranked carbon sequestration and storage as a sixth important ES of the NE Swale, only the five most important ES were considered in the valuation to incorporate the prioritized ES in the model. Stakeholders did not mention the natural filtering of pollutants from air and water as important ES provided by the NE Swale.

The societal benefits of the ES were identified from stakeholder interviews (Table 4.1). Every priority ES provides several benefits to the society and these benefits induce social value for the ES. Societal benefits like opportunity to access nature, ensuring public health, maintaining the water cycle, and resilience from disasters are the direct benefits to society from the provision of ES. The NE Swale is a unique landscape with native prairie grassland and wetlands providing habitat to plant and animal species and providing the opportunity to access and learn about nature and natural processes. Wetlands were identified as reducing property damage from flood events by managing stormwater runoff. The NE Swale also supports the provision of other ES, thus ensuring the viability of species.

Table 4.1: ES of the Northeast Swale and relative societal benefits as identified through interviews with stakeholders

Rank	*Ecosystem Service*	*Societal benefits*
1	Biodiversity/ habitat for plants and animals	Ensures a healthy ecosystem and viability of species; prevents extinction.
		Provides a corridor, breeding grounds and habitat for migratory birds.
		Helps in managing invasive pests, diseases, and species.
		Holds intrinsic cultural values.
2	Educational and scientific knowledge	Educational tool for understanding natural processes and history.
		Educational interpretation to improve the sense of intrinsic and natural value.
		Appreciation for nature is induced by knowledge.
3	Stormwater runoff storage	Reduces risk and damage to infrastructure from extreme weather/flood events.
		Enhances infrastructure by incorporating natural areas in urban design.
		Provides filtration of pollutants and toxins via aquatic vegetation.
		Manages influx of stormwater from new subdivisions and runoff from farmland.
		Helps in maintaining the health of South Saskatchewan River as the NE Swale flows directly to the river.
		Provides continuous water source to the ecosystem.
4	Scenic amenities (experience and sense of place)	Sense of place helps in forming community identity and contributes to quality of life.
		Contributes to public well-being as a civic amenity.
		Unique prairie landscape that provides opportunity for wildlife viewing and experiencing nature.
		Rich historical background of cultural importance.
5	Recreation (walking, cycling etc.)	Provides opportunity to connect with nature.
		Contributes to public health through recreational opportunity
		Passive recreational site for adjacent neighborhoods.
6	Carbon sequestration and storage	Supports resilience to climate change.
		Natural carbon sink close to urban center.

The interconnectedness of the ES was observed from the connections between many of the societal benefits mentioned by stakeholders in Table 4.1. For instance, the provision of habitat for plants and animals also ensures the robustness of the ecological network, supports pollutant filtration and carbon sequestration as important regulating services, and provides scenic amenities and supports education, recreation, and various cultural services. Scenic amenities and recreation are also interrelated, as appreciation for the nature or sense of the place increases the exigency and intensity of recreational activities. To avoid any double-counting induced by these interlinkages, and to ensure their meaningfulness to the public and decision-makers, representations of the ES or ecological endpoints, referred to as swale attributes were identified. As explained in Chapter 3, these swale attributes (Figure 4.1) are proxies for ES and meant to simplify the complex relationships between ES, societal benefits, and their valuation.

Swale attributes were defined based on characteristics of the NE Swale denoted to express the environmental values explicitly. These attributes were identified from the societal benefits, as the importance of the ES are often better perceived through the benefits they provide. Biodiversity, for example, is imperative to most ES; but the concept of biodiversity is often more understandable through the provision of societal benefits. Thus, based on the societal benefits, three ecological endpoints were identified as swale attributes that are imperative to provide benefits to society. For example, the foremost benefit from "stormwater storage" is the reduced risk of damage from flooding, denoted by the swale attribute "wetlands" depicting total wetland areas (Figure 4.1). The basic notion is that an extensive wetland area can provide storage of stormwater and manage run-off to reduce damage from severe flood events.

A prominent benefit of scenic amenities", "educational knowledge", and "recreation" services is the provision of opportunities to access and appreciate the nature, which is denoted by the width of the ecological corridor around the NE Swale and amount and type of recreational trails within the NE Swale (Figure 4.1). In principle, a wider ecological corridor should provide more opportunities for plant and animal species to grow and maintain the uniqueness of the area in an urban environment; and trails provide an opportunity for passive recreation and access to nature for city residents. The future planned neighbourhood to the north of the NE Swale was included as a swale attribute to understand how residents view trade-offs between the natural and developed landscape. Each of these swale attributes thus represents a bundle of ES provided by the NE Swale and simplifies the complexity of valuing and understanding ES for both residents and planners.

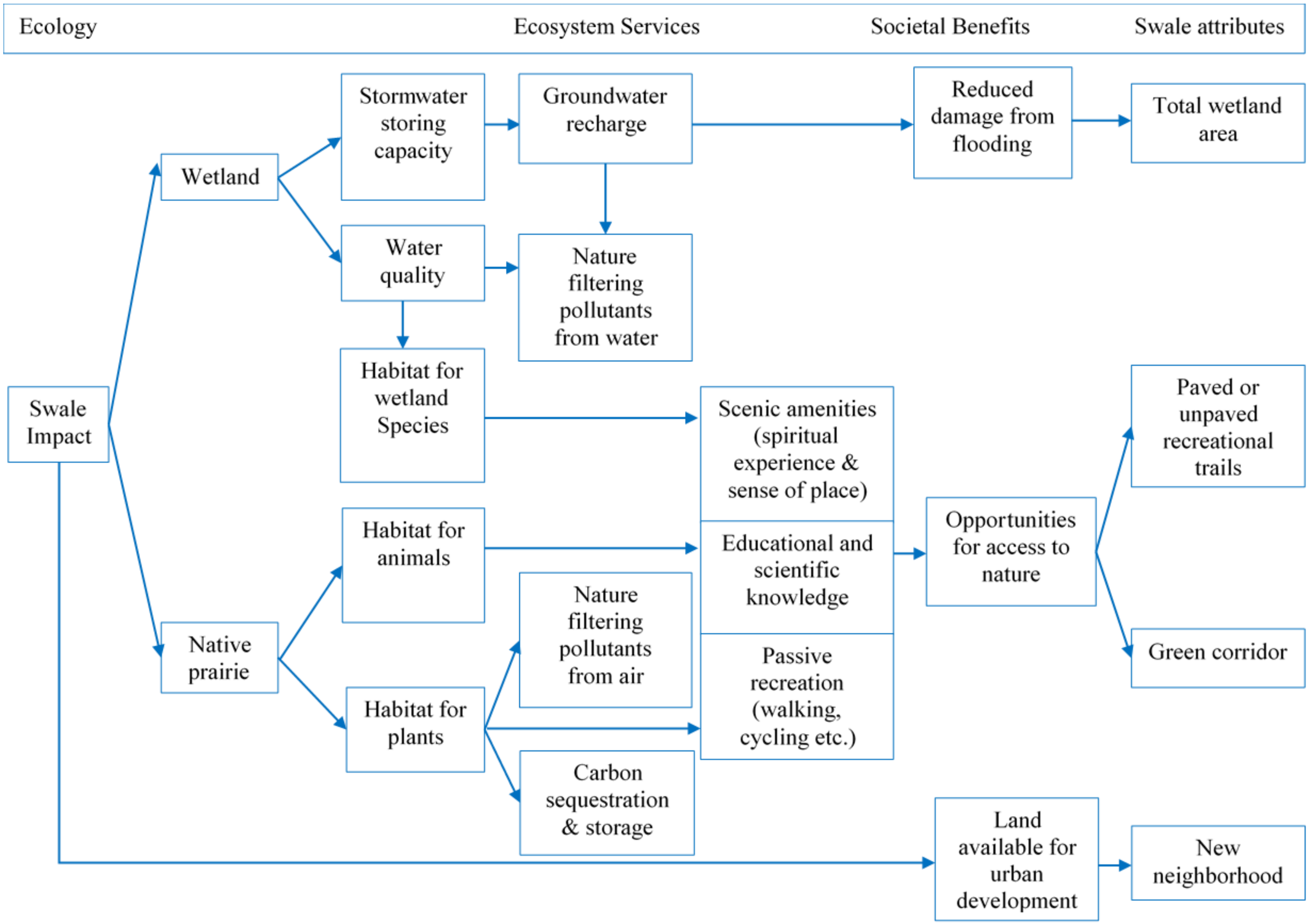


Figure 4.1: ES conceptual diagram for Saskatoon's Northeast Swale (adapted from Olander et al., 2018)

4.2 Reflections on future development of the Northeast Swale

The demographic characteristics of the sampled population were reported to identify potential effects on the choice of future scenarios and trade-offs between development and conservation. Around 70% of the sampled population were female, around 95% were homeowners and around 86% have been living in Saskatoon for more than 10 years (Table 4.2). Most of the sampled population have a university degree (64%) and have a higher (> $90,000) household income level (65%) (Table 4.2). The motivations of the sampled population to visit the NE Swale helped in understanding their connection with the place. While 99% of the sampled population has visited the NE Swale, only 55% visit the place frequently (i.e. more than 3 times a year) (Table 4.2). Around 35% of respondents engage in nature-related activities more than once a week, which is related to their compassion towards nature (Table 4.2). Only 28% of the sampled population knows about any of the management and development plans for the NE Swale, and 98% of the sampled population supports protecting the NE Swale (Table 4.2).

Table 4.2: Socio-demographic profile of the respondents

Demographic characteristics	***#***	***(%)***	***Demographic characteristics***	***#***	***(%)***
Gender:	104	100	*Duration living in Saskatoon:*	106	100
Female	73	70.2	<10 years	15	14.2
Male	31	29.8	>10 years	91	85.8
Age:	106	100	*Engagement in nature-related activities:*	105	100
18-64 years	81	76.4	Never	9	8.6
≥65 years	25	23.6	<Once a week	59	56.2
Education:	106	100	≥Once a week	37	35.2
University degree	68	64.2	*Visited the NE Swale:*	106	100
Others	38	35.8	No	7	6.6
Household income:	103	100	Yes:	99	93.4
Lower (≤$90,000)	38	36.9	<3 times per year	44	44.4
Higher (>$90,000)	65	63.1	>3 times per year	55	55.6
Ownership status:	106	100	*Knows about any future plan:*	106	100
Tenant	5	4.7	No	78	73.6
Homeowner	101	95.3	Yes	28	26.4
Duration living in current neighborhood:	106	100	*Supports protecting the NE Swale:*	106	100
<10 years	49	46.2	No	8	7.5
>10 years	57	53.8	Yes	98	92.5

The most prevalent reasons to visit the NE Swale identified from responses of an open-ended question include recreation (48.8%), nature appreciation (19.7%), scenic amenities (14.2%), and educational and scientific knowledge (6.3%) (Figure 4.2). The respondent's reasons for visiting the place are closely linked to the cultural ES, as these are the non-material benefits derived from direct engagement with nature. Respondents envisage these cultural ES through the societal benefits of accessing nature. While stakeholders prioritized cultural ES, respondents who are the beneficiaries have mentioned those as their reasons for visiting the NE Swale.

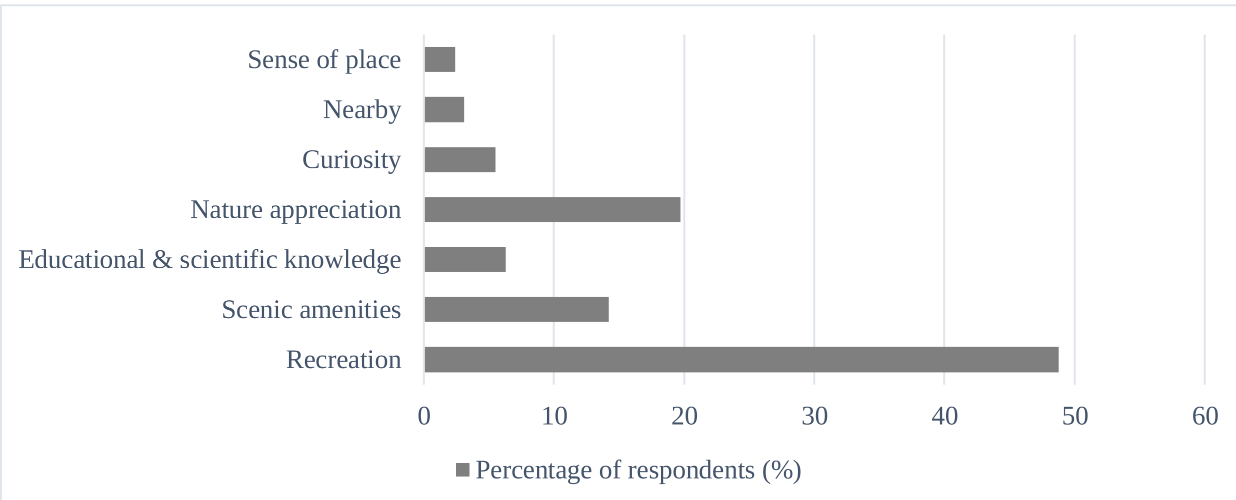


Figure 4.2: Respondent's reasons for visiting the Northeast Swale

The importance of swale attributes to respondents highlighted the importance of the ES provided by the NE Swale (Table 4.3). Respondents considered all swale attributes important, with new neighborhood and wetland areas (64% and 78%, respectively) considered more important than a green corridor and recreational trails (47% and 29%, respectively) (Table 4.3). Among all the swale attributes, wetland areas were considered the most important attribute, identified as "extremely important" by approximately 40% of respondents. In contrast, recreational trails were considered the least important swale attribute, and "extremely important" to only 8% of respondents. As the swale attributes included both ecological components (i.e. green corridor and wetland area) and development components (i.e. new neighbourhood and recreational trails), these results provide insights into understanding the significance and relevance of using these indicators for valuation tasks.

