Prairie Perspectives: Geographical Essays

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Canadian Association of Geographers
Association Canadienne des Géographes

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PRAIRIE PERSPECTIVES: GEOGRAPHICAL ESSAYS

Edited by
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Preface

The 43rd annual conference and business meeting of Prairie Division Canadian Association of Geographers (PCAG) was hosted jointly by Saskatchewan Polytechnic, Moose Jaw and the Department of Geography and Environment of the University of Regina over the weekend of September 27 to 29, 2019. Meeting facilities were provided by the Polytechnic. Sixty five registrants including 30 students and CAG President Dr. Sanjay Nepal of University of Waterloo attended the conference.

Friday evening was assigned to the annual PCAG Executive Meeting and to social activities with splendid catering and an open bar provided by the Polytechnic. On Saturday morning, 24 papers were presented across seven sessions. Of these, 18 were presented by students each of whom was awarded a Paul Simpson-Housley CAG Student Travel Award, plus an annual membership of the CAG.

Traditionally, PCAG annual meetings have been held during the last weekend of September. This timing means that weather conditions can vary considerably ranging from the hot and sunny conditions of an Indian summer, as experienced at the Russell, Manitoba meeting in 2009, to the near freezing and snowy conditions signalling the first approach of winter, as at the fabled 1984 meeting in Swan River when snow severely disrupted the field trip. The weather forecast for the Moose Jaw meeting was not promising. Despite this, the Saturday afternoon field trip to Claybank Brick Plant National Historic Site at the foot of the Dirt Hills took place under reasonably favourable conditions with a partially cloudy sky and temperature of 6°C. A guided tour of the Brick Plant was provided for the 28 field trip participants, and was followed by a short hike into the Dirt Hills where Dr. David Sauchyn, the field trip leader, provided a mini lecture describing the formation of the hills and aspects of the local surficial geology.

On Saturday evening, the Polytechnic once again demonstrated excellence by providing a truly sumptuous banquet at which Dr. Xulin Guo of University of Saskatchewan received PCAG's John H. Warkentin Award for her "Outstanding Scholarly Contributions to the Geography of the Western Interior." Dr. Guo's research focuses primarily on the application of remote sensing and geographic information science in biogeography. The evening's keynote address was given by Dr. Soe Myint of Arizona State University, School of Geographical Sciences and Urban Planning. Dr. Myint is a much-acclaimed expert in remote sensing and GIScience whose research focuses on urban land use, urban climate, drought, desertification and deforestation, and agricultural water use. His warmly received address titled *Interactions with Stakeholders in Scientific Research Activities* provided examples of conflicting expectations of research held by stakeholders and academics. The evening's activities concluded with the traditional slide contest which was held in an uncharacteristically sombre mood. On Sunday morning, activities concluded with the annual business meeting, but with few persons in attendance as temperatures hovered just above freezing and the first light snowfall of the season threatened to disrupt homeward travel.

Three research papers are presented in this volume of *Prairie Perspectives*. In the first of these, Jock Lehr and Brian McGregor escort the reader to rural Manitoba where they provide a detailed account of the decision-making process involved in colony branching among two Schmiedeleut Hutterite colonies. The economic, social, and political factors that bear upon this process and the geographical outcomes of branching are examined. The focus of attention then turns to Moose Jaw, Saskatchewan where Herve Lahamy, Christian Larochelle, and Abdul Raouf assess the accuracy of RPAS-based LiDAR for stockpile volume calculation. Their findings indicate that RPAS-based LiDAR would be unsuitable for use when survey projects require high levels of accuracy, but would be suitable where moderate levels of accuracy are acceptable. Moving overseas, Abdul Raouf, Rizwan Shahid, and Tayyab Shah examine change in literacy and educational opportunity in Punjab, Pakistan as revealed in multiple indicator surveys (MICS) conducted in 2007/8 and 2014. They find that although some closure in regional and gender-based disparities has taken place, districts in the rural south of Punjab still exhibit greater levels of disparity than more urbanized and wealthier northern districts.

Sadly, this volume also acknowledges the passing of our colleagues John Selwood of University of Winnipeg and Hansgeorg Schlichtmann of University of Regina.

Acknowledgements

I would like to thank the authors for submitting their manuscripts to the double-blind review process and meeting the challenges of revising them where deemed appropriate. Thanks are also extended to the reviewers for their critical assessments of the manuscripts, and to Julia Siemer at University of Regina for her guidance on cartographic issues. This volume marks a transition in the history of *Prairie Perspectives* with provision of technical expertise for production being transferred mid year from Weldon Hiebert at University of Winnipeg to Jasmine Liska at University of Saskatchewan. On behalf of all in the Division, I would like to thank Weldon for his many years of dedicated and uncomplaining service to the journal and wish him success and fulfillment in his retirement plans. In welcoming Jasmine to the journal, I extend thanks to her for accepting the challenge of the transition and look forward to working with her on future volumes.

Bernard D. Thraves
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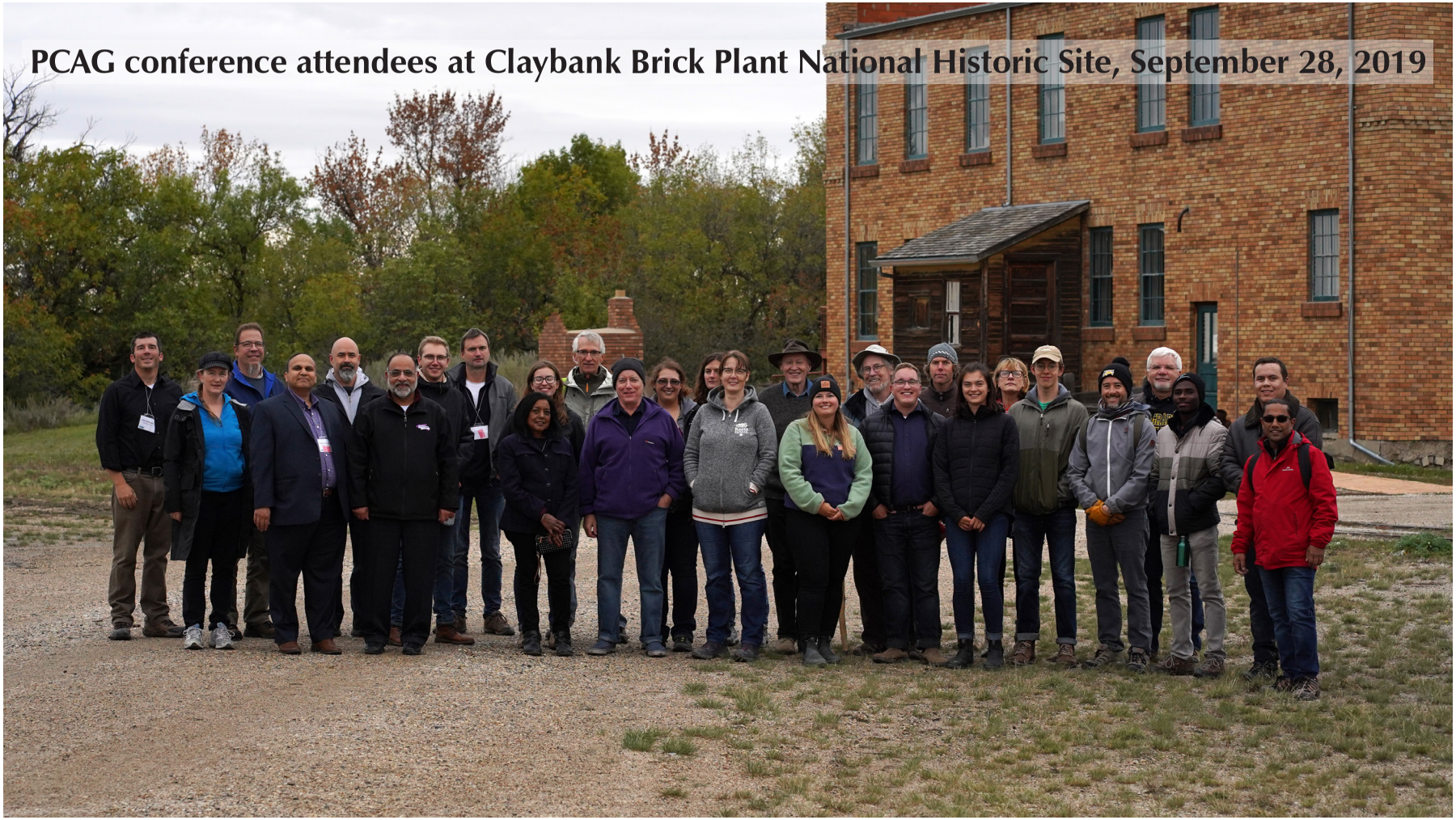
March 2021



PCAG conference attendees at Claybank Brick Plant National Historic Site, September 28, 2019

Left to right: Peter Whittington, Wenonah (Fraser) vanHeyst, Derrek Eberts, Muhammad Iqbal Tubbsam, Dion Wiseman, Abdul Raouf, Anthony Baron, Doug Ramsey, Denise Haqq, Lauren Dyck, Dave Sauchyn, Bernie Thraves, Alyssa Brewer, Rachel Herron, Julia Siemer, Rod McGinn, Catherine Goltz, Ben Moffat, Michael Kvern, Colin Whitfield, Leah Hicks, Ulrike Hardenbicker, Karl Friesen-Hughes, Brent Dolter, Joseph Piwowar, Frank Yamoah, Troy Watson, Sanjay Nepal

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Colony branching among the Schmiedeleut Hutterites of Manitoba

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Key Messages

- Hutterite colonies need to branch to maintain their populations below 160 people.
- Branching involves meticulous division of assets and populations.
- New colony locations are now determined primarily by land prices and distance.

The Hutterites, a German-speaking Anabaptist Christian society that practices communal living, first settled in North America in 1874. In 1918, responding to persecution in the United States, they migrated to Canada. Five colonies from the Schmiedeleut group acquired land in Manitoba's Cartier Municipality. Today, there are 117 colonies in Manitoba and over 500 in North America. Since Hutterites do not proselytize, this expansion is from natural increase only. Colony size is restricted to about 160 people by economic and social considerations. When a colony approaches optimum size, it splits and branches out, creating a daughter colony. The branching process is complex and unique, designed to ensure fairness and equality. The economic, social, and political factors that bear upon this process and the geographical implications of branching are examined and explained with reference to Manitoba colonies currently involved in the process.

Keywords: Hutterites, diffusion, colony branching, Schmiedeleut, Manitoba

Introduction

The Hutterian Brethren (Hutterites) are a German-speaking, Christian Anabaptist group that practices communal living. Their origins, like those of the Mennonites and other Protestant groups, lay in Europe at the time of the Reformation. Persecuted for their Anabaptist and pacifist beliefs they migrated eastwards from Tyrol and Moravia to present-day Ukraine where they practiced community of goods (Horsch 1994). In 1874–1876, to escape Russian pressure to assimilate and to compromise their pacifist beliefs, they migrated to the United States, where they established three colonies in South Dakota. By 1918, these had grown to 21 colonies falling into three groups (*leut,* plural *leute*), the Schmiedeleut (Smith's group), Dariusleut (Darius' group), and Lehrerleut (Teacher's group), named after their leaders.

In 1898, with the eruption of the Spanish-American War, and fearing the introduction of conscription by the United States, the Dariusleut established a colony near Dominion City, Manitoba, as a bridgehead for further movement into Canada should it be deemed necessary. The Dominion Government offered guar-

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antees of exemption from military service, freedom from the swearing of oaths, the right to establish private independent schools, the right to live communally, and the right to share all property (Hofer, Johnny 2019, 22–23). At the conclusion of hostilities, and with the threat of conscription fading, they retreated to the United States.

After the United States entered the First World War against Germany in 1917, the Hutterites were subjected to anti-German hysteria, exacerbated by their adherence to pacifist values and refusal to serve in the US armed forces. Following enforced conscription, seizure of assets and the death of some unwilling Hutterite conscripts in Alcatraz prison, Hutterite leaders elected to abandon their holdings in the United States and move to Canada (Stoltzfus 2013, 23–39, 125–128). In 1919, 15 Lehrerleut and Dariusleut colonies bought land in Alberta whilst five Schmiedeleut colonies acquired land in Manitoba. Between 1919 and 1920, the colonies in the United States began to move to Canada, where the Schmiedeleut re-established in Manitoba's Cartier Municipality.

For generations, even before they left Ukraine, Hutterites had idealized, and sometimes practiced, communal life as an expression of true Christianity and the true way to observe the values of equality, sharing, and pacifism. Colony life as established in North America reflects the ideals of the early Christian Church and, along with worship, is an expression of their faith. Thus, each household has its own dwelling, but all meals are taken communally, and all needs—food, clothing, shelter, household items, medical and dental care—are provided for by the colony. Each member receives a small monthly allowance for personal spending, currently $3 a month for Schmiedeleut members (Hofer, J. 2017). Everyone works according to their ability to do so, although traditionally there is a rigid division of labour by gender. Men and older boys work on the colony farm, or latterly, in colony industries; women and older girls work in the domestic sphere and colony garden.