Table 4.3: Respondent's opinions on importance of swale attributes

	Not at all important (%)	*Not very important (%)*	*Somewhat important (%)*	*Very important (%)*	*Extremely important (%)*	*Total (%)*
New neighborhood	2.9	8.6	24.8	41.9	21.9	100
Green corridor	1.9	16.2	34.3	21.9	25.7	100
Wetland area	2.8	5.7	13.2	37.7	40.6	100
Recreational trails	5.7	21.7	43.4	21.7	7.6	100

The MVA has prioritized the protection of the NE Swale for a long time. That said, a debate is ongoing about the effectiveness of current planning approaches for minimizing the impacts of development on the NE Swale and so, responses from the community can help inform good decision-making on the future of the area (Table 4.4). Most respondents (~90%) agreed that the NE Swale is an important natural area, provides ES that are important to people, and should be a protected space. Additionally, most respondents (~91%) thought that good city planning is important to protect the ES of the NE Swale and that the impacts of any development plans should be assessed before decisions are made and projects are implemented. Moreover, ~41% of respondents thought that current land-use planning is *not* providing an adequate level of protection for the NE Swale. However, approximately 35% of respondents have no opinion about this statement, which suggests a lack of familiarity or disregarding current land use planning processes.

Most respondents (~78%) were unaware of future development plans for land uses around the NE Swale (Table 4.2), suggesting that most of the sampled population was not engaged in the recent city planning process - whether by choice or for other reasons. Approximately 23% of respondents knew about the north-commuter parkway project, and ~22% of respondents knew about the Saskatoon freeway project (Figure 4.3). One respondent added the Saskatoon north partnership for growth (P4G) regional plan and projected growth concept plan in the open-ended question, which was not included in our initial list. Among 106 respondents, 28 specific comments about the development plans were collected from the open-ended question. Respondents emphasized on their expectations or concerns about the plans they know about in those comments. Most of the comments were focused on the University Heights 3 and Saskatoon Freeway project, indicating the importance of these two initiatives to the respondents. One respondent commented about the University Heights 3 noting: “We already have too many new homes in this city! It has become difficult to sell a house or rent suites due to overdevelopment.” Another respondent commented about the Saskatoon freeway: “It seems unnecessary and most likely to damage and/or have negative impact on the swale”.

Table 4.4: Respondent’s opinions on statements of conservation of the Northeast Swale

	Disagree (%)	*Agree (%)*	*No Opinion (%)*
The NE Swale is an important natural area in Saskatoon.	6.6	92.5	0.9
The NE Swale should be a protected space.	7.6	90.6	1.9
The ecosystem services provided by Northeast Swale are very important to me.	8.5	87.7	3.8
Impacts to the NE Swale should be assessed before any development plans are implemented.	5.7	92.5	1.9
Good city planning can help protect the ecosystem services provided by the NE Swale.	7.6	90.6	1.9
Current city land use planning provides an adequate level of protection for the NE Swale.	41.5	22.6	35.9

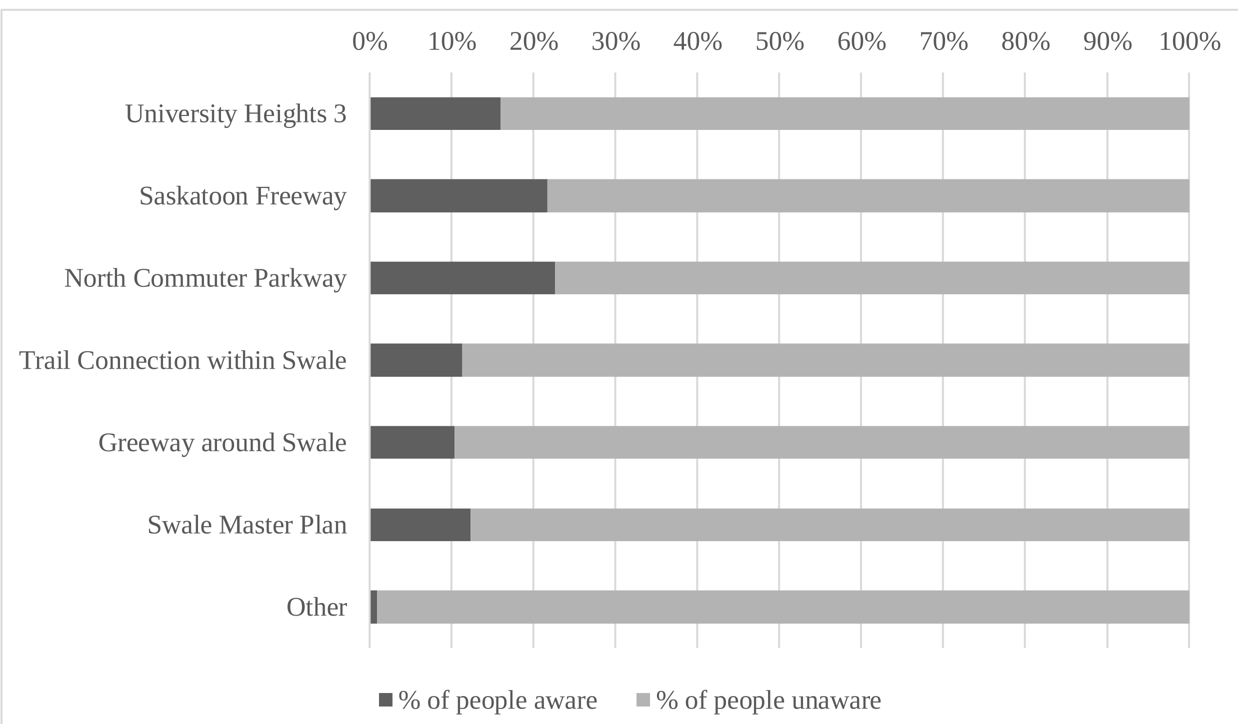


Figure 4.3: Awareness level of respondents about future development plans

These 28 comments were categorized under six common themes of concerns about and expectations from the development plans. The most enunciated concern of the respondents about the University Heights 3 project was the negative effects of development when they expected a balance between development and environmental conservation (Figure 4.4). The common expectation of respondents regarding transportation infrastructure projects (i.e. Saskatoon freeway and north commuter parkway) was the diversion of traffic from the city, but they were also concerned about the increasing traffic movement within the NE Swale and the potential negative effects of development (Figure 4.4). Respondents expected protection of the environment and ES from the greenway project as mentioned in the Master Plan of the NE Swale (Figure 4.4). In addition, respondents expected enhancement of recreational opportunities from the trail connections within the NE Swale (Figure 4.4). Overall, respondents expressed concerns about the negative effects of development and losing the sense of place of this unique native prairie landscape. Respondents also recommended relocating the University Heights 3 project so residential development would not encroach as much on the NE Swale. Several respondents also noted down that the Saskatoon freeway project should be relocated to circumnavigate the city.

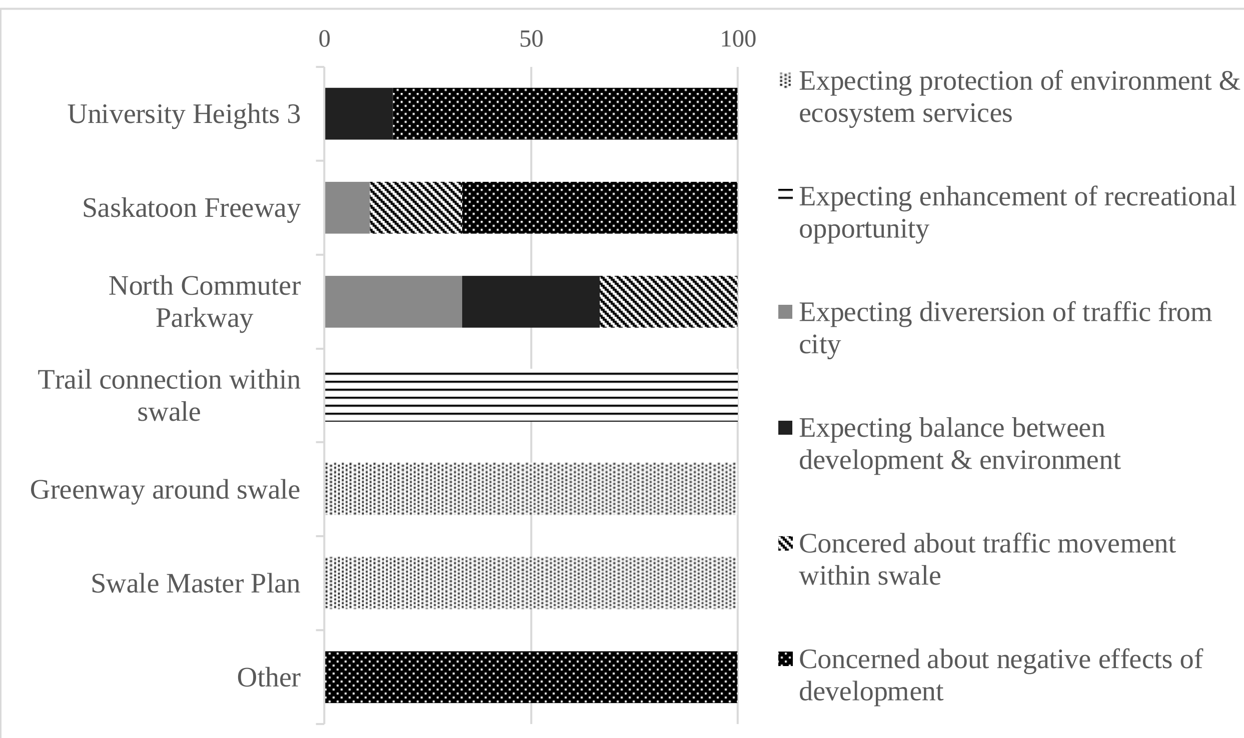


Figure 4.4: Expectations and concerns of respondents about future development plans

The concerns about the development plans intensified because of the different jurisdictions and administrations of multiple authorities at the NE Swale area. While the residential development and the north commuter parkway are being developed by the city, the provincial government is implementing the freeway project and MVA is in charge of the masterplan including greenway and trail connections. Among all the authorities, the respondents ranked the City of Saskatoon as the most responsible authority to pay for the protection of the NE Swale (Table 4.5). The provincial government was considered the second most responsible authority to pay for protecting the NE Swale (Table 4.5). Respondents thought the least responsible authority should be the Northeast Swale Watchers (NSW) (Table 4.5). A wide variety of responsible authorities made up the 'other' category. Respondents mentioned federal government, user fee, NGOs (e.g. Ducks Unlimited, Nature Conservancy, etc.), corporate sponsors, and developers that won the bids to develop around the NE Swale as potential paying authorities. The respondents of this research were comprised of the residents of surrounding neighbourhoods of the NE Swale; however, they think that all residents of Saskatoon should be responsible to pay for protecting the NE Swale.

Table 4.5: Ranking of which authorities the respondents think should be responsible for paying to ensure protection of the Northeast Swale

Rank	*Authority*	*Type of Authority*
1	City of Saskatoon	City government
2	Government of Saskatchewan	Provincial government
3	All residents of Saskatoon	Direct/indirect user with varied proximity
4	Meewasin Valley Authority	Conservation authority
5	Residents living in neighbourhoods adjacent to the NE Swale	Direct/indirect user with close proximity
6	Others	Different organizations
7	Northeast Swale Watchers	Group of concerned citizen

4.3 Model estimation results

From the choice experiment data, preference parameter and marginal willingness to pay (MWTP) values for the swale attributes were estimated using three logistic regression models; conditional logit model (CL), mixed logit model (ML), and a latent class model (LC) with two groups. This section includes the results of the regression analysis along with the marginal willingness to pay (MWTP) values of the swale attributes and future scenario analysis.

4.3.1 Preferences for swale attributes

The regression coefficients can be used to determine whether and how a change in a swale attribute might influence the preference for a scenario, such as the status quo condition or a change from the status quo. The regression coefficients identified with the three models represent the size and direction of the effects of the swale attributes on the choice of a given land use scenario. The direction of the coefficients of the regression models indicates the preference parameter; positive coefficients denote preference and negative coefficients denote aversion. A positive coefficient for a swale attribute denotes that attribute is preferred and it positively influences the probability of a scenario being chosen; a negative coefficient denotes that the attribute is not preferred and it decreases the probability of choosing that scenario. All the socio-demographic data inputs into the regression models were binary, based on the categories and sub-categories shown in Table 4.2. Table 4.6 showed the coefficients estimated from two different models, CL and ML model. The significance (p-values) of coefficients denoted by (*) showed that other than more wetland areas, all swale attributes were statistically significant throughout the models. The positive coefficients denote an increase in welfare with an increase in the level of a swale attribute, and negative coefficients denote a reduction in welfare with an increase in the level of a swale attribute. The negative coefficients of the payment variable (annual tax increment) in the models indicated that higher payment levels reduce the probability of choosing a given scenario, which is consistent with the random utility theory (see Chapter 3).

The coefficients of the status quo variable (0.701 in the CL model; 0.489 in the ML model) indicated that respondents are more likely to choose the status quo over other scenarios (Table 4.6). This ‘status quo effect’ indicates a preference for maintaining current conditions in and around the NE Swale, which can be influenced by attitudes towards environmental change, rejection of a competing scenario, or complexity of the choice task (Adamowicz et al., 1998). As

79% of respondents agreed to the statement that the survey was clear and easy to understand, the reason for choosing the status quo could be a case-specific attitude or scenario rejection.

Table 4.6: Estimated models on preference for swale attributes

	Conditional Logit Model	*Mixed Logit Model*	
	Mean	*Mean*	*Standard deviation*
Status quo	0.701** (0.151)	0.489** (0.234)	
New neighborhood	-0.117 (0.103)	-2.263** (0.434)	4.810** (0.538)
High green corridor (60-meter)	0.492** (0.128)	0.746** (0.225)	1.276** (0.332)
Low green corridor (20-meter)	0.368** (0.138)	0.504* (0.282)	1.202** (0.282)
More wetland area	-0.117 (0.121)	-0.054 (0.219)	1.152** (0.225)
Less wetland area	-0.945** (0.154)	-1.724** (0.289)	1.462** (0.329)
Crushed gravel trails	0.237* (0.140)	0.299 (0.276)	1.556** (0.244)
Natural grass trails	0.610** (0.142)	0.872** (0.228)	0.901** (0.269)
Tax	-0.003** (0.000)	-0.005** (0.001)	

Standard errors are in parenthesis.
**denotes $p \leq 0.05$
*denotes $p \leq 0.10$

The CL model showed that respondents were averse to a future scenario with a new neighborhood development (-0.117) and reduced wetland area (-0.945) and preferred a future scenario with a green corridor (0.368 for a 20-meter corridor; 0.492 for 60-meter corridor), and recreational trails (0.237 for crushed gravel trails; 0.610 for natural grass trails) (Table 4.6). The magnitude of the coefficients inferred that wider green corridors are preferred to narrower ones, and natural grass trails are preferred to the crushed gravel trails. The coefficient of increased wetland area (-0.117) was statistically insignificant, but the coefficient of less wetland area (-0.945) was statistically significant and negative, denoting strong eversion towards a scenario with reduced wetland area. This means that respondents preferred the current condition of wetland areas and did not want any future scenario with a reduced wetland area.

Respondent’s preferences were relatively similar for both the CL model and the ML model with different magnitudes except a new neighbourhood and crushed gravel trails. This means respondents had a greater preference for scenarios that did not reduce wetland areas in the NE Swale and for scenarios that included natural grass trails. As most of the respondents indicated recreation, scenic amenities, and nature appreciation as their primary reason for visiting the NE Swale, they had emphasized the swale attributes and scenarios that enable those services. ML model capturing the preference heterogeneity among the respondents reported a higher aversion for the new neighbourhood (-2.263). The standard deviation presented in the ML model of the coefficient of the new neighbourhood (4.810) showed that the preference for a new neighbourhood around the NE Swale varied widely among respondents. However, the preference for a new neighbourhood was statistically insignificant in the CL model. Similarly, preference for crushed gravel trails was statistically insignificant in the ML model showing preference heterogeneity among respondents. Additional information on the reason behind this variation in the ML and CL model was identified by the LC model, reporting information on two subsets or groups of respondents with heterogeneous preferences (Table 4.7).

Table 4.7: Estimated results of Latent Class model with demographic covariates explaining Subgroup A of respondents

	Latent Class Model	
	Group A (0.3)	*Group B (0.7)*
	Mean	*Mean*
Status quo	-0.993** (0.279)	0.685** (0.341)
New neighborhood	0.602** (0.137)	-2.198** (0.338)
High green corridor (60-meter)	0.632** (0.184)	-0.118 (0.243)
Low green corridor (20-meter)	0.604** (0.175)	0.138 (0.313)
More wetland area	-0.039 (0.173)	0.206 (0.311)
Less wetland area	-0.608** (0.198)	-1.206** (0.370)
Crushed gravel trails	0.447** (0.189)	-0.177 (0.384)
Natural grass trails	0.376** (0.192)	0.883** (0.315)
Tax	-0.002** (0.000)	-0.005** (0.001)
Demographic covariates	*Effects on latent class membership probability*	
Homeowner	-2.889** (1.393)	
Visit NE Swale (>3 times per year)	-0.894* (0.548)	
Knows about any future plans	1.386** (0.594)	

Standard errors are in parenthesis. Size & direction of demographic covariates explain Group A. Probability of being in Group A is 30% and being in Group B is 70%.
**denotes p ≤0.05
*denotes p ≤0.10

The upper part of Table 4.7 showed the estimated preference parameters from the LC model and the lower part showed the effects of demographic covariates on latent class membership probability. The latent class membership probability denotes the probability of a respondent being a member of a certain group (Group A and B) where the groups are comprised of respondents with similar socio-demographic characteristics and similar preferences. The probability of a respondent belonging to Group A was 30%, and the probability of belonging to Group B was 70%. The direction (+/-) of the coefficients of demographic covariates shown in the lower part of Table 4.7 explained the characteristics of Group A and Group B respondents. Group A respondents were likely to be tenants (-2.889), less frequent visitors of NE Swale (-0.894), and aware of future plans (1.386) (Table 4.7). These respondents preferred future scenarios with a new neighbourhood developed (0.602), a green corridor around the NE Swale (0.632 for 60-meter and 0.604 for 20-meter), and recreational trails developed (0.447 for crushed gravel and 0.376 for natural grass) (Table 4.7). Members of this group expressed aversion towards only those scenarios with reduced wetland areas (-0.608), along with the status quo scenario (-0.993). Group B respondents, in contrast, tend to be homeowners (-2.889), more frequent visitors of the NE Swale (-0.894), and unaware of development plans (1.386) (Table 4.7). These respondents showed a preference towards the status quo scenario (0.685), a strong aversion towards future scenarios with a new neighbourhood (-2.198) and reduced wetland areas (-1.206), and a preference for future scenarios with natural grass trails (0.883).

4.3.2 Influence of socio-demographic characteristics on preferences of swale attributes

The interaction between socio-demographic covariates with swale attributes in the CL model showed the effects of demographic characteristics on the preferences of swale attributes (Table 4.8). Demographic characteristics like gender, age, education, and income level were found to have effects on preferences for swale attributes. Additionally, some social characteristics like homeownership, frequency of visit, environmental awareness, etc. were found to affect preferences on swale attributes.

Results showed that respondents who were male (0.816), did not support protecting the NE Swale (1.762) and aware of development projects like University Heights 3 (0.674), the freeway (0.401) and North Commuter Parkway (0.398) preferred scenarios that included a new neighbourhood. Whereas respondents who frequently visited the NE Swale (-0.802) and engaged in nature-related activities (-1.073) were averse to scenarios with a new neighbourhood (Table 4.8). Respondents aged ≥ 65 years preferred increased wetland area (0.548) but were averse to a 60-meter wide green corridor (-0.749). Respondents with higher household income wanted the NE Swale to remain in its current condition (0.508) or preferred future scenarios with a wider green corridor (0.409) but did not prefer scenarios with reduced wetland areas (-0.480) (Table 4.8). Homeowners around the NE Swale did not prefer scenarios with crushed gravel trails (-1.207) due to either environmental impacts or maintenance issues. These findings are foreseeable since frequent visitors and active nature supporters appear to want the NE Swale to stay in its natural setting rather than being more developed in the future.

Table 4.8: Effects of socio-demographic covariates on preferences of swale attributes

Demographic Covariates	*Swale attributes*	*Coefficients*
Male	New neighbourhood	0.816** (0.223)
Homeowner	Crushed gravel trails	-1.207** (0.569)
Aged ≥65 years	High green corridor (60 meter)	-0.749** (0.297)
	More wetland area	0.548** (0.277)
University degree	Less wetland area	-0.521* (0.305)
Higher household income (≥$90,001)	Status quo	0.508* (0.299)
	High green corridor (60 meter)	0.409* (0.259)
	Less wetland area	-0.480* (0.299)
Visit NE Swale (>3 times per year)	New neighbourhood	-0.802** (0.212)
	Less wetland area	-0.491* (0.301)
	Natural grass trails	0.447* (0.283)
Nature related activity (≥ Once per week)	New neighbourhood	-1.073** (0.244)
Do not support protecting the NE Swale	New neighbourhood	1.762** (0.419)
	Less wetland area	0.864* (0.516)
Knows about University Heights 3	New neighbourhood	0.674* (0.266)
Knows about Freeway	New neighbourhood	0.401* (0.245)
Knows about North Commuter Parkway	New neighbourhood	0.398* (0.235)

Standard errors are in parenthesis.
**denotes p ≤0.05
*denotes p ≤0.10

4.3.3 Marginal willingness to pay (MWTP) values for swale attributes

Using the coefficients presented in Table 4.6 and Table 4.7, the MWTP for the swale attributes were calculated (see Chapter 3; Eq. (3.3)). Positive MWTP values reflect a perceived increase in welfare and a negative MWTP reflects a perceived decrease in welfare attributable to a change in the particular swale attribute, both expressed in monetary terms. These values were presented in $ per household per year and were based on a proposed (hypothetical) annual property tax increase in the survey instrument. The swale attributes (new neighbourhood, green corridor, wetland area, and recreational trails) were considered non-cost attributes; the "tax" (-0.003 for CL model; -0.005 for ML model; -0.002 for Group A, LC model; -0.005 for Group B, LC model) was considered as the cost attribute and used as a payment vehicle in the survey.

According to the CL model, the MWTP values presented the monetary value of an increase in welfare for a future scenario with a green corridor ($190 for 60-meter; $142 for 20-meter) and trails ($92 for crushed gravel; $236 for natural grass) (Table 4.9). The monetary terms of decreases in welfare were $45 in the case of the development of a new neighbourhood and $366 for reduced wetland area (Table 4.9). The MWTP values for reduced wetland area and natural grass trails were relatively similar throughout the models. The ML model more accurately captured the wide variety of preferences among the respondents and reported a much bigger MWTP value of the decrease in welfare ($440) for a new neighbourhood (Table 4.9). However, the coefficient for the attribute, a new neighbourhood was statistically insignificant for the CL model.

For the Group A respondents of the LC model, the value of the increase in welfare for a new neighbourhood was $299, $314 for a 60-meter wide green corridor, $300 for a 20-meter wide green corridor, $222 for crushed gravel trails, and $187 for natural grass trails (Table 4.9). In addition, the value of the decrease in welfare for the reduced wetland areas was $302 (Table 4.9). For the Group B respondents of the LC model, the value of the increase in welfare for natural grass trails was $179 and the value of the decrease in welfare was $448 for a new neighbourhood, and $245 for reduced wetland areas (Table 4.9). Both groups of participants had a similar aversion towards the reduced wetland areas, indicating the high importance of the wetland areas to both groups of respondents.