There is a considerable body of literature dealing with the structure of Hutterite society and the details of colony organization (Peters 1965; Hostetler 1974; Ryan 1977; Hofer, J. 2004; Janzen and Stanton 2010; Katz and Lehr 2014). Many of these, and other studies, mention the process of colony diffusion, and some consider the social and political issues that have influenced the geography of colonies in North America (Laatsch 1971; Evans 2010, 2013). The process of branching was outlined by Peters (1976), while Evans and Peller (2018) recently examined the mechanisms that trigger and guide the process of branching of colonies of all three Hutterite leute and statistically analyzed the effects of various economic and political factors determining the location of colonies. The scope of their survey mandated a general approach. In contrast, this paper focuses on the colony branching process with specific reference to two Manitoba colonies: James Valley and its daughter colony Starlite. Necessarily, it briefly discusses the history of colony branching, and the geography of expansion, before recounting the process of branching currently underway in James Valley and Starlite. The information on which the paper is based was gathered during field visits to James Valley, Horizon, and Monarch colonies between 2016 and 2019, and on the lead author's more than 30 years of interviews and conversations with Hutterites in Schmiedeleut colonies in Manitoba and North Dakota.

The triggers for branching

Hutterite leaders realized long ago that large settlements find it difficult to retain a strong sense of community. They are keenly aware that social harmony depends on all colony members having a job and eventual opportunity to take responsibility for managing an aspect of the colony's economy. While agriculture remained labour intensive and the principal source of colony income there was no problem providing jobs for all. Mechanization and automation in agriculture and access to cheap mass-produced goods changed things. Some jobs disappeared or became redundant, making it difficult to provide enough job opportunities for a colony of over 160 people. Young men were denied opportunity for advancement into positions of responsibility. This, coupled with one of the highest birth rates in the developed world, made it necessary for colonies to develop opportunities for their younger members, prevent social breakdown, and ensure the continuity of their unique society.

Once established in Manitoba, the Hutterites' natural increase soon compelled the largest colonies to branch out, creating new colonies to accommodate their expanding populations. There are now over 534 established and embryonic colonies in North America, of which 384 are in western Canada. Manitoba has 117, Alberta 189, and Saskatchewan 76 (Figure 1). There are two colonies in the Peace River district of British Columbia (Murphy 2019). Hutterites do not proselytize, and it is rare for an outsider to join and remain in their community, so this expansion has been driven solely by natural increase. To simply acquire more land and expand an existing colony does not solve the employment issue nor the issues attending the governance of a large community. Starting a completely new colony and endowing it with enough land for it to be economically viable is the only remedy. The ideal situation is to obtain land close to the existing colony, which reduces the cost of establishment and facilitates maintenance of family ties. This is not always economically possible nor, in the past, was it politically feasible, as will be discussed below.

Not all branching is a response to population increase. Colonies have solved internal discord by branching when the population was nowhere close to the optimum number. For example, Bloomfield Colony, when beset with internal conflict, branched when its population was little more than 100 people, establishing a daughter colony, Westroc, scarcely six miles (10 km) away. Similarly, Heartland Colony was created after an acrimonious legal case divided Lakeshore Colony, with one side leaving to establish their own colony.

In the early 1990s, a schism occurred within the Schmiedeleut colonies over the question of leadership and the introduction of more liberal values. The complex issues behind this split

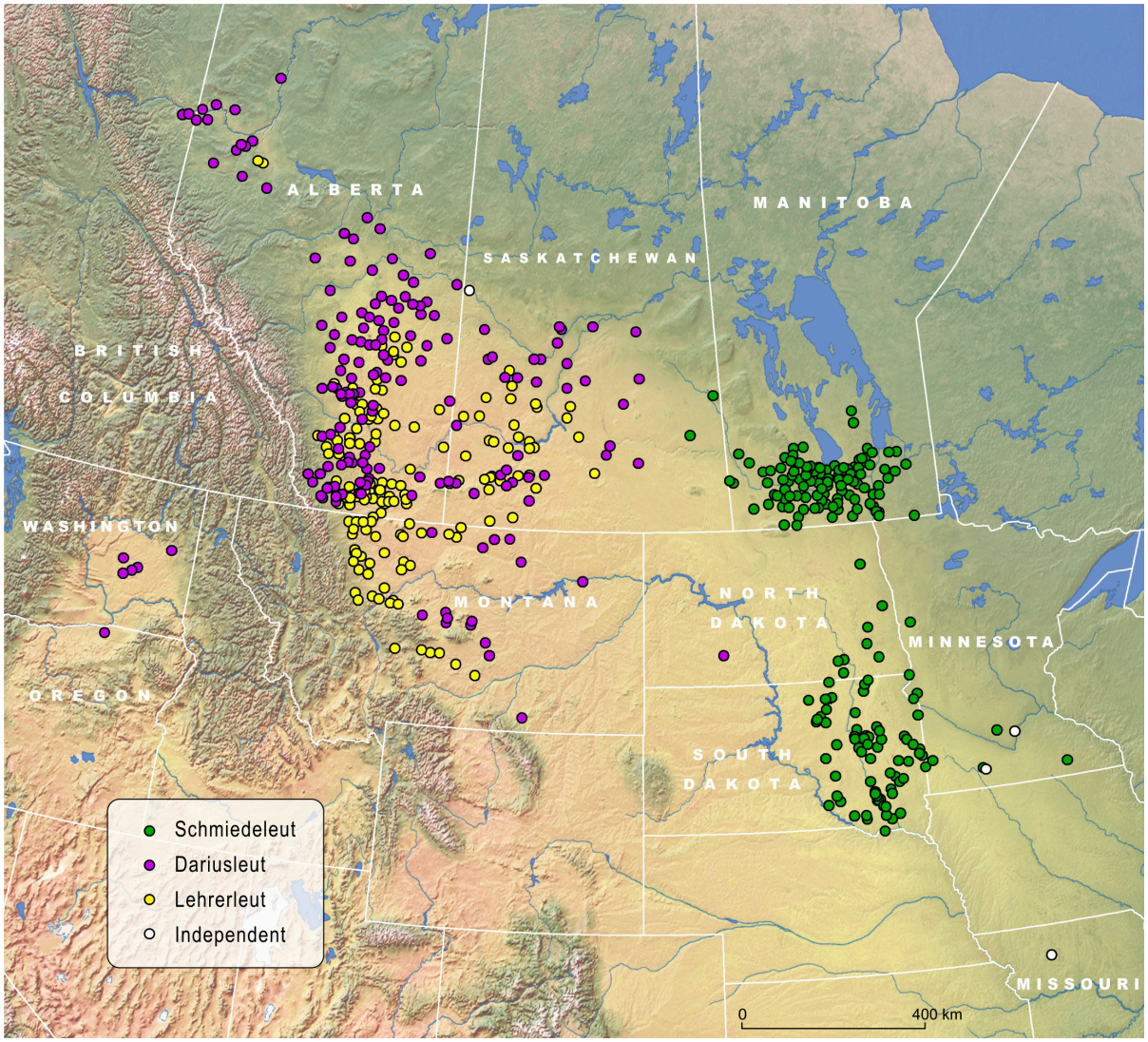

Figure 1
Hutterite colonies in North America in 2019
Cartography: W. Hiebert
Basemap: Natural Earth

are discussed in detail by Janzen and Stanton (2010) and Katz and Lehr (2014). In most cases entire colony populations agreed on their stance but some colonies were divided as to which side they would support. To avoid friction some of these colonies hastened the process of branching to enable families supporting each side to live together on one colony. An unfortunate consequence of this premature branching was the undercapitalization of both the mother and daughter colony and real financial hardship for both, which in some cases has lasted for over a decade (Hofer, G. 2019). The surge in colony branchings in the latter half of the 1990s is directly attributable to internal friction triggered by the schism.

In the past two decades, many Hutterite colonies have chosen to industrialize to delay the need to branch. Introducing an industrial operation generates additional income, but, perhaps more importantly, it provides more jobs and opportunities for colony members to achieve positions of responsibility, and thus delays somewhat the need to branch. In the 1970s, it was rare to find a colony that had any industrial endeavour; today very few colonies do not have an industrial component. James Valley Colony and its embryonic daughter colony, Monarch, are unusual in not having any significant source of income other than agriculture. Rock Lake Colony, near Rosser, for example, has an economy that rests on three endeavours: a farm operation, a metal fabrication shop (Bruder Built Manufacturing), and a sand and gravel operation (Hofer, B. 2018; Gross 2018).

Colony expansion in Manitoba

In 1918, five Schmiedeleut colonies in South Dakota (Bon Homme, James Valley, Maxwell, Milltown, and Rosedale), moved north to Manitoba to re-establish themselves in Cartier Municipality. Cartier's population was then largely French-speaking

and less xenophobic than areas that were solidly British. Many Francophones were opposed to conscription and had fewer reservations about selling land to pacifist German-speaking immigrants. The colonies all purchased land that was either on the banks of the Assiniboine River or situated on one of its paleochannels. Within a year of its arrival in Manitoba, Rosedale Colony branched, creating a daughter colony, Iberville, which was also located within Cartier Municipality (Figure 2). Milltown Colony branched in 1922, creating the first colony outside Cartier Municipality when it purchased the entire Mennonite village of Blumengart, whose inhabitants had all left for Mexico. During the inter-war period colonies continued to branch. All purchased land in southern Manitoba, primarily in Cartier Municipality and adjacent rural municipalities. In the 1950s, mechanization changed labour needs, reducing job opportunities, and spurred more frequent branching. James Valley did not need to branch until 1946 and Iberville, established in 1919 by Rosedale Colony, did not branch until 1947 when tractors began to replace horses and their colony populations reached beyond optimum size (Figures 2 and 3).

Following Canada's declaration of war on Germany in 1939, Hutterites once again felt the chill winds of anti-German prejudice. There were allegations that the presence of Hutterite colonies led to the decline of rural businesses, pushed up land prices, and contributed to rural depopulation. Although none of these claims withstood scrutiny, popular opinion pressured provincial governments across western Canada to place restrictions on the spread of colonies and enact strategies that prevented the concentration of colonies in certain areas. In Alberta, for example, an Act compelled any new colony to locate at least 40 miles (64 km) from an existing colony (Laatsch 1971; Katz and Lehr 2014; Evans and Peller 2018). No such legislation was enacted in Manitoba but a "gentleman's agreement" was concluded between the provincial government and the Hutterite leadership, which stipulated that henceforth colonies would be no larger than 5,120 acres (2,072 ha), with at least 10 miles (16 km) between colonies, and there would be no more than two colonies in any rural municipality (Katz and Lehr 2014, 62–64).

In 1969, the Manitoba colonies made it clear they no longer considered themselves bound by this agreement since it flew in the face of emerging concepts of human rights. In 1971, New Rosedale Colony purchased a disused Commonwealth Air Training Plan airfield near Macdonald, Manitoba, as a site for a new colony. Its location contravened the Gentleman's Agreement. The Provincial Premier at the time, Edward Schreyer, was sympathetic. Realizing it was discriminatory and would not

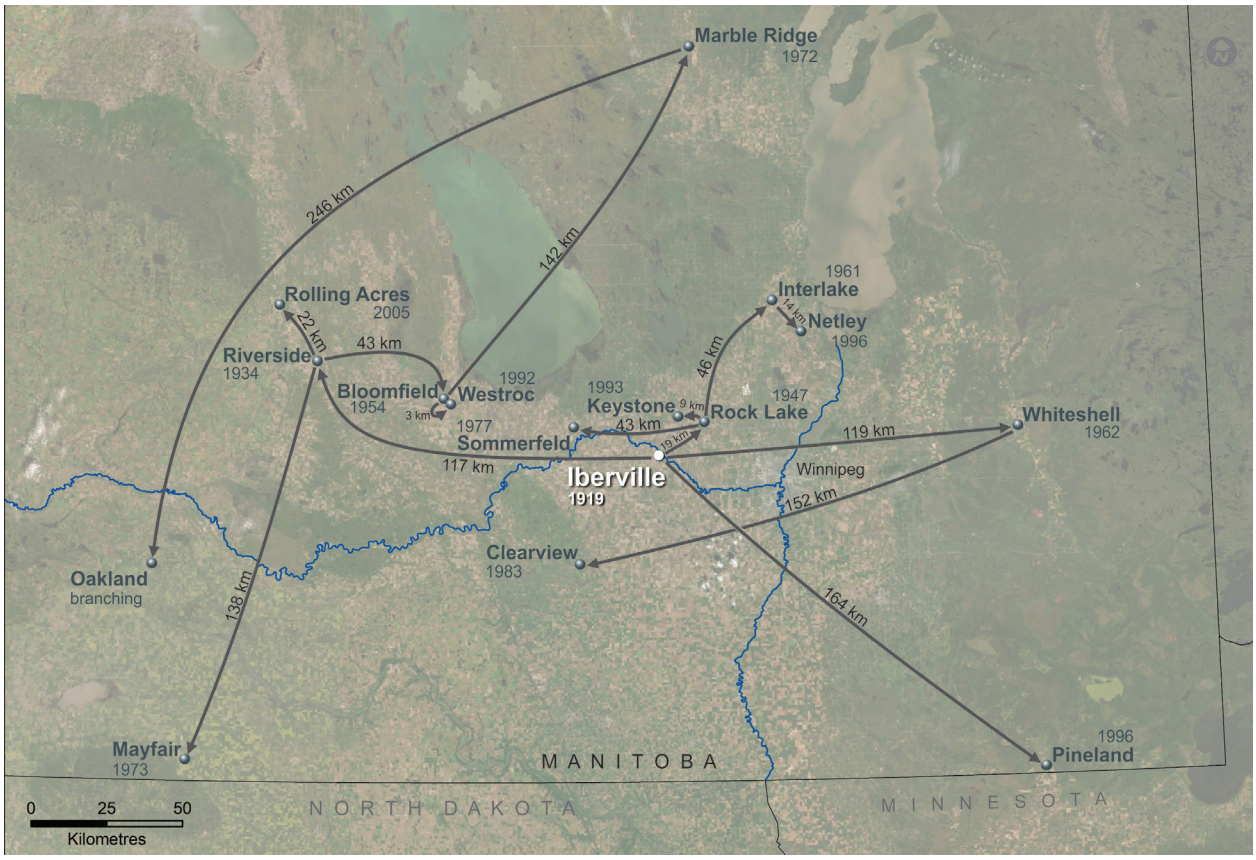

Figure 2
Iberville Colony's branching history
Cartography: B. McGregor
Basemap: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

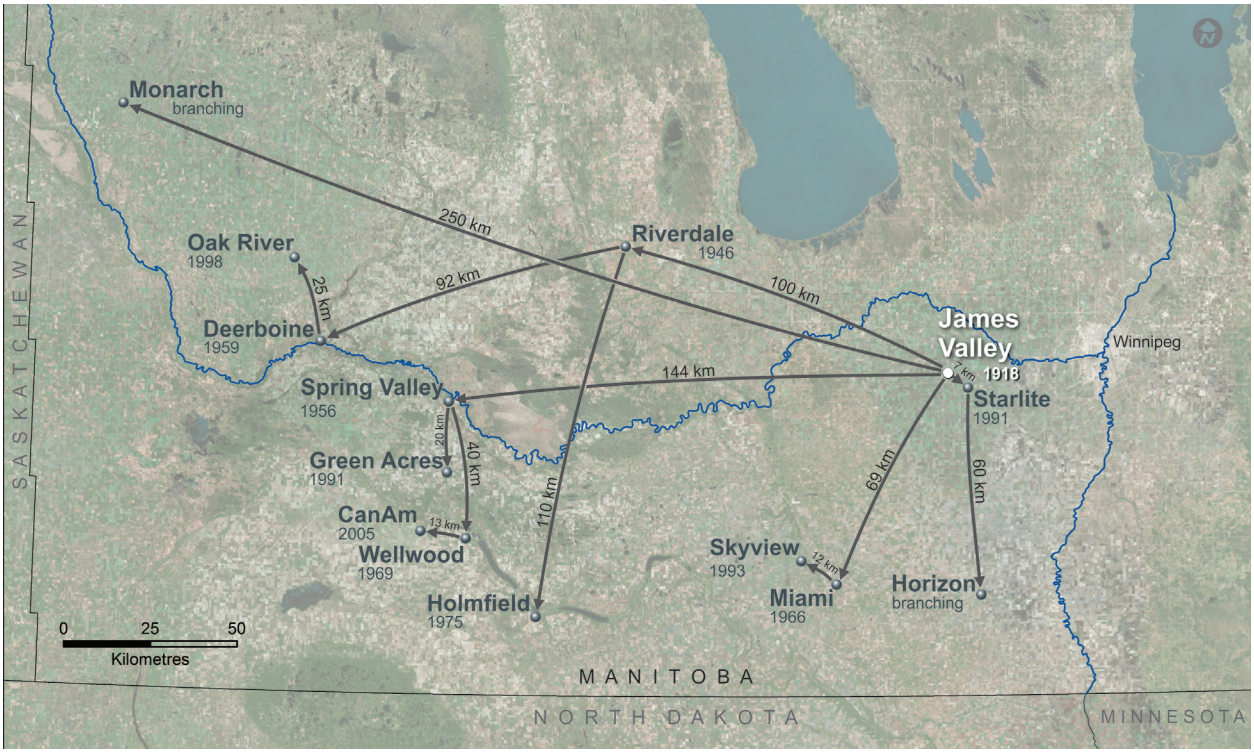

Figure 3
James Valley Colony's branching history
Cartography: B. McGregor
Basemap: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

withstand a legal challenge, he declared the Gentleman's Agreement invalid. Airport Colony now occupies the site of the former base. Thereafter, colony locations within Manitoba were free of restrictions; they are determined solely by the costs involved in colony branching, which in turn, are largely a reflection of land availability, its quality, and price. The impact of the removal of any legal restrictions upon colony location was certainly evident when James Valley Colony branched again in the 1980s. Its new colony, Starlite, was located scarcely six miles (10 km) away on newly purchased land supplemented by a portion of the 3,000 acres (1,214 ha) then owned by James Valley (Figure 3).

Hutterite principles and the mechanism of colony branching

In Hutterite society the structure of colony governance follows a pattern that has endured since their early years in Europe. Although day-to-day decisions are made by the minister, colony boss, and farm boss, decisions involving major expenditures are voted on by all eligible colony members, that is, by all baptized male members of the colony. Women have no vote, but their opinions and wishes, especially on domestic issues, are conveyed through their husbands and brothers (Katz and Lehr 2014, 160–176). It is apparent, for example, that women's opinions were considered in the process of selecting a location for the new colony when James Valley recently acquired land near Foxwarren, as discussed later in this paper. On the other hand, most women express little interest in decisions about the purchase of agricultural machinery or other financial matters that they consider to be beyond the domestic sphere.

The ethical and religious principle that underpins Hutterite life, and which separates them from other Anabaptists such as the Mennonites and Amish, is that of equality and community of goods. To this end, when a decision to branch out and create a new colony is agreed upon, no decision is made as to which families will remain on the existing colony and which will eventually move permanently to the new colony. Thus, any decisions that affect the new colony are made in a completely dispassionate way without favouring either the mother or daughter colony. No shortcuts are made in developing the infrastructure and economy of the new colony. It is important that the standard of housing and agricultural equipment on the new colony equal that of the old. Those who build the new colony and operate it until the final act of branching remain unsure as to whether it will be their new home until a few weeks, even days, before the new colony formally becomes independent. When the time comes to make the formal split, two groups of families are assembled, each of which includes people with the requisite skills and trades required to operate a colony. This is less difficult than might be thought, as most men have experience of working in several aspects of colony life, assisting with plumbing, carpentry, mechanical jobs, animal care, and so forth.

As far as possible the two groups are formed through mutual consent but if agreement cannot be reached lots are drawn to decide who will be placed in each group. Nuclear families are not divided nor are widows assigned away from their close relatives (Hofer, G. 2019). Division of the colony's assets at final branching is meticulous. All assets are inventoried and valued, and, if the population cannot be divided perfectly evenly, financial adjustments are made to ensure neither colony is disadvantaged. Dairy and other agricultural quotas are split. If this is not appropriate to the new colony's agricultural economy, financial restitution is made. The inventory of physical resources is meticulous. Any outstanding debts, and mortgages on land, are assumed equally by the two colonies.

An accounting of the branching of James Valley in 1966, when its daughter colony, Miami, became independent, shows the level of detail at which assets were inventoried. The 27 outhouse toilets were divided between the two colonies, as were all other assets such as machinery, scrap lumber, wood for burning, railway ties, livestock, and grain in storage. Buildings on both colonies were valued and appropriate financial adjustments were made. Each family was to keep its own garden shed and an undertaking was made by James Valley to provide Miami Colony with eggs and chickens until it was able to provide its own supply (Hofer, Johnny 2019, 170–171).

As far as possible, the process of dividing assets is completely dispassionate. It is quite possible that a family that has lived on the daughter colony since its inception, which might well encompass a period of several years, will find itself back on the mother colony when the final act of branching is completed (Hofer, Marion 2018; Hofer, G. 2019). Even after branching is complete, and the new colony has financial independence, a special relationship between the mother and daughter colony continues until the daughter colony itself branches. Until that time, as a reflection of the close socially supportive relationship that exists between them, it is customary for the daughter colony to invite members of its mother colony to the engagement party (*hulba*) of any of its members (Hofer, S. 2017).

Despite the meticulous concern to divide physical and economic colony assets equably, the economic progress of colonies that branch is not always equal. Leadership ability is an intangible and not always evident attribute that is crucial to the economic and social well-being of a colony. Colonies that branch can see wide divergence in their economic progress and degree of social harmony that may be attributable to the ability (or lack thereof) of senior colony managers on each colony. Despite the meticulous concern to be equitable, disparity is inevitable. In part this is due to the division of property being made on a purely financial basis. At the time a colony formally splits buildings and infrastructure are valued. Because the buildings on the mother colony are older, they have less value, conversely the newer buildings on the daughter colony are valued more highly. Thus, at the time of the split the new colony may have fewer facilities because those it has are of greater value. There are also many "small things" (such as landscaping) that an older colony will have but are not present on a newly minted colony and do not enter the valuation equation. Some new colonies, such as Pineland and Little Creek colonies, could not afford to build a kitchen and for up to 20 years cooked in a makeshift kitchen located in "the shop" (Hofer, G. 2019; Hofer, Maria 2019). Generally, the inevitability of some disparity caused by the financial valuation of assets, means that most new colonies find it difficult financially for their first ten years or so (Hofer, G. 2019).

The creation of Monarch Colony by James Valley Colony

The branching history of James Valley Colony is depicted in Figure 3. After locating in Manitoba in 1918, it did not branch until 1946 when its first daughter colony, Riverdale, was established near Gladstone. Ten years later a second branching created Spring Valley Colony near Brandon. After another ten years it branched again, creating Miami Colony near Miami on the Manitoba Escarpment. It next branched in 1991 when Starlite Colony was created. This series of branchings took a heavy financial toll on James Valley, since at each branching the colony effectively lost half of its assets.

By 2010 James Valley's population had again risen to over 140 people, half of whom were under 15 years of age. It became clear to colony leaders that with an increase expected to push the population well over 160 people within the next decade, it would be necessary to branch once again. It is difficult, however, to define precisely when the branching process was started. Initially, informal discussions soon ruled out repeating the Starlite strategy. Land prices in Cartier Municipality were far too high for James Valley to be able to afford the purchase of enough land to sustain a colony. Colony leaders then considered purchase of land in the Pembina Valley region of southern Manitoba but rejected the idea after weighing the region's land prices, topography, and land quality. Land in the Interlake region also was available at an affordable price but since it was located close to Lake Winnipeg the leadership feared the interests of cottagers would dominate the politics of the rural municipality and the concerns of cottagers would outweigh those of agriculturalists (Hofer, J. 2017). Attention then turned to the possibility of acquiring land in east central Saskatchewan, where affordable land was available. While the location was economically attractive, misgivings were expressed about its distance from James Valley. In the short term this would make developing the new colony more difficult and costlier, but the long-term social consequences aroused the greatest concern. Many, especially women, feared a reduction of contact with friends and relatives given the four to five hour driving time between James Valley and the potential site. The option was rejected, and the colony continued to search for land in Manitoba.

Such considerations did not deter other Manitoba colonies from acquiring land in Saskatchewan. Cypress Colony, for example, now in the process of branching, purchased land near Kamsack, Saskatchewan, for its new colony, Clarion. The latter is about 236 miles (380 km) distant, some four hours by road from the mother colony. Coolspring and Brentwood colonies, also in the process of branching, have acquired land near Melville in

Saskatchewan (Hofer, Johnny 2017; Murphy 2017). This move west from Manitoba by the Schmiedeleut does not sit particularly well with some of the Dariusleut in Saskatchewan, who fear competition for land from the Schmiedeleut and concomitant increase in land prices (Wollman 2017).

Through the services of a real estate company, in 2014 James Valley received notice that a large 3,040-acre (1,230 ha) operating grain farm with grain storage bins and buildings near Foxwarren, Manitoba, was on the market for $10.5 million. From James Valley Colony's perspective, it had several advantages in terms of land quality, price, and land contiguity, although at 170 miles (273 km) away (about three hours by road), the distance from James Valley was greater than wished. Nevertheless, after securing a mortgage against James Valley's land, the farm was purchased, and the decision made to crop the land pending the establishment of a colony. A team of six men was dispatched to prepare the land for the coming year. They resided temporarily in a local motel, returning to James Valley for the winter. Working the land familiarized them with the area and facilitated the selection of the site for the placement of the new colony buildings.

When the previous owner vacated the property, its large farmhouse was converted to accommodate three Hutterite families—the newly appointed colony minister, David Hofer, who was formerly the second minister at James Valley, and two of his sons' families. This location then constituted the temporary hub of the embryonic colony, pending the development of a permanent colony site on an adjacent quarter section (Hofer, D. 2017a).

After the colony began to work the land, they were approached by a neighbouring farmer who wished to sell but insisted that no real estate agents be involved. His view was that both sides would benefit from excluding agents and the cost of commissions on land sales. When the colony minister suggested they meet in a lawyer's office to reach an agreement, the farmer demurred, asking "Why not sit down on the truck tailgate and reach a country-style deal?" (Hofer, D. 2017a). This adjacent farm, comprising 4,620 acres (1,870 ha) with a house and buildings, was thus acquired (Figure 4). Its farmhouse was later rented to the colony's two non-Hutterite schoolteachers.

Initially the new colony was referred to simply as James Valley Farm or "the farm." As more people moved to the farm a name was needed. Several suggestions were made, including the witticism "Foxwarren Peace," a pun on Tolstoy's novel, *War and Peace,* though one not out of keeping with Hutterite values.