Table 4.9: Marginal willingness to pay for swale attributes (in $ per household per year)

	Conditional Logit Model	*Mixed Logit Model*	*Latent Class Model*	
			Group A (0.3)	*Group B (0.7)*
New neighborhood	-45.27	-439.71**	299.86**	-448.06**
High green corridor (60 meter)	190.58**	144.75**	314.65**	-23.99
Low green corridor (20 meter)	142.54**	97.92*	300.75**	28.17
50% more wetland areas	-45.14	-10.49	-19.29	42.06
50% less wetland areas	-366.22**	-344.72**	-302.83**	-245.91**
More crushed gravel trails	92.02*	58.11	222.62**	-36.16
Some natural grass trails	236.43**	169.41**	187.29**	179.98**

Values are in Canadian dollars (2019).
**denotes $p \leq 0.05$
*denotes $p \leq 0.10$

4.3.4 Analysis of alternative future scenarios

Alternative future scenario analysis presented the most and least preferred scenarios by the respondents, based on the probability of the sample population choosing that scenario in the choice experiment survey and compensating surplus (CS) estimated from three models. While MWTP values gave a plausible representation of the perceived welfare of changes in the quantity or quality of swale attributes, CS was used to quantify the changes in individual welfare under alternative management scenarios. The probabilities of choosing a scenario were calculated from the maximum utility (see Chapter 3; Eq. (3.1 and 3.2) and CS was calculated using Eq. (3.4) (see chapter 3 and see Appendix V for an example of detailed calculation). Statistically insignificant data was not included in the calculation of CS. As each choice set had three alternative scenarios with the status quo scenario in common, the probability of choosing the status quo scenario will be different for each choice set. To compare the probability of choosing an alternative scenario with the probability of choosing the status quo scenario, both probabilities for each choice set were reported separately (Table 4.10). An alternative scenario was chosen only if it offered greater utility than the status quo scenario. To make this concept vivid, the status quo scenario was included in every choice set in the questionnaire. The maximum utility of choosing the status quo scenario is 0.701 (see Chapter 3, equation (3.1)). Thus, scenarios with a utility greater than 0.701 were considered a desired alternative future scenario.

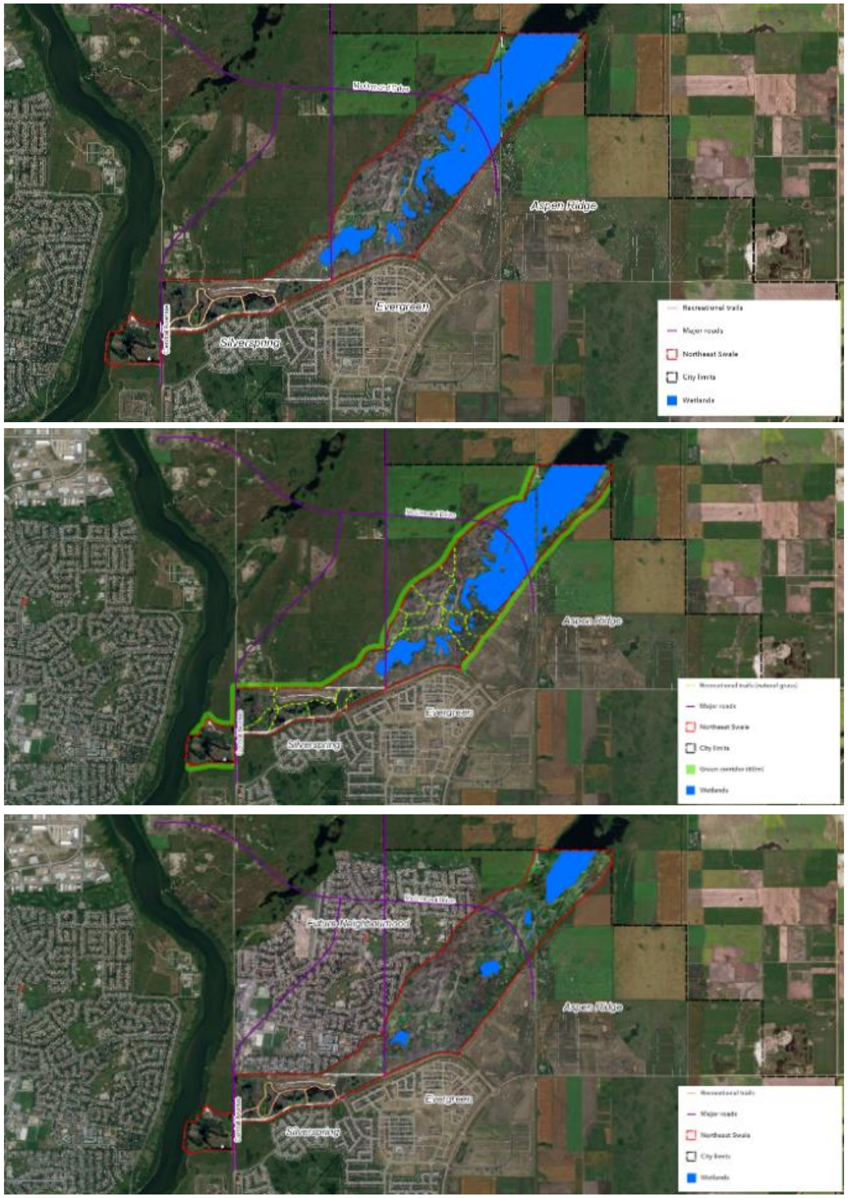
Results showed that only two scenarios (7B and 4A, Table 4.10) had a perceived utility (1.102 and 0.978, respectively) greater than the status quo scenario (0.701). In turn, these scenarios had a higher probability of being chosen (0.56 and 0.47 respectively) than the status quo scenario (0.37 and 0.36 respectively). While these two scenarios (7B & 4A) were more desirable for the respondents than the status quo, all the other scenarios included in Table 4.10 were less desirable than the status quo scenario according to the probability calculation. This implied that respondents would prefer a future NE Swale environment characterized by the conditions depicted in scenarios 7B or 4A, followed by the status quo. The most preferred future scenario (7B, Table 4.10) included *no* new neighborhood developed, a 60-meter wide green corridor around, *no* change in the wetland areas, and some natural grass trails developed within the NE Swale (Figure 4.5). The difference between scenario 7B and 4A was the width of the green corridor (60-meter in 7B and 20-meter in 4A) and areas of wetlands (status quo in 7B and more in 4A). Similarly, the difference between 7B and status quo was in the width of the green corridor (60-meter in 7B and no change in status quo) and the presence of natural grass trails (some natural grass trails in 7B and no change in status quo). In contrast, the least preferred future scenario (7A, Table 4.10) included a new neighborhood developed, *no* green corridor around, a major loss of wetland area, and *no* change in recreational trails within the NE Swale (Figure 4.5). The difference between 7A and the status quo scenario was the presence of a new neighbourhood developed and reduced wetland areas in 7A. The maximum utility attained under scenario 7A was -1.062 and the probability of choosing scenario 7A was 0.06; both less than the utility attained under the status quo. The visualization maps presented in Figure 4.5 compared the status quo, most, and least preferred scenarios to depict the most and least desirable changes in swale attributes.

While probabilities were calculated from coefficients of only the CL model, CS of each scenario were estimated for all the three models. CS is a closed form of utility in dollar terms of the differences in welfare associated with the status quo scenario and the alternative scenario (see Chapter 3, equation (3.4)). The probability of choosing a scenario presented the most and least preferred scenarios and the CS values estimated the monetary implication of choosing those scenarios. The estimated positive CS values represent the amount society would be willing to pay to maintain the welfare level if the definite set of swale attributes in a scenario could be achieved. Whereas, the negative CS values represent the amount society would need to be compensated to maintain welfare level if the definite set of swale attributes in a scenario could not be achieved. Results showed that the CS of scenario 7B ($427 per household in Cl model; $314 in ML model and $276 in LC model) was the highest and CS of scenario 7A (-$366 in CL model, -$784 in ML model and -$486 in LC model) was the lowest for all the three models, which aligns with probability value (Table 4.10). The CS value of 7B depicted that the respondent's willingness to pay was $314 per household to see a 60-meter green corridor and some natural grass trails developed within the NE Swale with *n*o change in wetland areas and *no* new neighbourhood developed. In other words, if scenario 7B could not be realized, the respondents were willing to be compensated $314 per household as compensation. Similarly, the CS value of 7A depicted that the respondents were willing to be compensated $784 per household if a new neighbourhood was developed and wetland areas were reduced in the future NE Swale scenario. In calculating the CS values, statistically insignificant values were ignored in every model. The CS values of the three models showed that CS value reported in the CL model was overestimation than the other two because the coefficient of the new neighbourhood was statistically insignificant in the CL model and was removed from the calculation.

Table 4.10: Ranking of future alternative scenarios based on conditional logit model

Rank[1]	*Scenario*[2] *#*	*Attributes*					*Maximum utility of choosing a scenario*	*Probability of choosing a scenario*	*Probability of choosing SQ scenario*	*CS*[8] *(CL model)*	*CS*[8] *(ML model)*	*CS*[8] *(LC model)*
		Neighborhood[3]	*Green Corridor*[4]	*Wetland area*[5]	*Trails*[6]	*Tax*[7]						
1	7B	SQ	High	SQ	NG	100	1.102	0.56	0.37	427.0	314.2	276.6
2	4A	SQ	Low	More	NG	500	0.978	0.47	0.36	378.9	267.3	272.4
3	6B	SQ	SQ	SQ	NG	50	0.61	0.31	0.34	236.4	169.4	182.2
4	2A	SQ	Low	SQ	CG	500	0.605	0.37	0.40	234.6	97.9	157.0
5	5B	SQ	High	More	SQ	50	0.492	0.35	0.43	190.6	144.8	94.4
6	10B	SQ	SQ	SQ	CG	250	0.237	0.27	0.43	92.0	0	66.8
7	3B	SQ	SQ	More	SQ	250	0	0.20	0.40	0	0	0
8	8B	New	SQ	More	NG	500	0.61	0.40	0.44	236.4	-270.3	-41.5
9	3A	New	High	SQ	CG	500	0.729	0.41	0.40	282.6	-294.9	-62.5
10	6A	New	High	More	CG	250	0.729	0.35	0.34	282.6	-294.9	-62.5
11	8A	SQ	Low	Less	CG	50	-0.34	0.16	0.44	-131.7	-246.8	-106.0
12	1A	New	Low	SQ	SQ	250	0.368	0.37	0.51	142.5	-341.8	-133.5
13	10A	New	Low	More	SQ	100	0.368	0.31	0.43	142.5	-341.8	-133.5
14	9B	New	SQ	More	CG	50	0.237	0.32	0.51	92.0	-439.7	-156.9
15	9A	SQ	High	Less	SQ	500	-0.453	0.16	0.51	-175.6	-199.9	-168.6
16	1B	SQ	SQ	Less	CG	100	-0.708	0.12	0.51	-274.2	-344.7	-196.2
17	2B	New	High	Less	NG	50	0.157	0.23	0.40	60.8	-470.3	-210.1
18	5A	New	Low	Less	NG	250	0.033	0.22	0.43	12.8	-517.1	-214.3
19	4B	New	SQ	SQ	SQ	100	0	0.18	0.36	0	-439.7	-223.7
20	7A	New	SQ	Less	SQ	500	-0.945	0.07	0.37	-366.2	-784.4	-486.7

[1]Ranking based on the results of all the three models.
[2]Scenario # denotes to the reference number of scenarios included in choice set questionnaire. First choice set number (1 to 10) and then position in the set (A or B).
[3]New denotes to development of a new neighbourhood around the NE Swale; SQ denotes to the present scenario.
[4]High denotes to development of 60-meter wide green corridor around the NE Swale; Low denotes to development of 20-meter wide green corridor around the NE Swale; SQ denotes to the present scenario.
[5]More denotes to 50% increased wetland area within the NE Swale; Less denotes to 50% decreased wetland area within the NE Swale; SQ denotes to the present scenario.
[6]CG denotes to development of crushed gravel trails within the NE Swale; NG denotes to development of natural grass trails within the NE Swale; SQ denotes to the present scenario.
[7]Annual tax increment values reported in choice experiment set.
[8]CS denotes to compensating surplus; statistically insignificant values were ignored.



Current scenario for the NE Swale (Status Quo)

No green corridor around the NE Swale

Some recreational trails within the NE Swale

Most preferred scenario for the NE Swale

No new neighbourhood developed

60-meter wide green corridor around the NE Swale

No change in wetland area

Some natural grass trails developed within the NE Swale

Least preferred scenario for the NE Swale

New neighbourhood developed adjacent the NE Swale

No green corridor around the NE Swale

Major loss of wetland area

No change in recreational trails within the NE Swale

Figure 4.5: Current, most preferred, and least preferred scenarios of the Northeast Swale.