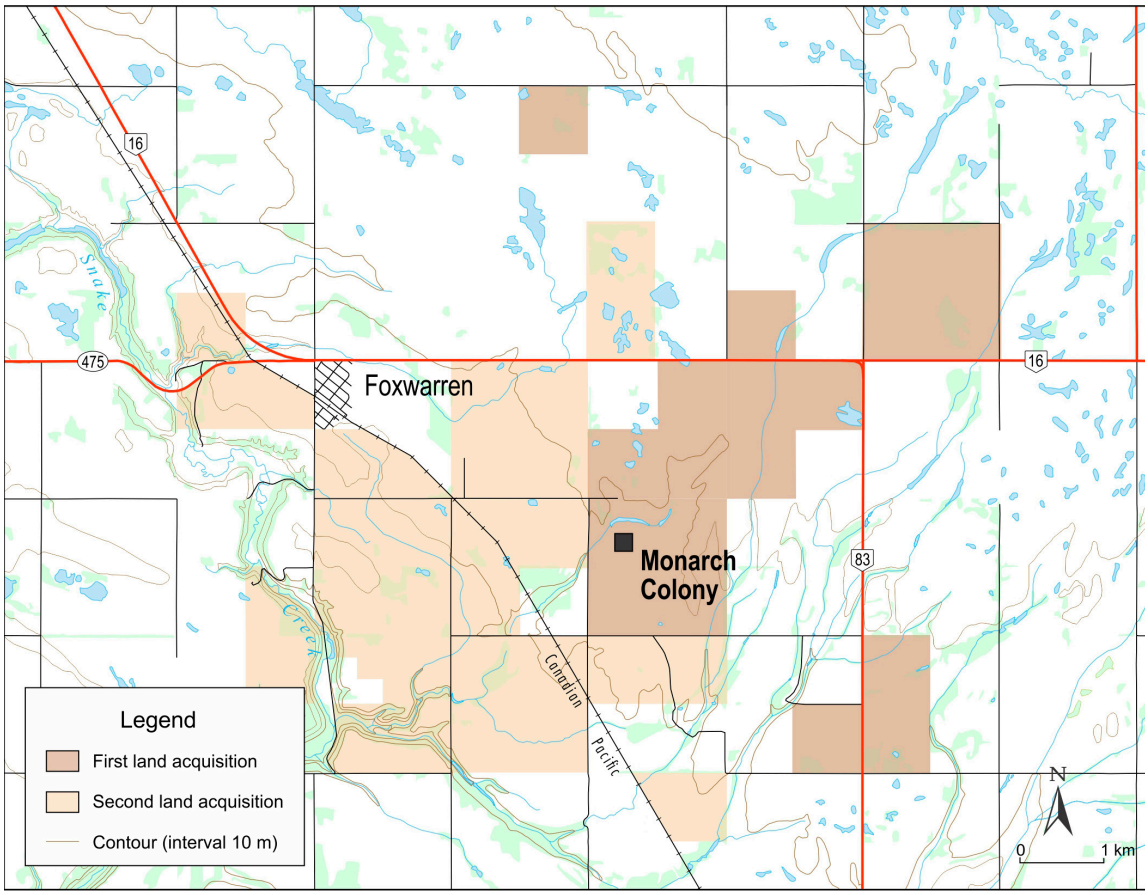

Figure 4
Monarch Colony land holdings
Cartography: W. Hiebert
Basemap: Open Government Licence – Canada

The three most popular suggestions were voted on. Monarch, after the Monarch butterfly, was the winner (Murphy 2017).

From the outset, the intention was for Monarch Colony to have a mixed agricultural economy, "grain and dairy cattle, maybe some hogs and chickens," although at present, except for a small 10-acre (4 ha) vegetable garden for colony needs, Monarch remains exclusively devoted to grain. There are no plans to develop industry since Monarch is presently short of labour. David Hofer, the minister, noted that "going into industry is good in the sense it provides jobs which are limited when the colony only has agriculture" (Hofer, D. 2017a). Monarch, at least for the next decade, will have high labour demands.

The costs associated with branching have increased dramatically over the past 50 years as a result of higher land prices, the need to purchase quotas for dairy operations, and the increasing complexity of agricultural technology. When Miami Colony branched from James Valley Colony in 1966, the total value of both colonies was estimated at $228,950 ($1,776,964 in 2019 terms). When Starlite branched from James Valley in 1991 the total assets of both colonies were estimated to be $4,349,603 ($7,158.503 in 2019) Hutterite leaders estimate the total cost to establish Monarch as a fully independent colony will be in the region of $35 million (Hofer, Johnny 2019, 172, 187).

This is a heavy financial burden that will be born equally by James Valley and Monarch when the latter becomes fully independent. Some Hutterite leaders express concern that with high land prices and the high capital inputs required for modern agricultural operations, any rise in interest rates will render colony branching impractical unless industrial activity assumes a more important role and agriculture is scaled down to a level enough only to serve a colony's immediate needs. If that is the case, the area needed for colony agricultural operations could be reduced to "a hundred acres or so" (40 ha), a far cry from an average sized Manitoba farm at 1,192 acres (482 ha) or Hutterite colony of about 4,500 acres (1,821 ha) (Ryan 2013; Statistics Canada 2017).

Until the branching is complete, which is several years away, Monarch remains legally a part of James Valley Colony. Although in its daily operations it functions as a separate entity, the strategic decision-making rests with members of both operations. Social ties between James Valley and Monarch remain strong. To help reduce the frequency of the cooking duties for the women at Monarch, two young women travel from James Valley to Monarch every three weeks to assume the cooking duties for a week and give some respite for the Monarch women (Hofer, R. 2019).

The creation of Horizon Colony

Starlite Colony's branching followed a somewhat different trajectory. In 2007, when it became apparent that Starlite needed to branch, it began the search for land by inspecting eight potential sites in Manitoba and Saskatchewan before deciding to purchase 2,000 acres (809 ha) and later acquire a further tract of 2,500 acres (1,012 ha) near the village of Lowe Farm, Manitoba. Distance was a factor in the decision-making. The Saskatchewan location was rejected primarily because it was considered too remote from Starlite whereas the Lowe Farm site at about 37 miles (60 km) or an hour's drive south of Starlite (Figure 2) did not pose the same logistical issues (Hofer, G. 2019). Despite this, the land purchased was somewhat fragmented (Figure 5).

Since their new colony was within a daily commute distance, Starlite was able to install the colony infrastructure (including geothermal heating) and build two duplex-style houses before any members of their community commenced permanent residency on the new site (Figure 6). Most of the work was done by Starlite members, although contractors were used for some specialized tasks such as applying stucco, taping walls, and some electrical installation (Hofer, G. 2019).

Development was rapid. The first buildings erected were a machine shop and cement plant, which were built in 2010; two houses were completed in 2011, and another house and sewage lagoon were constructed in 2012. Construction also began on the church. On 7 November 2012, the first two families moved from Starlite to the new colony; followed by four more families one week later. In 2013, a "ready to move" (RTM) mobile home was moved on to the site and another family moved down from Starlite. One more house was built and the church was completed. Construction began on the colony kitchen in 2014. The barn office was built in 2015 and a second large machine shop was added in 2016 (Figure 7). Construction started on two more four-family houses, which were completed in 2019.

As with many colonies the name of the new colony was selected from suggestions given by community members. The leadership made it clear that it did not want a "double-barreled" name. Three suggestions were posted in the bulletin board—Sunrise, Kelowna, and Horizon. Members indicated their preferences, with Horizon being the most popular (Hofer, Maria 2019).

Gerald Hofer, the present minister at Horizon, considers 4,500 acres (1,821 ha) to be economically marginal if the colony relies only on its principal crops of canola, wheat, and soybeans. Fortunately, a hog operation with some 400 sows was included with the purchase of one land parcel, enabling the colony to diversify its agricultural operations

In 2019, Horizon's manufacturing and laser-cutting metal enterprise contributed some 10% of colony income, with the potential to provide additional income and jobs in the future (Hofer, G. 2018). Like most colonies, Horizon also has a vegetable garden of about 7 acres (3 ha) that fulfills the colony's needs; surplus produce is hauled to Winnipeg where it supplies a major supermarket chain on a seasonal basis.

By November 2019, Horizon had eight families comprising 55 people, still far less than the 26 families and some 150 people remaining in Starlite (Hofer, Maria 2019). Inability to reach agreement on the division of the population, which involves the splitting of extended family groups, has delayed conclusion of the branching although the process is expected to be completed in 2020.

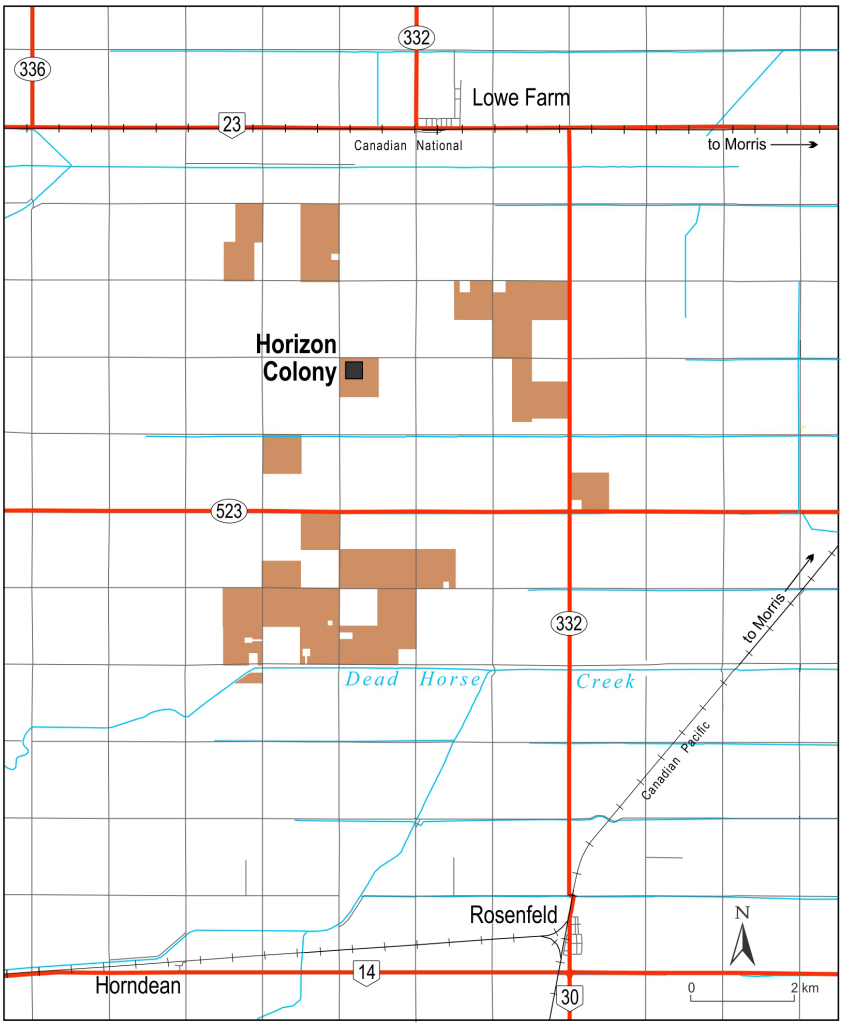

Figure 5
Monarch Colony land holdings
Cartography: W. Hiebert
Basemap: Open Government Licence – Canada

Figure 6
Duplex-style housing units at Horizon Colony, 2018
Photography: J. Lehr

Figure 7
Machine shops at Horizon Colony, 2018
Photography: J. Lehr

Designing new colonies

When the Hutterites first located in Canada, colonies followed a standard layout. Domestic buildings, usually duplexes accommodating two or three families, were placed around three sides of a quadrangle with the kitchen/dining hall along the fourth side. Agricultural buildings were placed separately away from the living quarters. In the 1970s, some new colonies began to arrange the placement of domestic buildings differently, locating them in a circle around the kitchen/dining hall. This layout facilitated access to all dwellings by vehicles and ensured equality of access to the central services. Its drawback was the difficulty of accommodating new dwellings as the colony's population grew. From its inception Starlite was planned in this style. Even James Valley began to move towards this plan as it expanded its accommodation in the early 2000s. Figure 8 illustrates the beginning of what will be a long and slow transition to a new colony plan for James Valley.

A variant of the circle plan has become increasingly common in the past decade. Dwellings are placed in a horseshoe formation with the kitchen/dining hall spanning the gap at the top of the horseshoe. This arrangement of dwellings has been adopted by both Monarch and Horizon colonies (Figures 9 and 10).

Plans for the new colonies were drawn up before the branching process was initiated. James Valley Colony members decided on a horseshoe shape plan for Monarch, which was accepted without any significant modification. By using a horseshoe plan they hoped to keep the advantages of the circle formation in terms of access yet allow room for additional dwellings at the ends of the horseshoe if more were needed (Hofer, D. 2017b).

Monarch's infrastructure (e.g., sewer, hydro) was installed by 2017, although no buildings were yet in place. Several RTM units constructed on James Valley Colony were moved on to the site late in 2016 and placed on preconstructed concrete basements aligned across the open end of the horseshoe (Figure 11). Each RTM serves as temporary accommodation for one family until permanent houses can be built. One RTM unit houses the kitchen, another the dining area and laundry, and another two RTMs house the colony school. Among the first utilities established on the new colony were a water purification plant, an electricity network, and a sewage disposal system. Early in 2017 construction began on a large machine shop. This provides space for storage and repair of agricultural machinery and other

Figure 8
Plan of James Valley Colony in 2018
Cartography: W. Hiebert

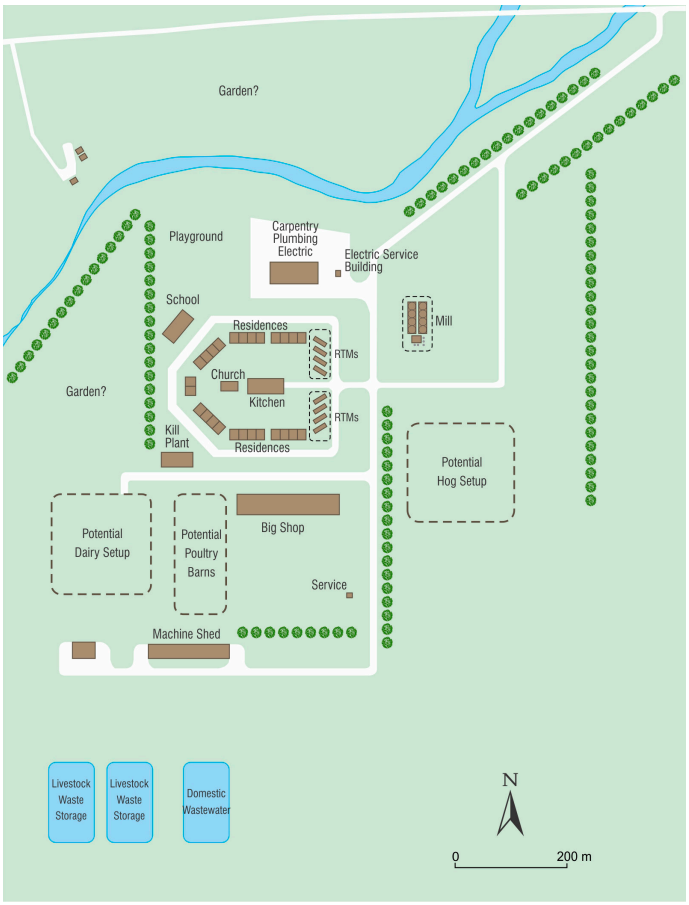

Figure 9
Plan of Monarch Colony in 2018
Cartography: W. Hiebert

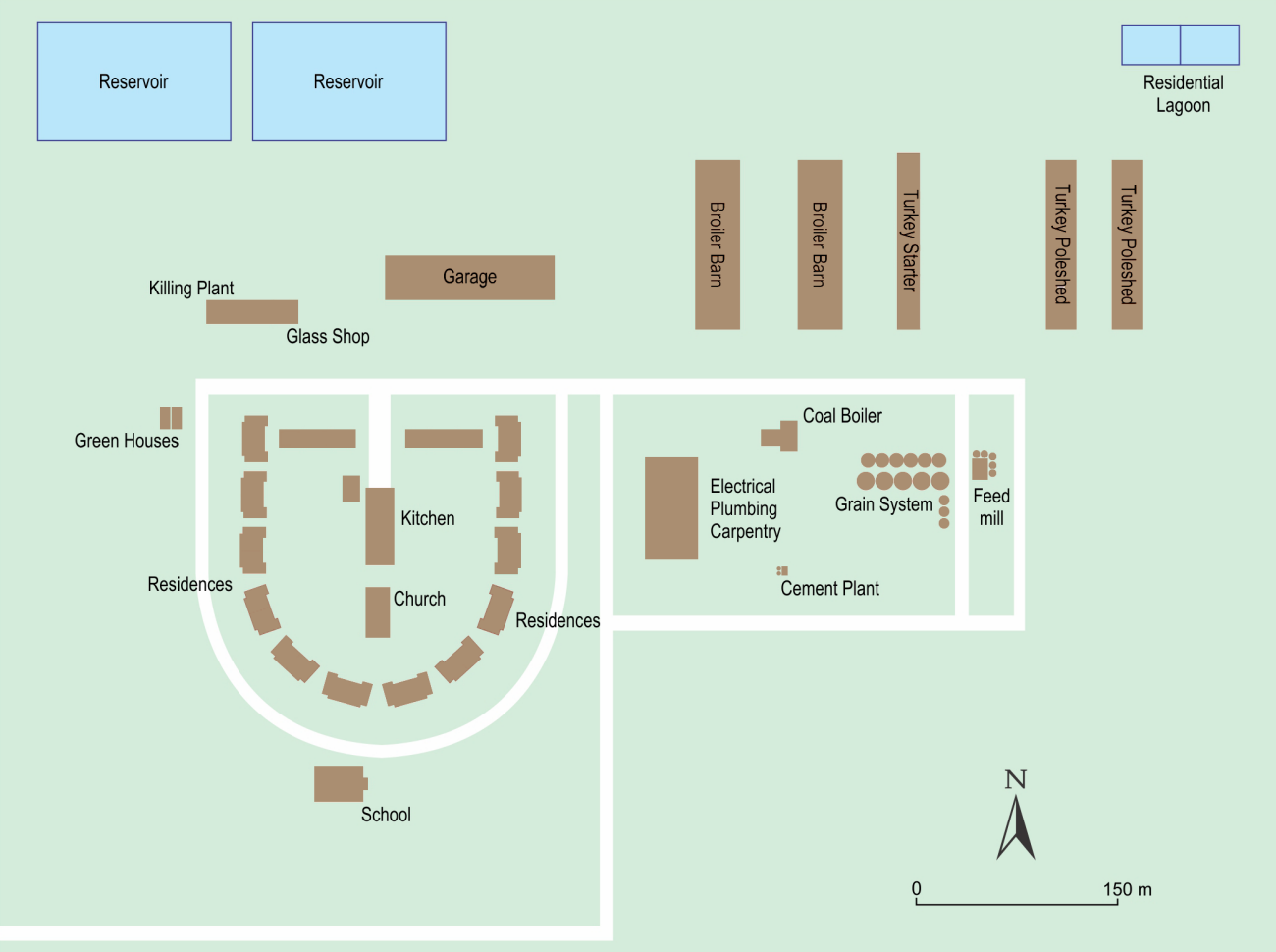

Figure 10
Plan of Horizon Colony in 2018
Cartography: W. Hiebert

Figure 11
Ready to move (RTM) mobile home units at Monarch Colony, 2017
Photography: J. Lehr

vehicles, and also houses the carpenters' shop. Later in the same year a sewage lagoon was excavated, freeing the colony from reliance on sceptic tanks (Hofer, D. 2017a).

Outsider attitudes

The Rural Municipality of Prairie View, within which Monarch is located, was created in 2015 through the amalgamation of two smaller rural municipalities with declining populations. Decker Colony to the north of Brandon also falls within this new municipality. Municipality administrators were thus familiar with colony needs. Monarch's members commented that they felt extremely welcome in the area, more welcome than in Cartier RM, which had a high concentration of colonies (Hofer, Michelle 2017). In Prairie View RM, an area that has experienced rural depopulation over past decades, the industrial and agricultural base of Decker, a long-established colony, adds to the tax base. As Monarch develops it will also contribute to the local tax base, something most rural municipalities welcome. Many federal and provincial grants to rural municipalities are made with formulae

that factor in population counts, hence the presence of a colony with upwards of 50 people can make a considerable difference to the income of a rural municipality. This revenue boost comes at little cost as the basic communications infrastructure is usually already in place and, in most respects, colonies are self-sufficient, providing their own water, sewage disposal, fire protection, and school buildings. Furthermore, Hutterite populations are dense, more easily serviced than comparable numbers of people scattered on small acreages (Gaudry 2018). It is worth noting that Hutterites do not speculate in land; they purchase land to farm it and, since colonies seldom fail, they remain on the land. Any population gain within a municipality that results from the creation of a colony will be permanent.

Hutterites regard their colonies as arks of Christianity adrift in a sea of sinful secular values. While on the one hand their leaders wish to reduce exposure to the outside secular world, they recognize the inevitability of interacting with it and the need to maintain good relations with their neighbours. Many colonies contribute to rural firefighting capabilities and support local food banks and other charitable organizations. In some colonies, members serve as volunteer first responders (Wollman 2017). Still in its embryonic stage, Monarch has not yet developed strong relationships with the surrounding community, though its members are becoming a familiar sight in the nearby town of Birtle.

Attitudes to their new, and possibly temporary, home by daughter colony members vary. Michelle Hofer who, on marriage, moved from her home colony of Pembina to her husband's colony (James Valley), as is customary, noted she liked the rolling scenery around Monarch and along the Birdtail River, which reminded her of her home colony on the Pembina Escarpment (Hofer, Michelle 2017). She remarked, "There's all kinds of wildlife around here, even bears, and the scenery is nice." Asked whether she would rather remain in Monarch or return to James Valley when branching was finalized, she smilingly replied, "That depends on who stays and who comes" (Hofer, Michelle 2017). Members of Horizon Colony, who moved from Starlite, situated in a more treed area near the Assiniboine River, commented that the constant prairie wind at Horizon "takes some getting used to" (Hofer, G. 2018). Since Horizon is in a very sparsely populated area and relatively difficult to find, the 3,000 trees the colony intends to plant are for windbreaks and aesthetics rather than to screen the colony from the outside world.

Almost all colonies in the parkland belt and many in more arid regions have residences, and sometimes agricultural buildings, screened from public view by vegetation. Colonies are usually set back from roads and are designed to be inconspicuous. Monarch is sited on open ground, exposed to the elements and public view from adjacent highways. It plans to plant 2,000 trees around the colony that, in 20 years or so, will shield it from public view (Hofer, D. 2017a).

Conclusion

The branching process is essential to the survival of the Hutterite way of life based on community of goods. It controls the size of colony populations, keeps them administratively and economically viable, and ensures the creation of meaningful jobs for an expanding population. The process is governed by concepts of equality, fairness, and holding all things in common that are deeply entrenched in Hutterite culture.

To outsiders Monarch now appears to be a fully functioning Hutterite colony, albeit an embryonic one. It is still some years away from being so, however. It will be another several years before Monarch is fully independent of James Valley (Hofer, J. 2017). Monarch's finances remain the responsibility of James Valley; financial decisions are made by the James Valley leadership, and Monarch's members are still members of the James Valley congregation. When the final split occurs those presently in Monarch may well return to James Valley, replaced by families who have had little direct connection with Monarch. In 20 to 30 years, when Monarch's population begins to approach 140 people, thoughts will once again turn to branching and the process will be repeated. Horizon Colony is much further along the branching process and will likely become a fully independent colony late in 2019 or during the spring of 2020. Even after branching, family ties will ensure the continuation of a strong relationship between the mother and daughter colony.

It is also clear that it is almost impossible to achieve total equality in the division of colony assets. Placing a financial value on all physical assets is fraught with problems, especially when there is a long time between branchings and there is a great disparity in the assessed value of buildings on the two colonies. The burden, it seems, falls mostly on those who are selected to populate the daughter colony. It is also evident that branching carries huge financial obligations that will continue to affect both the mother and daughter colony for many years.

Although this discussion has been confined to the Schmiedeleut colonies of the Hutterite Church, the branching processes of Dariusleut and Lehrerleut colonies are very similar. A common concern is the need for equality between mother and daughter colony and the maintenance of fairness and randomness in the assignment of members to the respective colonies at the time of the final split.

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Comparative analysis of ground elevations derived from RPAS-based LiDAR and ground-based TLS/RTK data

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Key Messages

- Ground-based surveying techniques are time consuming but provide more accurate spatial information than RPAS-based LiDAR systems.
- Ground elevation errors in DEM generated from RPAS-based LIDAR point cloud data do not follow a normal distribution and may increase with slope.
- RPAS-based LiDAR is unsuitable for projects requiring accuracy at the centimetre or sub-centimetre level, but is effective for projects where ground elevation accuracy requirement is moderate.

Remotely piloted aircraft systems (RPAS) are becoming increasingly popular within geomatics engineering as data collection platforms. Advancement of light detection and ranging (LiDAR) and development of light weight LiDARs have made it possible to mount LiDAR systems on RPAS. These LiDARs are capable of acquiring three-dimensional spatial information and have opened up new application areas such as stockpile volume calculation. Multiple options are now available for such applications including differential levelling, real-time kinematic (RTK) and terrestrial laser scanning (TLS). However, ground elevation accuracy derived from RPAS-based LiDAR point cloud data needs to be evaluated for its suitability in specific applications. Research reported here evaluates the accuracy of ground elevations derived from RPAS-based LiDAR point cloud data by comparing them with elevations extracted from RTK and TLS ground-based equipment. Field experimentation was conducted in a controlled environment to isolate random errors arising from mixed vegetation on a stockpile. The results indicate that RPAS-based LiDAR data has root mean square (RMS) errors of 2.4 cm and 2.1 cm when compared with RTK and TLS respectively. Thus, RPAS-based LiDAR is effective for surveying areas where the ground elevation accuracy requirement is moderate.

Keywords: RPAS, LiDAR, RTK, TLS, elevation accuracy

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Introduction

Remotely piloted aircraft systems (RPAS) are a relatively new technology, yet are increasing in popularity within the geomatics industry as data capturing platforms due to their cost-efficient nature. New applications of RPAS-based sensors are emerging on a regular basis. Advancement of light detection and ranging (LiDAR) and development of light weight LiDAR systems has made it possible to mount them on RPAS for data capturing and spatial information gathering. The literature shows that RPAS-based systems and ground-based terrestrial laser scanning (TLS) are considered as standard surveying techniques in acquiring high quality point cloud data for three-dimensional surface reconstruction (Lo Brutto et al. 2017). The use of airborne LiDAR systems for flood-zone mapping, landslide identification, forest characterization (Wulder et al. 2012), mapping of land topography, vegetation canopies, and geomorphic changes (Brock and Purkis 2009) has been demonstrated already. In particular, RPAS-based LiDAR can be used effectively for surveying earthwork projects and providing stockpile volume calculations (Siebert and Teizer 2014). Some researchers have argued that LiDAR survey technology provides one of the best methods of acquiring dense 3D information from the earth surface (Liu 2008; Ganendra and Mobarakeh 2018).