Table 4.10 presented only the 20 scenarios used in the choice set, which was identified using the D_0-error experimental design. In reality, there could be 54 possible alternative scenarios (2×3×3×3=54) based on different combinations of levels of swale attributes. Based on the estimated CS values of three models, eight scenarios desirable to the society were identified (Table 4.11). If any of these eight scenarios are to be realized, then it is important to estimate the benefits of the action, which is the increase in the net social welfare as represented in the estimated CS values of Table 4.11. The CS values represented the amount society would need to be compensated to maintain welfare levels in case of failure to realize the definite set of swale attributes in that scenario. For example, a change in swale attributes from the status quo to scenario 1 had a CS of $314 per household (according to the ML model). In case of a failure to develop a 60-meter wide green corridor and some natural grass trails in the NE Swale, with *no* change in neighbourhood condition and wetland areas, payments of $314 per household would be required to compensate for welfare loss of the residents. None of these eight scenarios included a new neighbourhood or change in wetland areas; denoting the respondent's desire to keep the NE Swale in an unaltered situation. Any of these eight scenarios could be adapted as an improvement in the status quo scenario in making land use decisions, while, the first scenario would be the most preferred one by society.

Table 4.11: Ranking of desirable future scenarios using compensating surplus value

Rank[1]	*Attributes*				*CS*[5] *(CL model)*	*CS*[5] *(ML model)*	*CS*[5] *(LC model)*
	Neighborhood[2]	*Green Corridor*[3]	*Wetland area*[2]	*Trails*[4]			
1	SQ	High	SQ	NG	427.0	314.2	276.6
2	SQ	Low	SQ	NG	378.9	267.3	272.4
3	SQ	SQ	SQ	NG	236.4	169.4	182.2
4	SQ	High	SQ	CG	282.6	144.8	161.2
5	SQ	Low	SQ	CG	234.6	97.9	157.0
6	SQ	High	SQ	SQ	190.6	144.8	94.4
7	SQ	Low	SQ	SQ	142.5	97.9	90.2
8	SQ	SQ	SQ	CG	92.0	0	66.8

[1]Average ranking of the hypothetical scenarios based on MWTP values of three models.
[2]SQ denotes to the present scenario; Status Quo.
[3]High denotes to development of 60-meter wide green corridor around the NE Swale; Low denotes to development of 20-meter wide green corridor around the NE Swale; SQ denotes to the present scenario.
[4]CG denotes to development of crushed gravel trails within the NE Swale; NG denotes to development of natural grass trails within the NE Swale; SQ denotes to the present scenario.
[5]CS denotes to compensating surplus; statistically insignificant values were ignored.

Chapter 5: Discussion

This research developed and applied an ES-based SEA framework for the valuation of ES in an urban planning context. Specifically, this research demonstrated an approach to incorporate the explicit consideration of ES in a future-oriented environmental assessment framework to support strategic policy and land use planning decision-making for urban ecological areas. The distinguishing components of the proposed methodology from existing approaches are stakeholder involvement in prioritization of ES, identification of proxies of ES from societal benefits to avoid double counting in valuation, using detailed and systematic stated preference techniques, identification of preferred future land-uses and tradeoffs between competing options, and providing meaningful strategic direction to planners and decision-makers. This chapter discusses the implications of the research findings and contributions and limitations of the ES-based SEA framework.

5.1 Understanding residents' preferences for the current and future state of the Northeast Swale

Results of this research showed that Saskatoon's residents living adjacent to the NE Swale largely preferred futures characterized by more natural environmental settings, including a green corridor, wetlands, and natural grass trails and excluding the development of new residential neighbourhoods or reductions in wetland areas. Previous studies have demonstrated similar preferences for natural areas experiencing pressures from urban growth (Foelske et al., 2019; Birol et al., 2006; Chen et al., 2017; Chen and Chen, 2019). Berg et al. (2007) explained the preference for natural environmental settings as an expression of urban resident's desire for contact with nature.

The development of a new residential neighbourhood was found to be a negative predictor of preferred future conditions, a finding that is substantiated in Foelske et al. (2019) who showed that residents who experienced rapid urban growth in recent years have a lesser preference for more residential growth. The negative effect of reduced wetland area on preferences for future scenarios revealed the importance of wetlands as an attribute of the NE Swale, as reinforced in several pieces of literature on the valuation of wetland ecosystems (e.g. Allen and Moore, 2016; Birol et al., 2006; Chen et al., 2017; Dias and Belcher, 2015; Shoyama et al., 2013). Mao et al. (2019), for example, showed that minimizing losses from the deterioration of wetlands was more important to individuals than improvements, which explains the aversion for reduced wetland area for residents adjacent to the NE Swale.

Respondents also showed a preference for a green corridor around the NE Swale, with more preference for a wider green corridor, which corresponds to findings presented by Grammatikopoulou et al. (2012) on preferences for water buffers and Mei et al. (2018) on preferences for buffer zones and green space around wetlands. However, Allen and Moore (2016) found a lack of preference for increased riparian buffers and explained it as a misconception among respondents on the role of riparian buffers. Residents' preference for recreational trails in urban ecological areas was not surprising and is an important ecological use-value (see Chen et al. 2017; Carlsson et al. 2003). The preference for natural grass trails over crushed gravel trails shows the desire of residents to preserve the perceived naturalness of the NE Swale while maintaining the opportunity to access nature (e.g. Boll et al. 2014).

Interestingly, and notwithstanding increasing urban pressures, respondents in this research showed a significant preference for the status quo scenario with no change in the current situation. The reason behind the preference for the status quo scenario may be attributed to a range of factors, including satisfaction with existing environmental goods and services (Chen et al., 2017; Perni and Martínez-Paz, 2018), reluctance to change due to perceived negative environmental impacts (Chen et al., 2017), lack of familiarity with the area (Perni and Martínez-Paz, 2017), or a lack of trust of organizations in charge of management (Chen et al., 2017; Perni and Martínez-Paz, 2017). However, Allen and Moore (2016) explained that preference for a status quo scenario can be a 'protest response' of respondents, meaning disagreement of the respondents with the hypothetical scenarios or the attributes used.

The LC model revealed the presence of preference heterogeneity among the respondents, identifying a sub-group of respondents with a homogeneous preference for the status quo scenario or a more natural scenario characterized by homeownership and frequency of visit. Acharya and Bennett (2001) found that open space has positive effects on property values and homeowners prefer natural environments around their houses. Moreover, Mei et al. (2018) found that house prices increase with the presence of special ecosystems, like wet prairies. The positive effect of natural space on house prices can be an incentive for adjacent homeowners to protect the NE Swale. The positive effect of frequent visits to the NE Swale on preferences for natural improvement is consistent with several studies, for example, Grammatikopoulou et al. (2012) showed in southern Finland that respondents who less frequently visited an area showed lower interest in the environment. Similarly, Czajkowski et al. (2014) showed that the frequent users of a forest in Poland are more willing to pay for forest management enhancing ES. Hwang et al. (2019) also showed a positive association between the frequency of park visits and preferences for urban green space in Singapore. The positive effect of visiting a place on preferences for ES was explained as a use-value of biodiversity in Birol et al. (2006).

The other socio-demographic characteristics of the respondents that were found to affect preferences of swale attributes are engagement in nature-related activities and support for protecting the swale. Engaging in nature-related activities improves environmental knowledge and awareness, which may be an explanatory factor of preferences for conservation of the NE Swale as a natural environment (see Brahic and Rambonilaza; 2015; Chen et al., 2017; Grammatikopoulou et al., 2012; Shoyama et al., 2013). The respondents who support protecting the NE Swale showed their concerns for the NE Swale, and researchers have found that environmental concern has a significant positive influence on willingness to pay for ES (see Birol et al., 2006; Hassan, 2017; Ning et al., 2019). Segmentation of respondent's preference heterogeneity is common in literature, to take socio-demographic characteristics and attitudes of the respondents into consideration while designing public goods (see Birol et al., 2006; Ja-Choon et al., 2013; Grammatikopoulou et al., 2012; Hassan, 2017). The results indicated that homeowners and visitors of the NE Swale constituted the larger group of respondents who will be most affected if the ES are depleted and were more willing to protect the NE Swale. This socio-demographic aspect of preferences for swale attributes should be taken into consideration when designing future plans and decision-making.

The MWTP values showed a willingness to pay for improved environmental conditions and willingness to be compensated for degradation of the NE Swale and interpreted as an estimation of the perceived change in welfare associated with such a change. Specifically, respondents were willing to pay (their perceived welfare increased) $144.75 per household per year for a 60-meter wide green corridor, $169.41 for natural grass trails. In contrast, there were also perceived losses of welfare with changes in the NE Swale. Respondents had a perceived decrease in welfare or were willing to be compensated, $439.71 for the development of a new neighbourhood, $344.72 for a major loss of wetland areas. Read and McPhedran (2019) found ES related to the wetlands in the NE Swale had the highest economic value in a benefit transfer study, which is consistent with the results of this research. Other researchers also found positive WTP for green corridors and recreational trails: for example, Carlsson et al. (2003) estimated WTP SEK 601.41 for walking facilities in a wetland in Sweden, Dias and Belcher (2015) estimated WTP $64.73 for the riparian areas in prairie wetlands of Saskatchewan, and Grammatikopoulou et al. (2012) estimated WTP $10.58 for a 15-meter natural water buffer in southern Finland. As MWTP values presented the value of individual swale attributes, the CS values presented a monetary estimate of an overall scenario as demonstrated by previous literature (see Birol et al, 2006; Chen and Chen, 2019; Dias and Belcher, 2015). The CS value increases with a change from the status quo scenario to scenarios with a preferred ecological and social condition as expected and substantiated by many previous studies (see Birol et al, 2006; Czajkowski, et al., 2014; Dias and Belcher, 2015). For the NE Swale, this means that residents living adjacent to the area were willing to pay for improved socio-ecological conditions: $314 for the most desired scenario with a 60-meter green corridor, the current level of wetland area, and natural grass trails. This CS value can be used as an economic term for the management of future scenarios of the NE Swale. If the desired futures of the NE Swale could not be realized, the CS amount is payable to the residents living adjacent to the area. Therefore, the CS value could be accounted for as a cost in cost-benefit analysis of any future project having those negative effects on the swale environment.

5.2 Implications for land use policy and planning

The NE Swale is a remaining instance of the gradually waning prairie grassland ecosystem and provides important and valued ES to the residents of Saskatoon. The residents of Saskatoon living adjacent to the NE Swale hold considerable socio-cultural values for those ES, which were estimated in economic terms in this research. Region-specific ES assessments incorporating socio-cultural benefits are considered worthwhile in land-use planning (BenDor et al., 2017; Haase et al., 2014; Broekx et al., 2013). The societal benefits of reducing the damage of flooding and increasing the opportunity to access nature, as identified in this research, stipulate the exigencies of natural areas to urban residents. According to the findings of this study, the development of a new neighbourhood and losing wetland areas would negatively affect resident's socio-cultural values for the NE Swale. As a result, any future development, residential projects, and other modifications, which can reduce wetland areas in the NE Swale, should be reconsidered by incorporating the MWTP values in the cost-benefit analysis. Since respondents were expecting protection of environment and ES from the Master Plan, green corridor and trails would positively affect the socio-cultural values of the NE Swale. Priority could be given to wider green corridor and natural grass trails as estimated in this research. The preference for natural grass trails as agreed by most of the respondents was identified as a cost-effective option providing maximum societal benefits to the residents.

There was considerable preference heterogeneity within the residents living adjacent to the NE Swale, which should be taken into consideration in land use planning and decision-making. Since preferences can change with the socio-demographic characteristics of the respondents (Birol et al., 2006), understanding the trade-offs between different beneficiary groups can improve decision-making in ES-based assessment (Geneletti, 2013). The preferences of homeowners and frequent visitors could be prioritized in land use planning and decision making for the NE Swale, as they constitute the larger beneficiary group. Furthermore, the relatively homogeneous preferences for wetland areas and natural grass trails between the two sub-groups of respondents demonstrated the high importance of these two attributes. Any possible future scenario will involve a combination of all or some of the swale attributes included in this study, and a tax amount imposed on residents could be adjusted based on the CS value associated with that scenario. However, the economic values reported in this research could be an overestimation as estimations were based on preferences of the adjacent residents of the NE Swale. Therefore, using these economic terms to evaluate other urban natural areas would need to make this assumption in consideration. If the research could be extended to the whole city, spatial heterogeneity among the preferences could be estimated.

Since current city planning in Saskatoon is reactive to growing demands, areas alongside the NE Swale are planned to be developed within the next few years. However, the implications of disregarding a place that holds such socio-cultural values are not reflected in any long-term plans affecting the area. The respondents comprising the sample population for this research identified the City of Saskatoon as the responsible authority for the protection of the NE Swale. However, current city planning practice was discerned to be deficient for the protection of the NE Swale and respondents prioritized impact assessment of development projects before implementation as a solution. Instead of assessing the environmental impacts of projects on an ad-hoc basis, the environmental assessment process in Saskatchewan could be reconsidered to accommodate the impacts of potential changes in land uses and ES due to future development during planning processes. As there is no legal requirement for impact assessment for many development projects in Saskatchewan (Sizo et al., 2016a; Westbrook and Noble, 2013), ES-based SEA approach can help to develop a shared vision for the region while translating ES into societal benefits (Slootweg and van Beukering, 2008). For achieving this, appropriate educational measures for awareness building and advocacy for the shared vision is imperative along with scientific data.