For mapping topography, the geomatics industry now has several alternative tools available to it including RPAS-based LiDAR or previously existing techniques such as differential levelling, TLS, or real time kinematics (RTK). Digital elevation models (DEM) and digital surface models (DSM) generated through RPAS-based systems are comparable with other data acquisition techniques such as TLS and traditional RTK (Mancini et al. 2013). However, comparative analysis of ground elevation accuracy using RPAS-based LiDAR, RTK, and TLS is rarely reported in the literature. For example, a recent literature review on beach topography and sand dunes indicated that only 3 of 47 studies compared ground elevations generated by two data gathering techniques (Casella et al. 2020).

The vertical accuracy of LiDAR data is a function of multiple parameters including the number and distribution of ground control points (GCPs), on-board data collection systems, flight characteristics, and data processing procedures and software (Wei and Guo 2018; Yurtseven 2019). Some researchers have argued that designing a well distributed GCP network can help to mitigate errors (Tonkin and Midgley 2016). They may also be mitigated through the use of aerial photographs for identifying GCPs and by conducting accuracy analysis of LiDAR point cloud data (Raouf et al. 2017; Peng et al. 2018). Further, the ground elevation accuracy of LiDAR point cloud data should still be validated through the use of data obtained from traditional surveying equipment such as total station and global navigation satellite systems (GNSS) (Wedajo 2017). Integrated use of LiDAR point cloud data and optical sensors has been used by many researchers in validating their results for landslide mapping and characterization of instances where precise elevation and spatial information is required (Raouf et al. 2017; Peng et al. 2018; Rossi et al. 2018). The current study focuses on the comparison of ground elevations extracted from RPAS-based LiDAR point cloud data with ground-based RTK and TLS observations.

Study area

Ground elevation accuracies of RPAS-based LiDAR derived DEM depend upon the topography of the study area. Complex topography with highly broken and vegetated terrain will introduce more errors in ground elevations than terrain without such challenges (Akturk and Altunel 2018). However, they can be minimized either by constraining the flight area without GCPs (Uysal et al. 2015) or through the use of well distributed GCPs (Raouf et al. 2017). The focus of this study is to evaluate the elevation accuracy of DEM generated from RPAS and ground-based surveying equipment for stockpile volume calculations. To achieve this, a study area was identified at a bike park west of the YARA Centre in Moose Jaw, Saskatchewan (Figure 1a). This area is small in size and has sparse vegetation cover. It also has varying elevations due to the presence of several stockpiles of mixed soil and gravel (Figures 1b). The largest of the stockpiles measuring 35 m x 30 m and featuring several wooden ramps for biking activities was selected for elevation accuracy analysis

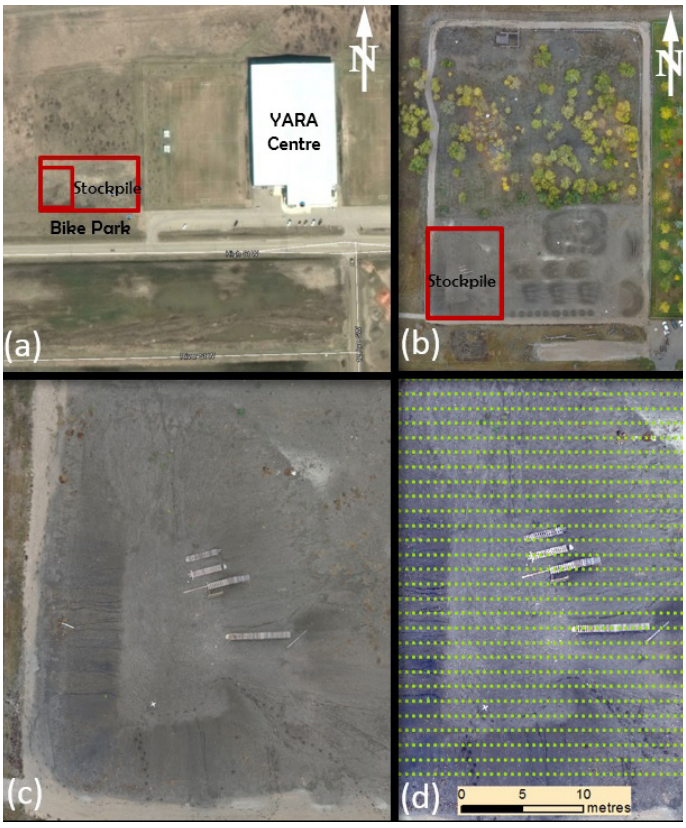

Figure 1
The study area: (a) the location of the study area, (b) selected stockpile within the study area, (c) zoomed image of the selected stockpile, (d) a regular grid of 1 m x 1 m superimposed on the selected stockpile

(Figure 1c). It was assumed that this environment would achieve maximum vertical accuracy of the LiDAR point cloud data.

Data collection

A commercially available DJI M600 Pro Quad Copter RPAS equipped with A3 Pro Flight Controller, D-RTK GNSS receiver and Zenmuse Z3 gimbal was used to collect the LiDAR data. Additional sensors mounted on the RPAS included a Velodyne VLP-16 LiDAR and a Sony A6000 24MP camera with a 16 mm focal length and a wide 33° viewing angle. The images were taken on September 24, 2018 under cloudy sky conditions with an 18 km/h wind. Autumnal timing for image collection was selected to minimize the effect of vegetation on elevation analysis. The RPAS was flown at a height of 50 m above ground level (AGL) in a north-south direction and then in an east-west direction at an average speed of 5 m/s to cover the entire study area. It collected 53,484,212 LiDAR data points and 276 RGB (red, green, blue) images with an 85% overlap. The distribution of GCPs used for geo-referencing is shown in Figure 2.

The RTK and TLS point clouds were collected with the same control variables in place. The TLS data was collected using a Topcon GLS-1500 terrestrial laser scanner with operating wavelength of 1,535 nm, having a 360° horizontal and + 35° vertical field of view. With a scanning range of 1 to 500 m, it required four scans using four scan locations to complete the 3D scan of the selected stockpile. Three stations were mounted around the stockpile and the fourth station was set up on top of it to cover the entire selected area (Figure 3). All scans were acquired within a spacing parameter set at 0.03° in both horizontal and vertical directions thereby creating a dense point cloud data set of the study area. Three static retro-reflective targets were used at locations visible to all four stations for accurate geo-referencing of the point cloud data acquired through TLS stations. Collection of RTK data required 832 ground scans using NAD 83 CSRS 1997 datum with each scan lasting three seconds, and were randomly collected on the chosen stockpile using Topcon GR3 GNSS receivers.

Data processing

Data cleaning and registration/geo-referencing were the two main steps that were performed during data processing of both ground-based TLS and RPAS-based LiDAR point cloud datasets. Eight markers were placed in the study area for geo-referencing of the optical and LiDAR data acquired from RPAS-based sensors (Figure 2). While the tetras targets (depicted in yellow) were used for general alignment and orientation, the narrow targets (depicted in red) were placed to increase positional accuracy.

Sparse vegetation cover comprising mostly grass, wooden ramps, and bicycles are the primary explanation behind data noise and undesirable points in both datasets, which must be removed for accurate processing. Points pertaining to the test stockpile were registered and geo-referenced for final accuracy analysis. The original TLS point cloud data consisting of 1,799,583 points was reduced to 751,153 points after cleaning. Four TLS scans from four different locations were registered and geo-referenced using three static retro-reflective targets.

Accuracy statistics of the TLS scan registration/geo-referencing process indicate that errors in the spatial domain are + 3 mm, + 6 mm and + 0 mm in x, y and z directions respectively. Similarly, the original point cloud data acquired by the RPAS mounted LiDAR system consisted of 53,484,212 points which were reduced to 474,970 points after cleaning. A comparison of the original and cleaned point cloud datasets acquired through TLS and RPAS mounted LiDAR is shown in Figure 4.

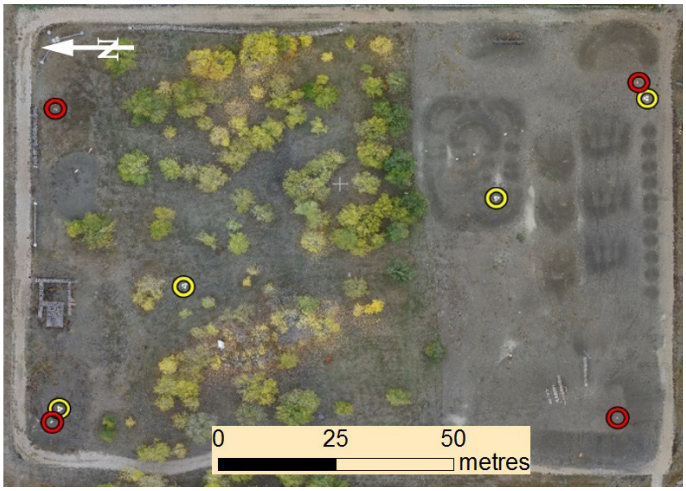

Figure 2
GCP distribution showing narrow targets in red and tetras targets in yellow

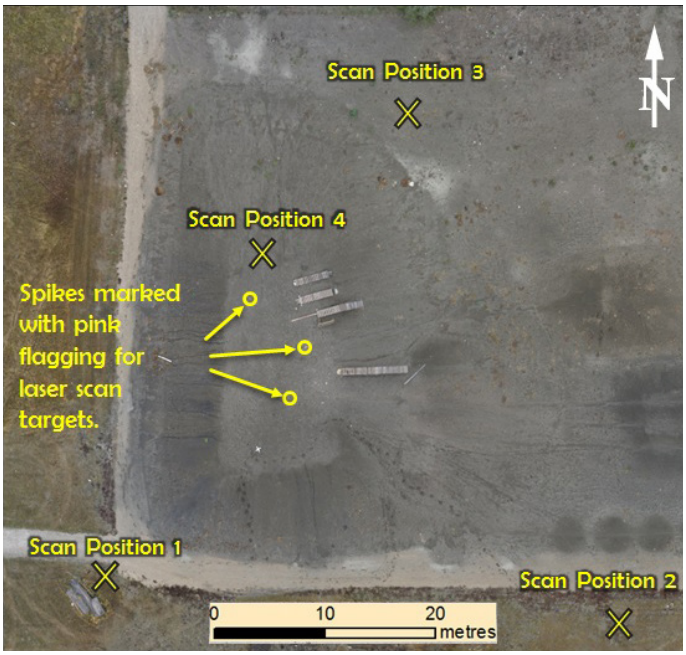

Figure 3
TLS scan positions and spikes used for the registration

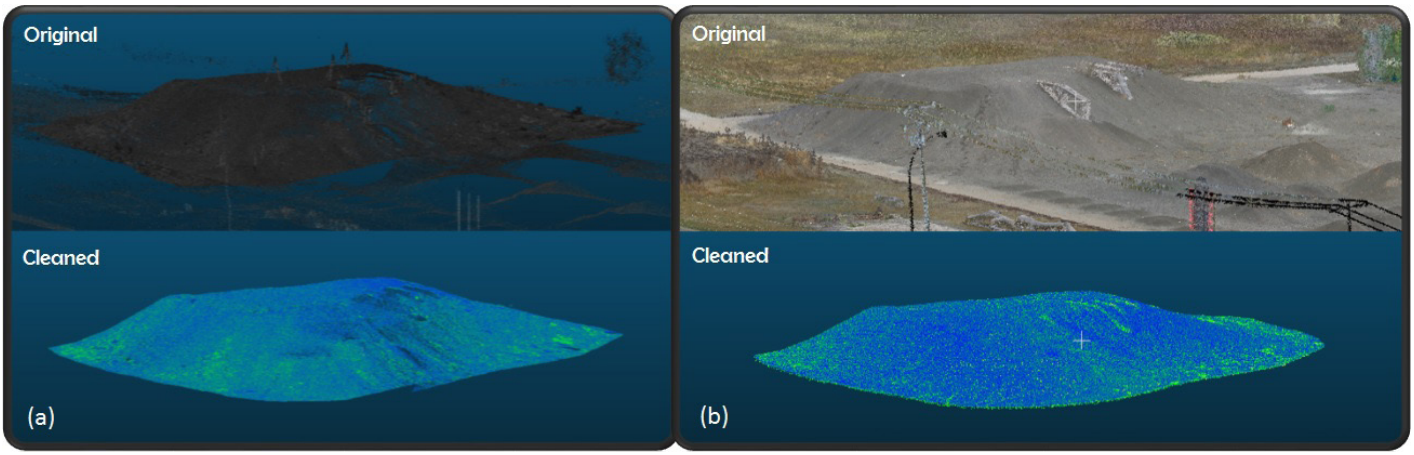

Figure 4
A comparison of original and cleaned point cloud datasets: (a) TLS dataset, (b) LiDAR dataset

The three datasets collected are made of random points. In order to achieve a meaningful comparison, a regular grid of 1 m spacing was superimposed on the study area (Figure 1d). The elevation information at each node was interpolated by using the inverse distance weighted (IDW) tool of spatial analyst extension in ArcMap 10.6. Once interpolated using the model described above, the three elevations at each node of the grid were compared with each other.

Comparative analysis

The ground elevation accuracy analysis was conducted by comparing interpolated elevations from the RPAS-based LiDAR point cloud data with the interpolated elevations acquired from the RTK and TLS point clouds. The aforementioned grid covering the stockpile generated 1,148 nodes. Scatter plots of interpolated elevation differences are presented in Figure 5. The mean elevation difference between the ground and the stockpile's highest point extracted from both RTK and TLS point cloud data is 544.0 cm, while it is at 544.5 cm when extracted from the RPAS-based LiDAR point cloud data. This results in a mean ground elevation error of 0.5 cm in the LiDAR data.

The average elevations extracted from the RTK and TLS data are same, which shows that TLS is more accurate in comparison with the data collected through RPAS-based LiDAR. Greater accuracies of TLS data can also be observed in comparing Figures 5a and 5b. For this reason, TLS data was not compared with RTK data. Only LiDAR point cloud data was compared with the TLS and RTK data. The elevation differences of the two datasets (RPAS-RTK and RPAS-TLS) were classified into ten classes using an equal interval classifier with each band having an interval 0.6 cm. These differences were plotted on histograms and also on grids using the same colour scheme to identify the spatial distribution of the errors (Figure 6).

Figure 6 shows similar trends of elevation differences, when RPAS-based LiDAR data is compared with RTK or TLS. Thus, it is further evident that RTK and TLS datasets are comparable with one another. However, RPAS-based LiDAR data shows varying elevation errors at different locations when compared with RTK and TLS datasets. An area pertaining to the top, relatively flat portion of the stockpile shows errors generally in the range of −0.6 to +0.6 cm and accounts for the two largest bands

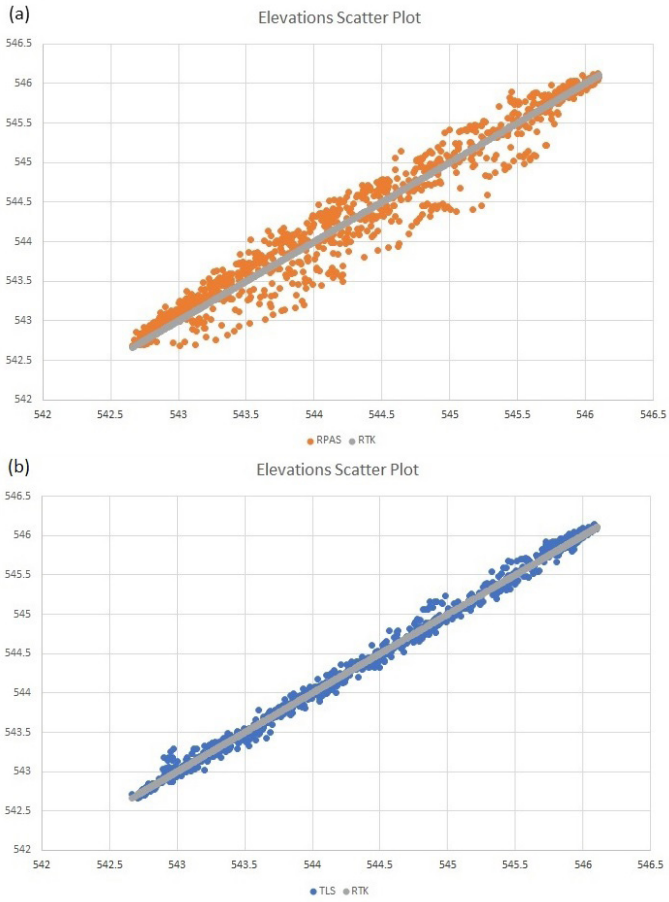

Figure 5
Scatter plots showing relationship between (a) RPAS-based LiDAR with RTK data, and (b) RPAS-based LiDAR with TLS data

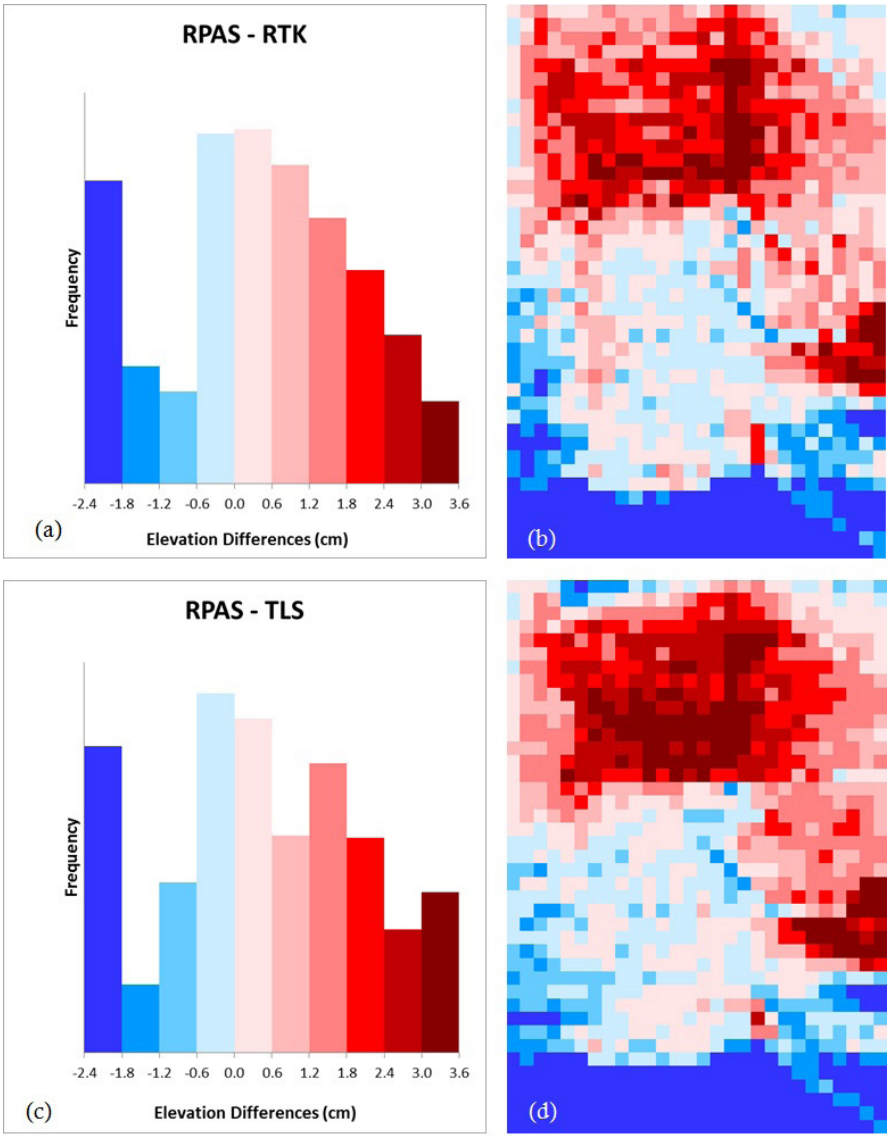

Figure 6
An elevation accuracy analysis of LiDAR point cloud data: (a) differences between RPAS-based LiDAR elevations and RTK GNSS elevations, (b) spatial distribution of differences between RPAS-based LiDAR elevations and RTK GNSS elevations, (c) differences between RPAS-based LiDAR elevations and TLS elevations, (d) spatial distribution of differences between RPAS-based LiDAR elevations and TLS elevations

(subclasses) in the error analysis. The northern and southern sides of the stockpile are steeper and are marked by greater elevation differences. Those on the northern side of the stockpile are positive whereas those on the southern side are negative. Most of the positive elevation differences along the northern slope are in the range of 2.4 to 3.6 cm whilst virtually all of the negative differences along the relatively steeper southern slope range between −1.8 and −2.4 cm. At this juncture, an explanation for such polar differentiation in the sign and magnitude of the differences is not known but might be related to the north-south flight pattern of the RPAS. Generally, the eastern and western sides of the stockpile have gentle slopes and are associated with low or moderate errors of up to + 1.2 cm. This said, the wooden biking ramps on the eastern side of the stockpile show greater elevation errors typically in the range of 3.0 to 3.6 cm due to abrupt topographic changes along the ramps.

Figure 6 illustrates that about 35% of data points (nodes) record relatively high elevation differences (> ± 1.8 cm), 34% show moderate differences (+0.6 to +1.8 cm), and the remaining 31% have comparatively low differences (<+ 0.6 cm) in both the RPAS-RTK and RPAS-TLS datasets. The results illustrate that RPAS-based LiDAR data has root mean square (RMS) errors of 2.4 cm and 2.1 cm when compared with RTK and TLS respectively. The results of ground elevation accuracy, in a controlled environment, are better than previously reported RMS errors of 5.7 cm in challenging topography (Akturk and Altunel 2018).

It was also observed that the ground elevation differences are not completely random, and depend upon the topography of the stockpile as sloping surfaces show greatest errors, as reported in earlier literature (Escobar Villanueva et al. 2019).

Conclusion

A wide range of air and ground-based surveying techniques can be used to develop DEM. Each technique has its own advantages and disadvantages. Ground-based surveying techniques are time consuming but provide more accurate spatial information. RPAS-based LiDAR systems can cover extensive areas within a short period of time but DEM generated from LiDAR point cloud data is relatively less accurate than DEM derived from ground-based surveying data collection tools. Moreover, RPAS-based LiDAR systems are usually more expensive to operate, requiring several administrative and legal formalities to complete before a project can be started.

The objective of this study was to compare ground elevations generated from data collected though RPAS-based LiDAR with similar elevations obtained using RTK and TLS. Field experimentation used 1,148 comparison points with varying elevations within a small study area. On each of those nodes, the elevation values derived from all three datasets were interpolated using IDW technique for comparison and accuracy analysis. The study illustrated that about 35% of data points (nodes) recorded relatively high elevation differences (> ± 1.8 cm), 34% showed moderate differences (+0.6 to +1.8 cm), and the remaining 31% had comparatively low differences (<+ 0.6 cm) in both the RPAS-TLS and RPAS-RTK datasets. The RPAS-based LiDAR data has root mean square (RMS) errors of 2.4 cm and 2.1 cm when compared with RTK and TLS respectively. The use of different interpolation techniques to generate DEM from data collected by the RPAS-based LiDAR or different AGL for RPAS flight might have reduced these errors. Also, more conclusive or confirmatory findings might be attained by adopting alternative flight trajectories, for example one flown from south to north, or from repeating the experimental design on stockpiles with different slope characteristics. These considerations provide scope for future research.

Based on the data acquisition conditions, the comparison has shown that RPAS-based LiDAR is less accurate than RTK and TLS. It is concluded that for survey projects requiring a high level of accuracy at the centimetre or sub-centimetre level, RPAS-based LiDAR would not be the ideal topographic equipment to use. Other ground surveying equipment such as RTK and TLS would provide better options. This said, RPAS-based LiDAR would be suitable where moderate level accuracy is acceptable.

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The authors are thankful to Mr. Ryan Brazeal, Geomatics Technology Manager at Caltech Surveys Ltd. who generously collected the UAV mounted LiDAR data for this study. We also wish to thank the anonymous reviewers of this paper for their continuous guidance and support to improve the readability of the manuscript. Any errors or omissions are the sole responsibility of the authors.

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Regional disparities in education: Findings from multiple indicator cluster surveys (MICS) conducted in Punjab, Pakistan

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Key Messages

- MICS conducted for 2007/8 and 2014 provide evidence of gains in literacy and educational opportunity for primary school children, youth, and young adults.
- Gains in literacy and education have been widespread but advantage still favours relatively wealthy and more urbanized northern Punjab at the expense of southern Punjab.
- Gains in literacy and education have tended to be greater for females than males but they still lag behind males on most indicator variables.

Exploratory research examines change in the size and geographical pattern of five literacy and educational indicator variables in Punjab, Pakistan. Data is obtained from two Multiple Indicator Cluster Surveys (MICS) conducted at the provincial and district level. Changes in the value of the variables over the six-year period from 2007/8 to 2014 are calculated and plotted using a thematic mapping approach. Findings reveal a general improvement in the status of literacy and educational opportunity across most districts. Much of this improvement is expressed among children and young adults, and particularly among females. Historic contrasts in opportunity between the predominantly rural south of Punjab and the more urbanized and wealthier north show evidence of narrowing but remain pronounced. Although further improvement in literacy and education indicators is desirable, progress towards the achievement of Millennium Development Goals and Sustainable Development Goals has been achieved.

Keywords: Punjab, sustainable development goals, education, literacy, gender parities

Introduction

The economic condition of any country has a direct relationship with its literacy rate (Martínez and Fernández 2010; Cree et al 2012; Yeoh and Chu 2012). Today, education is considered a crucial investment for national development and has become a key strategy in the global fight against poverty (Tarabini 2010). The role of education is vital in improving local economies and increasing awareness of health and other social issues (Hannum and Buchmann 2005). It has encouraged developing countries to invest in human capital (Checchi 2001; Hanushek 2013).