The unawareness of most of the respondents about current development plans, however, also suggested the necessity of informing residents about and engaging them in, city planning processes. Stakeholder's participation in plan preparation and decision-making is essential in land-use planning to simplify the problem and to improve understanding of public benefits of planning approaches (Li et al., 2012; Geneletti, 2013; Ruskule et al., 2018). Furthermore, the NE Swale area within the city is defined as 'Future Urban Development' district in zoning by-laws of Saskatoon (Zoning Bylaw no. 8770 of the City of Saskatoon, 2020). There is scope to revise the zoning by-law to encompass the protection of this natural area in terms of an 'Urban Reserve Zone' as implemented in several other city zoning frameworks including Edmonton, Guelph and London (Edmonton Zoning Bylaw 12800, 2017; The City of Guelph Zoning Bylaw-14864, 1995; Zoning By-law no. Z-1 of the City of London, 2011).

This research provided guidance for incorporating ES concept in decision-making along with prompting the necessity of environmental assessment in regional planning. In theory, SEA works within a legal framework and is carried out by public agencies or proponents (CCME, 2009; Sizo et al, 2015). However, in practice, many countries do not have legal requirements for SEA and practice is often ad hoc, or in response to demands from stakeholders. As there is no legal requirement for impact assessment of many of the development pressures influencing the NE Swale, the empirical results of this study can be used as a policy instrument for the region implying the greater interest of the concerned residents. The results of this research can serve as a baseline environmental statement of the area to make informed decisions and mitigation strategies about future land use priorities and conservation strategies for the NE Swale based on the ES valued by residents.

5.3 Advancing ES-based SEA framework for urban areas

This study illustrated an ES-based SEA framework to support land use planning and decision-making. Integrating ES in SEA frameworks is getting significant attention globally due to the opportunity of this approach to guide urban policy, planning, and land use decision-making (Geneletti, 2011; Honrado et al., 2013; Slootweg, 2016). Generic SEA based on ES analysis is dependent on ES assessment including prioritization and classification of ES types (Barral and Oscar, 2012) as used in this study. However, existing ES-based SEA approaches are largely conceptual, lacking in the pragmatic application in terms of selection of an appropriate valuation method (Pandeya et al., 2016; Schmidt et. al., 2016), have limited engagement of stakeholders (Geneletti, 2013; Li et al., 2012; Ruskule et al., 2018), and do not fully integrate socio-cultural values (BenDor et al., 2017; Bezák and Lyytimäki, 2011). There are also few empirical examples of applications of SEA as a tool to integrate ES in ecological area planning in urban settings.

This study presented empirical results of the trade-off between development and conservation actions within the purview of integration of ES as urged in previous literature (see Daily et al., 2009; de Groot et al., 2012; Dupras and Alam, 2014; TEEB, 2010). In this research, the indicators or ES proxies are identified from societal benefits to engage stakeholders and incorporate social values for ES in a scenario-based valuation process. While many pieces of literature have emphasized the engagement of stakeholders in ES based approaches, few works of literature have successfully addressed the connection between societal benefits and ES (van Beukering et al., 2008). While existing literature considers ES in planning frameworks through the incorporation of enabling languages (Preston and Raudsepp-Hearne, 2017), an ES-based SEA framework can help facilitate socio-economic considerations into policy and planning process in a structured and transparent way. Doing so can allow for the identification of trade-offs between different beneficiary groups under different scenarios of land use and plan outcomes, which can improve the integration of ES in decision making and contribute to more informed ES-based planning processes (Geneletti, 2013). The general requirements of SEA including public participation and environmental consideration were followed in this research; however, the decision-making depends on the concurrence of the research outcomes with the implementation authority (Acharibasam and Noble, 2014).

5.4 Methodological considerations and limitations

The ES-based SEA framework presented in this research focused on four aspects of conventional valuation studies and environmental assessment practice, i) socio-economic value-based, ii) future-oriented, iii) stakeholder-based, and iv) empirical evidence-based. Conventional stated-preference valuation approach was used as a valuation tool in this research, as the efficacy of valuation of ES as an environmental assessment tool is widely supported in the literature (see Daily et al., 2009; de Groot et al., 2012; Dupras and Alam, 2014; TEEB, 2010). Valuation of ES provided information on preferences for ES in economic units, which is a long-term exigency of land-use planning (Costanza et al., 1997; Dupras and Alam, 2014). Despite the perceived complexity and potential biases of stated preference valuation techniques (Chan et al., 2006), choice modeling was used in this research due to the potential of this approach in economic value-based scenario analysis (Braat and de Groot, 2012). However, some of the region and context-specific outputs of this research could limit the transfer of values in other areas for future studies. As monetary terms, CS values provided the changes in values between alternative scenarios (Bateman et al., 2011) and visualization maps of the scenarios were used for better depiction of the alternative futures (Zoderer et al., 2016). Instead of translating the trend of current development into the future, any possible future scenario with the combination of the swale attributes was considered in this research. Moreover, 'Status quo' or 'no action' scenario is included in the research to depict the present-day position (Thrivel and Partidário, 1996) as a premise of consideration for the respondents, as the development projects are already taken or being talked about (Bateman et al., 2011). The stakeholders of the NE Swale were consulted, and their involvement was ensured throughout the process. The socio-demographic dimension of the preferences of different respondents can help in improving the current ES-based assessment practices (Geneletti, 2013; Preston and Raudsepp-Hearne, 2017; Zoderer et al., 2016). This research presented empirical evidence of the ES based SEA framework through the analysis of the NE Swale as entailed in BenDor et al. (2017), Broekx et al. (2013), Daily et al. (2009), de Groot et al. (2012), Dupras and Alam (2014), Haase et al. (2014), and TEEB (2010) to better integrate ES consideration in urban land use planning.

Chapter 6: Conclusion

The case study of the NE Swale has shown that the intrinsic values of societal benefits provided by the ES of urban natural areas can be effectively incorporated in land use planning and decision-making through the valuation of ES. Several frameworks and tools have been developed in a country or organization-based silos worldwide to explicitly incorporate ES consideration in land use planning and decision-making (Slootweg, 2016). While these frameworks have pioneered in ES-based planning in several parts of the world, real-world application of ES-based SEA encompassing socio-cultural consideration could be a pragmatic solution to the existing limitations identified in most of the approaches (BenDor et al., 2017).

6.1 Understandings from the Northeast Swale, Saskatoon

The purpose of this research was to advance an ES-based SEA framework to evaluate possible future land uses of the NE Swale. This research presented a method for ES-based SEA application through a case study of the NE Swale. The ES-based SEA framework applied in this research involved the non-market valuation of swale attributes identified from societal benefits provided by swale ES, and an analysis of alternative futures scenarios to identify the most and least preferred future land uses based on monetary valuation of ES and trade-offs. The framework emphasized understanding how people value ES provided by wetland systems in urban settings and how that should affect land use planning decisions. At present, several frameworks have established the effectiveness of ES approach in theory but demonstrated applications of these frameworks in a way that integrates scenario-based planning are generally absent. The choice experiment survey conducted in this research revealed that resident’s value the land use attributes of the NE Swale to conserve ES and prefer a future that ensures the continued provision of the swale ES. Respondents are most concerned about the negative impacts of urban development actions on the NE swale and recognized the importance of impact assessment before the implementation of any development actions. The preferred swale attributes are a wide green corridor around the NE Swale, maintaining the current state of wetland areas, and implementing natural grass trails. Two sub-groups of respondents have been identified according to ES values and land use preferences, based on socio-demographic characteristics.

This research contributes to understanding the social preferences in land use decision-making for the conservation of an urban natural area under development pressure. Socio-cultural aspects of the landscape are mostly ignored in conventional ES valuation practices (Schmidt et al., 2016; Zoderer et al., 2016). However, in strategic decision-making, incorporation of values and perspectives of stakeholders and beneficiaries are extensively recommended (Noble, 2015; Partidário, 1999). Interviews with stakeholders revealed that the complex and interconnected swale ES are perceived through the benefits they provide. The beneficiaries of swale ES also hold intrinsic value for these benefits, depicted through the ecological attributes of the NE Swale. On the other hand, the valued urban area of the NE Swale could be used for different future urban developments as defined in the zoning of the City of Saskatoon (Zoning Bylaw no. 8770 of the City of Saskatoon, 2020). While the current city planning approach adapts measures to minimize the negative impacts of development, the main impediment remains is the lack of strategic planning that explicitly incorporates ES. As most of the development actions within city boundaries for urban land use do not trigger regulatory impact assessment, the implications of these development actions are not being addressed and threats to ES remain unchecked.

The value of ES valuation as a tool to support strategic decision-making has been well argued in recent literature (Geneletti, 2011; Kumar et al., 2013; MEA, 2005; Partidário and Gomes, 2013; Preston and Raudsepp-Hearne, 2017; Ranganathan et al., 2008; Slootweg and van Beukering, 2008; TEEB, 2010). Among the valuation techniques, stated preference techniques are prevailing as it can be used to evaluate both use and no-use values (Bateman et al., 2011; Gómez-Baggethun et al., 2013). The choice experiment method has demonstrated advantages in estimating wetland ES (Birol et al., 2006; Dias and Belcher, 2015). The choice experiment of the future scenarios of the NE Swale used in this research identified the trade-off between natural and developed landscape features along with the monetary implications of possible futures.

The choice experiment approach used in this research includes the attributes representing future development and conservation plans proposed by different organizations. Therefore, the derived monetary estimates and preference trade-offs will be useful to land use planners and decision-makers in identifying an informed decision between development and conservation actions. The findings of this research could also be used as a policy instrument to inform government initiatives considering societal support for different actions in an effort to conserve swale ES. Resident’s support for wetland areas, green corridor, and natural grass trails suggest that society will be supportive of new measures for conserving the NE Swale than they are for any measures curtailing the provision of ES. The preferred future scenarios as suggested in this research will be supported by society. The findings of this research will facilitate ES informed and socially accepted decision-making.

6.2 Research contributions

Despite the abundance of ES-based research, limited research has been conducted to integrate ES concept incorporating socio-cultural values and perspectives of stakeholders in urban land use planning through real-world applications. This research served as a response to the need for a modified framework based on the ES-based frameworks and theories forwarded so far in literature through application in an urban context, as called for in Bendor et al. (2017). In doing so, this work adapted, and advanced current ES based approaches to prioritization of ES, non-market valuation, and future-oriented analysis to identify the implications of ES-based assessment.

One of the intents of this research was to address the gap between the science on ES assessment and practical application, especially the integration of values in assessment application, as identified by Thompson et al. (2019). To fulfill the purpose of this research, methods of valuation of ES addressing the socio-cultural values of stakeholders were explored to incorporate ES in strategic decision-making in an urban context. The process of valuation followed simplistic methods and best practices used in previous literature to identify effective data. To address the existing limitations of future-scenario based analysis (e.g. complexity and data scarcity) simple mathematical procedures were used to identify the monetary implications of future scenarios.

One of the key aspects intertwined in the research design was the engagement of relevant stakeholders. Stakeholders from different organizations such as government agencies, development agencies, academia, and non-government organizations shared their insights on the ES of the NE Swale and their societal benefits. Model application data was also collected from the direct beneficiaries of the NE Swale. Understanding the perceptions of stakeholders and beneficiaries on desired futures for the NE Swale, especially the trade-offs between development and conservation, and monetary estimates of future scenarios were the key components of this research. This research also highlighted the socio-demographic dimension of preference heterogeneity along with perceptions towards impact assessment and current planning practices. Information on the concurrent conservation activities and researches has been acquired from different NE Swale working group meetings. The findings of this research have been shared with the students of Silverspring School with the help of the

Education Coordinator of Saskatchewan Environmental Society, who are working with the Student Action for a Sustainable Future (SASF) program to help in increasing community awareness of the diversity of the NE Swale (Student Action for a Sustainable Future, 2019). The findings of this research have also been shared with the stakeholders of the NE Swale in a meeting organized by NSW (President's message, 2020).

This research attempted to understand the link between urban land-use pressure and ecosystems as identified by Dupras and Alam (2014) and Gómez-Baggethun et al. (2013), thus helping planning authorities to make informed decisions about land-use trade-offs and management strategies. ES was used as an input in this research to land use planning and decision-making to transfer the literature to planning at the regional or local realm, responding to the concerns raised by Haase et al. (2014). The monetary values of alternative future scenarios were estimated as a practical tool to resolve the land-use trade-off dilemma. Furthermore, the assessment steps described in this research could be used to make land use decisions on the development of other natural spaces in the city. Additionally, the baseline information on the ES could be a useful document for further studies on the NE Swale.

6.3 Limitations

One of the recognized limitations of this research was the collection of data only from three adjacent communities of the NE Swale, meaning that monetary estimates may not reflect the values of residents living at increasing distances from the NE Swale. The monetary values generated through this research also entirely dependent on the data collected from residents, which could be an overestimation. As the NE Swale is an ecological asset to the City, the perception of all the residents of the City of Saskatoon could bring additional insights into the process. Due to budget constraints, this research regarded preferences of the direct beneficiaries enjoying the use-values of the swale ES. While insights of residents from other parts of the city might be interesting, the familiarity of residents, residing in other parts of the city with the NE Swale was not certain. As a result, perceptions of residents of adjacent communities are taken into consideration given that the purpose of this research is to advance a tool and assessment approach.

Another limitation of this research is the geographical extent of the study area. The NE Swale is a 26-km long corridor - only 5-km of which is under the jurisdiction of the geographical boundary of the City of Saskatoon. This research mentioned the 5km corridor of the NE Swale within the urban boundary as the study area. However, the remaining areas are equally valuable and an inherent part of a healthy swale ecosystem. As the purpose of this research was to identify the impacts of urban development pressures on the NE Swale, only the areas in the urban context were included – areas where city plans, and land use decisions have a direct impact.

6.4 Future research

This research could be further advanced with survey data collected from residents of other parts of the City of Saskatoon to complement the data collected in this research. It is necessary to identify the spatial heterogeneity of the preferences for the swale attributes and the spatial factors affecting the preferences. Advancing a citywide research initiative could help in identifying possible options for development in other parts of the city as well. Furthermore, the framework used in this research could be followed to guide future land use decision-making in other urban natural areas. Natural areas are utilized as either parks or lands for future development, whereas, local residents hold different perceptions for these areas and it is important to incorporate their insights into the planning and decision-making process. Furthermore, future research could be done to see the effectiveness of the development actions being planned adjacent to the NE Swale through cost-benefit analysis considering the monetary estimates identified in this research. It is necessary to understand the cost of the development actions will change if the monetary values of the swale attributes and compensating surplus of the future scenarios are taken into consideration in decision-making. Identifying and prioritizing the ES available in other natural areas of the city will help in managing the urban ES. Further research could be done to see how urban activities affect the ES and how ES could be managed in most developed landscapes.

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Zoning By-law no. Z-1 of the City of London. (2011). Retrieved on April 06, 2020, from City of London website: https://www.london.ca/business/Planning-Development/zoning-by-law/Documents/CHAPTR49.pdf

Appendices

Appendix A: List of planning documents reviewed

Name	*Source*
Northeast Swale Development Guidelines, 2012	Stantec (2012)
University Heights Sector Plan, 2012	City of Saskatoon (2013)
Northeast Swale Resource Management Plan, 2013	Jones (2013)
SENSSA-Fulbright Ecoblitz Final Report	Steelman and Main (2013)
Meewasin Master Plan, 2015	Gersher and Akins (2015)
The Saskatchewan Environmental Society Annual Report, 2016	Brady et al. (2016)
Northeast Swale Mitigation Planning	Canada North Environmental Services (2016)
Proceedings of The 11th Prairie Conservation and Endangered Species Conference	Gersher et al. (2016)
Meewasin Annual Report, 2015 - 2016	Porteous (2016)
The River Current, Fall 2017	The Value of Wetlands (2017)
Meewasin Valley-wide Resource Management Plan	Tomlinson et al. (2017)
Meewasin Annual Report, 2017 - 2018	Porteous (2018)

Appendix B: Stakeholder's interview checklist with the List of the initially identified ES

We are seeking input from various interests to help us identify the priority ecosystem services for integration in our model design. The information you provide will be used for determining what services to input to our model development. Your input is important to helping us design and apply an assessment tool that captures the values of different interests.

We recognize that all ecosystem services are important. But for the purpose of designing our model we are focusing on a limited number of services (i.e. 5) as input. Additional ecosystem services can be integrated once our model is developed and tested.

Below is a list of NE Swale ecosystem services that we identified from various planning documents.

Please identify and rank the **TOP 5** ecosystem services provided by the NE Swale.

We realize that this can be difficult, and you may consider all services to be important. However, for the purpose of developing and testing our model we are looking for your input on what should be our priority focus. All input will be aggregated. Your individual responses will not be shared.

For the **Top 5** that you selected, please comment on *why* you selected these – i.e. why would you consider them to be the top 5 ecosystem services that we could consider on model development for the NE Swale? Please add your comments to the table.

Ecosystem services		Rank in order of importance (1 = most important)	Comments on your selection or ranking (Why you selected that ecosystem service?)
Cultural	Recreation (walking, cycling etc.)		
	Educational and scientific knowledge		
	Wildlife viewing		
	Historical artifacts		
	Scenic amenities (spiritual experience & sense of place)		
Supporting	Biodiversity		
	Soil erosion control		
	Habitat for diverse plants and animals		
	Recycling of nutrients by environment		
Regulating	Nature filtering pollutants from air		
	Nature filtering pollutants from water		
	Groundwater recharge		
	Storm water storage		
	Carbon sequestration and storage		

Appendix C: STATA command of efficient design

```
matrix levmat = 2,3,3,3,4

genfact, levels(levmat)

list, separator(18)


rename x1 neighborhood

rename x2 corridor

rename x3 wetland

rename x4 recreation

rename x5 tax

recode neighborhood (1=0) (2=1)

recode corridor (1=0) (2=20) (3=60)

recode wetland (1=0) (2=1) (3=2)

recode recreation (1=0) (2=1) (3=2)

recode tax (1=50) (2=100) (3=250) (4=500)


matrix optout = 0,0,0,0,0

matrix b = 0,0,0,0,0,0,0,0,0,0,0


dcreate i.neighborhood i.corridor i.wetland i.recreation i.tax, nalt(2) nset(10) fixedalt(optout)
asc(3) bmat(b)


list, separator(15) abbreviate(30)
```

Appendix D: Survey Questionnaire

Valuing the Ecosystem Services of Saskatoon's Northeast Swale

Saskatoon's Northeast Swale is a 26-km-long corridor of native prairie uplands and wetlands. It is home to many wildlife species. The Swale is of cultural importance and a valued place for recreation and its scenery. The Swale is also under increasing stress from changing land uses, climate, and a growing City.

Understanding how residents value the Northeast Swale, especially those who live near the Swale, is important for setting land use priorities for the City of Saskatoon, for conservation programming, and for planning future residential development.

Researchers at the University of Saskatchewan, with support from Environment and Climate Change Canada and the Natural Sciences and Engineering Research Council of Canada, are inviting homeowners in Aspen Ridge, Silverspring, and Evergreen to complete a short on-line survey.

Results of the survey will help inform future land use and planning priorities for the City of Saskatoon, conservation authorities, and land developers.

To continue on to the survey, click on the next button below.

Valuing the Ecosystem Services of Saskatoon's Northeast Swale

Lead Researcher: Dr. Bram Noble, Professor, University of Saskatchewan, b.noble@usask.ca, 306-966-1899.

Thank you for participating!

In this survey, you will be presented with 10 different sets of images of the Northeast Swale that show different future conditions and land uses.

Each image includes different levels of wetlands, walking trails, housing development, and property tax payments. You are asked questions about which future condition you would prefer.

The survey will take about 20-minutes to complete. The survey is hosted by Voxco, a Canadian-owned and managed company whose data is securely stored in Canada.

This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. The Board has indicated that there are no foreseeable risks. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca; (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

In order to complete this survey, you may be required to answer certain questions; however, you are never obligated to respond, and you may stop the survey at any time by closing your internet browser. Participation is strictly voluntary.

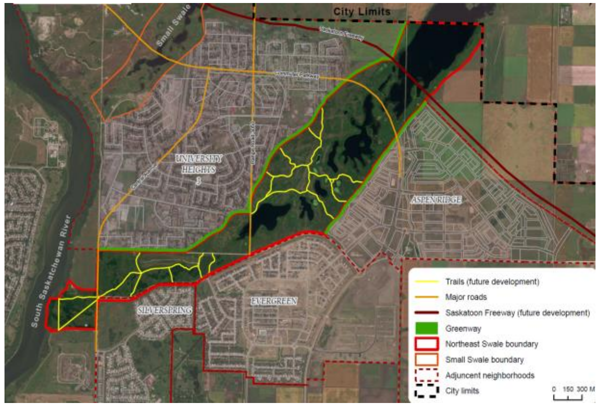
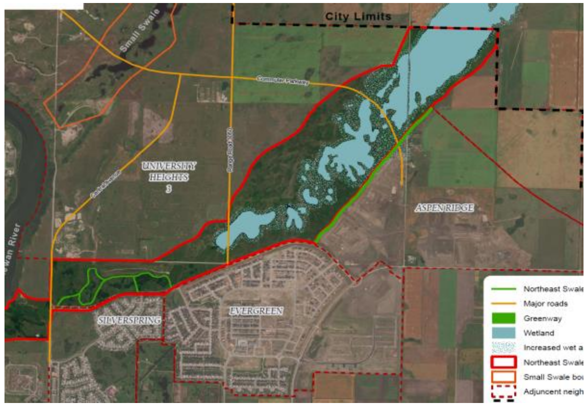
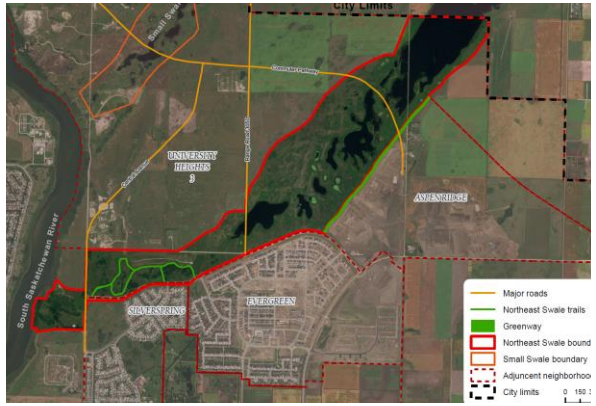
Survey responses are anonymous. Because of this, once you complete the survey and submit your responses they cannot be withdrawn.

By selecting **next** and completing this questionnaire, your free and informed consent is implied and indicates that you understand the above conditions to participate in this study.

Please consider saving or printing this page for your records.

SECTION 1: Different Future Conditions for the Northeast Swale

Instructions: In this section you will be asked to choose between different futures for the Northeast Swale. For each question, you will be presented with three images that show three different future conditions. You are asked to identify the one that you **most prefer**. When making your choice, be sure to consider the different conditions, including the different property tax rates that you would pay. There are 10 different questions or sets of images that you are asked to compare.

<table>
<tr><td colspan="4">Set 1 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.</td></tr>
<tr><td>The following factors will vary under different future scenarios</td><td>Scenario A

</td><td>Scenario B

</td><td>Scenario C

</td></tr>
<tr><td>Neighborhood</td><td>New neighborhoods are developed around the Swale.</td><td>No new neighborhoods are developed.</td><td>No new neighborhoods are developed.</td></tr>
<tr><td>Green corridor</td><td>20-meter green corridor to help protect the Swale.</td><td>There is no green corridor.</td><td>There is no green corridor.</td></tr>
<tr><td>Wetlands</td><td>No change in wet area.</td><td>Total wet area decreases by 50%.</td><td>No change in wet area.</td></tr>
<tr><td>Recreation</td><td>No new trails are developed for recreation.</td><td>Many new trails are developed for recreation, made from crushed rock or gravel.</td><td>No new trails are developed for recreation.</td></tr>
<tr><td>Property Tax</td><td>Your property tax increases by $250 per year to support the above uses and activities.</td><td>Your property tax increases by $100 per year to support the above uses and activities.</td><td>No additional property tax, beyond the usual annual adjustments.</td></tr>
<tr><td colspan="4">Which scenario would you prefer? ☐ ☐ ☐</td></tr>
</table>

Set 2 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	No new neighborhoods are developed.	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.
Green corridor	20-meter green corridor to provide enhanced protection for the Swale.	60-meter green corridor provide enhanced protection for the Swale.	There is no green corridor.
Wetlands	No change in wet area.	Total wet area decreases by 50%.	No change in wet area.
Recreation	Many new trails are developed for recreation, made from crushed rock or gravel.	Some new trails are developed for recreation, all from natural grass.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $500 per year to support the above uses and activities.	Your property tax increases by $50 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 3 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.	No new neighborhoods are developed.
Green corridor	60-meter green corridor provide enhanced protection for the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	No change in wet area.	Total wet area increases by 50%.	No change in wet area.
Recreation	Many new trails are developed for recreation, made from crushed rock or gravel.	No new trails are developed for recreation.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $500 per year to support the above uses and activities.	Your property tax increases by $250 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 4 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	No new neighborhoods are developed.	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.
Green corridor	20-meter green corridor to help protect the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	Total wet area increases by 50%.	No change in wet area.	No change in wet area.
Recreation	Some new trails are developed for recreation, all from natural grass.	No new trails are developed for recreation.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $500 per year to support the above uses and activities.	Your property tax increases by $100 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 5 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.	No new neighborhoods are developed.
Green corridor	20-meter green corridor to help protect the Swale.	60-meter green corridor to provide enhanced protection for the Swale.	There is no green corridor.
Wetlands	Total wet area decreases by 50%	Total wet area increases by 50%	No change in wet area.
Recreation	Some new trails are developed for recreation, all from natural grass.	No new trails are developed for recreation.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $250 per year to support the above uses and activities.	Your property tax increases by $50 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 6 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.	No new neighborhoods are developed.
Green corridor	60-meter green corridor to provide enhanced protection for the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	Total wet area increases by 50%.	No change in wet area.	No change in wet area.
Recreation	Many new trails are developed for recreation, made from crushed rock or gravel.	Some new trails are developed for recreation, all from natural grass.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $250 per year to support the above uses and activities.	Your property tax increases by $50 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 7 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.	No new neighborhoods are developed.
Green corridor	There is no green corridor.	60-meter buffer to help protect the Swale.	There is no green corridor.
Wetlands	Total wet area decreases by 50%.	No change in wet area.	No change in wet area.
Recreation	No new trails are developed for recreation.	Some new trails are developed for recreation, all from natural grass.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $500 per year to support the above uses and activities.	Your property tax increases by $100 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 8 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	No new neighborhoods are developed.	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.
Green corridor	20-meter green corridor to help protect the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	Total wet area decreases by 50%.	Total wet area increases by 50%.	No change in wet area.
Recreation	Many new trails are developed for recreation, made from crushed rock or gravel.	Some new trails are developed for recreation, all from natural grass.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $50 per year to support the above uses and activities.	Your property tax increases by $500 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 9 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	No new neighborhoods are developed.	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.
Green corridor	60-meter buffer to provide enhanced protection for the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	Total wet area decreases by 50%.	Total wet area increases by 50%.	No change in wet area.
Recreation	No new trails are developed for recreation.	Many new trails are developed for recreation, made from crushed rock or gravel.	No new trails are developed for recreation.
Property Tax	Your property tax increases by $500 per year to support the above uses and activities.	Your property tax increases by $50 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

Set 10 of 10: Consider the following three future scenarios for the NE Swale. Suppose scenario A, B and C are the only ones available.			
The following factors will vary under different future scenarios	Scenario A	Scenario B	Scenario C
Neighborhood	New neighborhoods are developed around the Swale.	No new neighborhoods are developed.	No new neighborhoods are developed.
Green corridor	20-meter green corridor to help protect the Swale.	There is no green corridor.	There is no green corridor.
Wetlands	Total wet area increases by 50%.	No change in wet area.	No change in wet area.
Recreation	No new trails are developed for recreation.	Many new trails are developed for recreation, made from crushed rock or gravel	No new trails are developed for recreation.
Property Tax	Your property tax increases by $100 per year to support the above uses and activities.	Your property tax increases by $250 per year to support the above uses and activities.	No additional property tax, beyond the usual annual adjustments.
Which scenario would you prefer?	☐	☐	☐

SECTION 2

In this section, you will be asked about the choices you made in the previous section. There are 7 questions in total.

1. Overall, how sure are you about the choices you made above?

1	2	3	4	5	6	7	8	9	10
Very unsure									Very sure

If you are unsure about the choices, you made, please tell us why?

____

2. Please indicate your agreement or disagreement with each of the following statements regarding the survey you just completed.

	Strongly Disagree	Disagree	Agree	Strongly Agree	No Opinion
a) The survey was clear and easy to understand.	1	2	3	4	N
b) In making decisions, I considered my current property tax.	1	2	3	4	N

3. When you were making choices among scenarios, how important were each of the characteristics below to your decision?

	Extremely important	Very important	Somewhat important	Not very important	Not at all important	Don't know
a) Neighborhood	1	2	3	4	5	N
b) Green corridor between neighborhood & swale	1	2	3	4	5	N
c) Wetlands	1	2	3	4	5	N
d) Recreation	1	2	3	4	5	N

4. Have you ever visited Northeast Swale?

- ☐ Yes
- ☐ No

2(a) If Yes, how often?

- ☐ Once only
- ☐ 1 to 3 times per year;
- ☐ > 3 times per year

2(b) What was the primary reason for your visit?

____

5. Do you know about the City of Saskatoon's future plans for land use around the Northeast Swale?
   - ☐ Yes
   - ☐ No

   If yes, please indicate which of the following development plans have you heard of?

   - ☐ University Heights 3 (Residential Development)
   - ☐ Saskatoon Freeway
   - ☐ North Commuter Parkway
   - ☐ Trail connection within swale
   - ☐ Greenway around Swale
   - ☐ Swale Master Plan
   - ☐ Other ____

6. Which one of these development plans, if any, matters most to you?
   - ☐ University Heights 3 (Residential Development)
   - ☐ Saskatoon Freeway
   - ☐ North Commuter Parkway
   - ☐ Trail connection within swale
   - ☐ Greenway around Swale
   - ☐ Swale Master Plan
   - ☐ Other ____

7. Why does this development plan matter to you?

   ____

8. Please rate these statements based on the extent to which you agree with them.

	Strongly Disagree	Disagree	Agree	Strongly Agree	No Opinion
a. The NE Swale is an important natural area in Saskatoon.	1	2	3	4	N
b. The NW Swale should be a protected space.	1	2	3	4	N
c. The ecosystem services provided by Northeast Swale are very important to me.	1	2	3	4	N
d. Impacts to the NE Swale should be assessed before any development plans are implemented.	1	2	3	4	N
e. Good city planning can help protect the ecosystem services provided by the Swale.	1	2	3	4	N
f. Current city land use planning provides an adequate level of protection for the Swale.	1	2	3	4	N

9. Who do you think should be responsible for paying to ensure protection of the NE Swale?

Rank	Authority
	City of Saskatoon
	Residents who live in neighborhoods that surround the Swale
	All residents of Saskatoon
	Meewasin Valley Authority
	Northeast Swale Watchers
	Saskatchewan Government
	Other____
	It is not important to protect the NE Swale

10. On average, how often do you participate in nature-related activities in Saskatoon?
    - ☐ Never
    - ☐ Less than once a month
    - ☐ One to three times a month
    - ☐ Once a week or more

SECTION 3: HOUSEHOLD INFORMATION

We would like to ask a few questions about your household. These questions will help us understand better different attitudes about the Swale. There are 8 questions in total.

11. What is the name of your street?

    ____

12. How long have you lived in your current neighborhood?
    - ☐ Less than one year
    - ☐ 1 to 5 years
    - ☐ 5 to 10 years
    - ☐ More than 10 years

13. How long have you lived in Saskatoon?
    - ☐ Less than one year
    - ☐ 1 to 5 years
    - ☐ 5 to 10 years
    - ☐ More than 10 years

14. Do you currently: ____ rent or ____own your home?

15. Gender:

- ☐ Female
- ☐ Male
- ☐ Other

16. How old are you?
    - ☐ 18 to 35 years of age
    - ☐ 36 to 64 years of age
    - ☐ Over 65 years of age

17. Please indicate the highest level of education you have completed.
    - ☐ Elementary School (Grade 1 to 8)
    - ☐ High School (Grade 9 to 12)
    - ☐ Trade School or Technical college
    - ☐ University
    - ☐ Graduate Degree
    - ☐ Other ____

18. What was your total annual household income last year, before taxes?
    - ☐ Below $30,000
    - ☐ $30,001 - $60,000
    - ☐ $60,001- $90,000
    - ☐ $90,001 - $120,000
    - ☐ Over $120,000

Thank you for completing the survey!

If you would like to be entered for a draw for one of three annual family passes to the Saskatoon Forestry Farm, please provide us with a means to contact you:

Email: _______________ or Telephone: ______________

The draw will happen after the survey closes, in August, 2019

Appendix E: Example of detailed calculation

Calculation of probability using conditional logit model:

The scenario B of choice set 7 includes no new neighborhood developed, has 60m green corridor around the swale, no change in wetland area and has some natural grass trails within the swale, the maximum utility obtained by an individual by choosing this scenario will be,

$V_B=\beta_{SQ}*SQ+\beta_N*N+\beta_{HC}*HC+\beta_{LC}*LC+\beta_{MW}*MW+\beta_{LW}*LW+\beta_{CGT}*CGT+\beta_{NGT}*NGT$

=(0.701*0)+(-0.117*0)+(0.492*1)+(0.368*0)+(-0.117*0)+(-0.945*0)+(0.237*0)+(0.610*1)

=0.492+0.610

=1.102

Now, the scenario A of choice set 7 includes a new neighborhood developed, no green corridor around the swale, 50% reduced wetland area and no change in trails within the swale, the maximum utility obtained by an individual by choosing this scenario will be,

$V_A=\beta_{SQ}*SQ+\beta_N*N+\beta_{HC}*HC+\beta_{LC}*LC+\beta_{MW}*MW+\beta_{LW}*LW+\beta_{CGT}*CGT+\beta_{NGT}*NGT$

=(0.701*0)+(-0.117*1)+(0.492*0)+(0.368*0)+(-0.117*0)+(-0.945*1)+(0.237*0)+(0.610*0)

=-0.117-0.945

=-1.062

In addition, the maximum utility obtained by an individual by choosing status quo scenario will be,

$V_{SQ}=\beta_{SQ}*SQ+\beta_N*N+\beta_{HC}*HC+\beta_{LC}*LC+\beta_{MW}*MW+\beta_{LW}*LW+\beta_{CGT}*CGT+\beta_{NGT}*NGT$

=(0.701*1)+(-0.117*0)+(0.492*0)+(0.368*0)+(-0.117*0)+(-0.945*0)+(0.237*0)+(0.610*0)

=0.701

The probability of choosing scenario B among the three choices in choice set 7 will be,

$$P(7B) = \frac{\exp(\mu Vi)}{\Sigma \exp(\mu Vj)}$$

$$= \frac{\exp(1.102)}{\exp(1.102)+\exp(-1.062)+\exp(0.701)}$$

=0.56

The probability of choosing scenario A among the three choices in choice set 7 will be,

$$P(7A) = \frac{\exp(\mu Vi)}{\Sigma \exp(\mu Vj)}$$

$$= \frac{\exp(-1.062)}{\exp(1.102)+\exp(-1.062)+\exp(0.701)}$$

=0.06

In addition, the probability of choosing status quo scenario among the three choices in choice set 7 will be,

$$P(SQ) = \frac{\exp(\mu Vi)}{\Sigma \exp(\mu Vj)}$$

$$= \frac{\exp(0.701)}{\exp(1.102)+\exp(-1.062)+\exp(0.701)}$$

=0.38.

Calculation of compensating surplus using mixed logit model:

The scenario B of choice set 7 includes no new neighborhood developed, has 60m green corridor around the swale, no change in wetland area and has some natural grass trails within the swale, the indirect utility obtained by an individual by choosing this scenario will be,

$V_B=\beta_{SQ}*SQ+\beta_N*N+\beta_{HC}*HC+\beta_{LC}*LC+\beta_{MW}*MW+\beta_{LW}*LW+\beta_{CGT}*CGT+\beta_{NGT}*NGT$

= (0.489*0) + (-2.263*0) + (0.746*1) + (0.504*0) + (-0.054*0) + (-1.724*0) + (0.299*0) + (0.872*1)

= 1.618

Indirect utility obtained by an individual by choosing status quo scenario will be,

$V_{SQ}=\beta_{SQ}*SQ+\beta_N*N+\beta_{HC}*HC+\beta_{LC}*LC+\beta_{MW}*MW+\beta_{LW}*LW+\beta_{CGT}*CGT+\beta_{NGT}*NGT$

= (0.489*1) + (-2.263*0) + (0.746*0) + (0.504*0) + (-0.054*0) + (-1.724*0) + (0.299*0) + (0.872*0)

= 0.489

Compensating surplus of choosing scenario 7B over status quo scenario,

$CS = -\left(\frac{1}{\beta c}\right)(VB - VSQ)$

$= -\left(\frac{1}{-0.005}\right)(1.618 - 0.489)$

= 314.2