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Moreover, the correlation between education and poverty is not only evident in developing countries. British youngsters, for example, living in relative poverty, have been shown to perform poorly in schools as compared with their peers who have better economic living conditions (Raffo et al. 2009). Education can even be considered as the new currency of opportunity to succeed, as demand for qualified individuals is increasing all over the world (Brown 2003). Poor children are up to 11 times less likely to enrol in primary education as compared with children from rich families (Boutayeb and Helmert 2011). The strong association between school enrolment and the financial status of families suggests that it can be used as an indicator of national development. Thus, education and school enrolment have been linked to Millennium Development Goals (MDGs) (Barrett 2011) and Sustainable Developments Goals (SDGs) (Unterhalter 2014; Sustainable Development Solutions Network 2015).

As increase in school enrolment is desirable for overall national development, the reasons for low school enrolment should be identified so that policies can be developed and implemented to improve regional education. Governments, non-governmental organizations (NGOs), and international agencies all agree on investing in education to achieve economic growth, human resource productivity, and national development. In other words, education is considered an indicator of development in many countries, and particularly in countries belonging to low-middle and low-income groups such as those identified by MDGs and SDGs (Barrett 2011; Unterhalter 2014; Sustainable Development Solutions Network 2015).

In order to measure progress towards an internationally agreed set of social sector goals including MDGs, the global Multiple Indicator Cluster Surveys (MICS) program was introduced in 1995 by UNICEF. The MICS program collects data for monitoring and understanding the situation of children and women, and has emerged as a powerful tool in providing periodic cross-sectional data on a regular basis in low-middle and low-income countries (Novignon et al 2015; Khan and Hancioglu 2019). MICS data is generally used for multi-country, national, and regional analyses (Novignon et al 2015; Khan and Hancioglu 2019). Data on literacy, primary school attendance, gender parity in education, and level of enrolment in private schools can indicate progress towards the elimination of gender inequalities and the attainment educational goals in least developed and developing countries. Such inequalities have led to the development of Millennium Goals to ensure that all boys and girls complete at least primary education (Tarabini 2010). However, the use of MICS data to investigate the status of global indicators at a local geographic scale is rarely reported. This research investigates the success of the MICS program at a local level by performing a geospatial comparison of surveys conducted in 2007/8 and 2014. The investigation is conducted in the form of a case study of literacy and education variables to better inform education planning and implementation at the district level in Punjab.

The study area

Pakistan is divided administratively into four provinces, two autonomous areas, and one federal territory. Of these, the province of Punjab is the second largest (205,344 km2) administrative unit. It is also the most populous and densely populated administrative unit having a population of 110 million in 2017 (Pakistan Bureau of Statistics 2018). Administratively, Punjab is divided into nine divisions, which in 2007/8 were further sub-divided into 35 districts (Figure 1). Districts form the smallest administrative units used in the collection of socio-economic data (e.g., population, distribution of industry, allocation of funds, and availability of resources) and for implementing government policies (Kalia 2016; Ali 2018). District populations range from 1.16 million in Hafizabad to 11.13 million in Lahore, the provincial capital (Pakistan Bureau of Statistics 2018). In 2009, the district of Jhang was subdivided into two new districts wherein the more southerly of the two retained the name Jhang whilst the more northerly district was named Chiniot and thus became the 36th district of Punjab. To maintain consistency of analysis, the results and discussion that follow are based on pre 2009 district boundaries.

Materials and methods

Research was conducted using MICS data collected in Punjab and referred to as the MICS-Punjab (Bureau of Statistics Punjab 2009; 2016). These surveys form part of a global international household survey program that provides key information that can be used to monitor progress towards the elimination of dis-

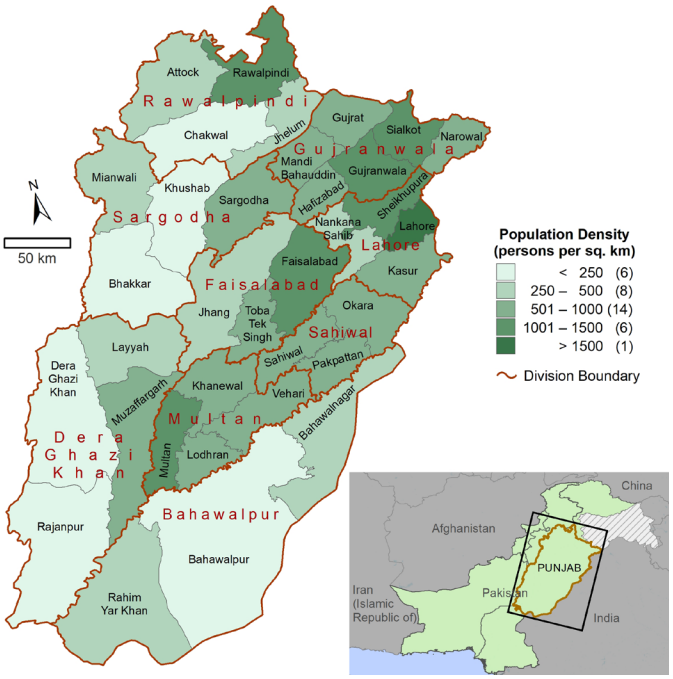

Figure 1
Study area showing population density by administrative districts of Punjab, Pakistan

parities and inequalities in sociodemographic status, including education. In Punjab, MICS surveys were conducted in 2007/08 (December 2007 to April 2008) and 2014 (June to September 2014) by the Bureau of Statistics Punjab in collaboration with UNICEF. The surveys collected data on a broad range of literacy and education variables that could be used as indicator sets for MDGs and SDGs.

Analysis in this paper is based on literacy rates for two population age groups and three measures of school attendance for children of primary school age (5 to 9 years). Specifically, analysis of literacy reviews changes in literacy rates of the population aged 10 years and above, and the population aged 15 to 24 years. Separate analyses are conducted for the total population and female population in each age group. For schools, the primary school net attendance rate (NAR) measures the percentage of children of primary school age in receipt of primary or secondary school education. Again, separate analyses are conducted for both the total and female populations. The primary school gender parity index (GPI) measures the primary school net attendance ratio for girls divided by that of boys. Equal attendance is indicated by a GPI of 1.0. Indices of less than 1.0 indicate that a smaller percentage of girls than boys are in receipt of education, whereas indices greater than 1.0 indicate the opposite relationship. The private primary school attendance rate simply measures the percentage of children aged 5 to 9 years attending private schools. A more complete definition of these variables and their presentation within the MICS reports is given in Table 1. A summary of selected MICS variables cross tabulated by urban and rural places of residence is presented in Table 2.

Geospatial techniques are used to examine and map temporal and spatial variation in the aforementioned literacy and education-related variables measured at the district level for survey years 2007/8 and 2014 (Bureau of Statistics Punjab 2009, 2016). ArcGIS Map 10.5 (ESRI, Redlands, U.S.) is employed to map spatial data, and Microsoft Office 2016 (Microsoft Access and Microsoft Excel) is used for statistical analysis of non-spatial data. Presentation of the findings proceeds by reviewing each indicator variable in turn, first by reviewing change in its value between 2007/8 and 2014, and second by evaluating its status in 2014.

Results and discussion

Literacy of population aged 10 years and over

Total population. Between 2007/8 and 2014, literacy among Punjab's population aged 10 years and over increased by 1.5 percentage points (Table 2). This change reflected relatively

Table 1
Description of MICS variables and their sources

Variable	Description	Source
Literacy rate of household members ≥ 10 years	percentage of household members age 10 years and over where it is reported that they are able to both read and write with understanding in any language excluding Quranic reading if this was the only response	Table ED.8A (BSP 2009) Table D.ED.10 (BSP 2016)
Literacy rate of household members 15–24 years	percentage of household members age 15–24 years where it is reported that they are able to both read and write with understanding in any language excluding Quranic reading if this was the only response [MDG 2.3]	Table ED.8C (BSP 2009) Table D.ED.12 (BSP 2016)
Primary school net attendance rate (NAR)	percentage of children of primary school age currently attending primary or secondary schools [MDG 2.1]	Table ED.3A (BSP 2009) Table D.ED.4 (BSP 2016)
Primary school gender parity index (GPI)	primary school net attendance ratio (adjusted) for girls divided by primary school net attendance ratio (adjusted) for boys [MDG 3.1]	Table ED.3A (BSP 2009) Table D.ED.4 (BSP 2016)
Private primary school attendance rate	percentage of children aged 5–9 years attending private primary schools	Table ED.3C (BSP 2009) Table D.ED.13 (BSP 2016)

Table 2
Literacy and educational opportunity in relation to place of residence in 2014

	Literacy Rate of Population Aged 10 Years and Over		Literacy Rate of Population Aged 15 to 24 Years		Primary School Net Attendance Rate (NAR) of Population Aged 5 to 9 Years		Primary School Gender Parity Index (GPI)	Private Primary School Attendance
	Total	Female	Total	Female	Total	Female		
	% [C]	% [C]	% [C]	% [C]	% [C]	% [C]	Index [C]	% [C]
Residence								
Punjab	60.8 [1.5]	52.1 [2.6]	75.9 [2.6]	72.4 [4.7]	57.9 [5.0]	56.8 [5.0]	0.96 [0.01]	45.6 [2.6]
Major cities	77.7 [0.3]	73.9 [0.0]	88.8 [2.1]	89.2 [0.7]	67.3 [3.4]	68.0 [1.9]	1.02 [-0.05]	70.6 [-6.3]
Other urban	71.9 [0.1]	65.6 [0.6]	84.3 [0.4]	84.6 [1.5]	68.2 [4.9]	68.9 [5.2]	1.02 [0.01]	56.6 [-4.2]
Rural	53.5 [1.5]	43.0 [3.0]	70.2 [3.0]	64.7 [6.4]	53.7 [4.9]	52.0 [5.3]	0.94 [0.02]	36.2 [6.0]

[C] denotes percentage point change from 2007/8 to 2014. Highlighting indicates greater percentage point change for females.
Source: BSJ (2009, 2016)

small increases in major cities (+0.3) and other urban areas (+0.1), but a more substantial increase in rural areas (+1.5). At the district level, the literacy rate increased in 20 of 35 (57.1%) districts between 2007/8 and 2014 (Figure 2a). Of these, greatest increases were recorded in the northern districts of Nankana Sahib (+7.2) and Kasur (+7.2), the central districts of Sahiwal (+5.6) and Vehari (+5.3), and in the southern district of Multan (+4.9). In contrast, decreases in literacy were recorded in 15 of 35 (42.9%) districts of which the greatest occurred in the southern district of Rahim Yar Khan (−5.1), the central district of Khanewhal (−3.0), and the northern districts of Gujranwala (−4.7), Jhelum (−3.5), and Mandi Bahauddin (−3.3).

Following the above changes, 60.8% of Punjab's population aged 10 years and over was identified as literate in 2014 (Table 2). Although literacy increased at a greater rate in rural areas between 2007/8 and 2014, much higher levels of literacy were still found in major cities (77.7%) and in other urban areas (71.9%), than in rural areas (53.5%). Despite the overall gain in literacy in the majority of districts there remained a pronounced north-south contrast in literacy rates in which districts in the relatively wealthy and more urbanized north registered substantially higher rates than districts in the poorer and predominantly rural south (Figure 2b). Thus in 2014, highest literacy rates were recorded in the northern districts of Rawalpindi (78.5%), Lahore (75.7%), Chakwal (74.5%), Jhelum (73.4%), and Gujrat (73.0%) whilst lowest rates were reported in the southern districts of Rajanpur (36.9%), Rahim Yar Khan (39.3%), Dera Ghazi Khan (43.5%), Lodhran (44.3%), and Muzaffargarh (47.0%). This said, the relationship between location and rurality on the one hand and change in literacy on the other was not straightforward. For example, between 2007/8 and 2014 literacy rates actually increased in the southern districts of Rajanpur (+3.8) and Muzaffargarh (+2.3) where literacy rates still remained low, but decreased in the northern districts of Jhelum (−3.5), Rawalpindi (−2.0), and Gujrat (−1.2) where literacy rates remained substantially higher (Figure 2a).

Female population. Literacy among Punjab's female population aged 10 years and over increased by 2.6 percentage points during the study period (Table 2). Much of this increase can be attributed to increases in rural areas (+3.0) and to a lesser extent in other urban areas (+0.6), but, perhaps surprisingly, not in major cities (0.0) where no change occurred. These increases in literacy were greater than those for the total population aged 10 years and over. Consequently, they suggest that increases in female literacy have taken place at a substantially greater pace than among the male population. At the district level, the female literacy rate increased in 26 of 35 (74.3%) districts (Figure 3a). As with the total population, the pattern of change was complex. Greatest percentage point increases occurred in the northern districts of Kasur (+8.9) and Nankana Sahib (8.7) but also in the central districts of Vehari (+7.5) and Okara (+6.2), and southern district of Multan (+6.1). Conversely, greatest decreases, although of lesser magnitude, occurred in the northern districts of Gujranwala (−2.7), Rawalpindi (−2.4), and Jhelum (−2.4), the central district of Bhakkar (−1.6), and the southern district of Rahim Yar Khan (−2.5). There is no ready explanation of why literacy rates decreased in some comparatively literate northern districts, although a possible reason might be found in substantial inward migration of relatively poorly educated persons from rural districts in southern Punjab.

In 2014, 52.1% of Punjab's female population aged 10 years and over was classified as literate (Table 2). Despite achieving greater increase in literacy between 2007/8 and 2014, female literacy remained lower than that of the total population (60.8%), and by inference, considerably lower than that of males. Moreover, female literacy rates remained lower in all districts, and in 16 districts the difference exceeded 10%. The provincewide pattern of literacy to emerge after the aforementioned changes

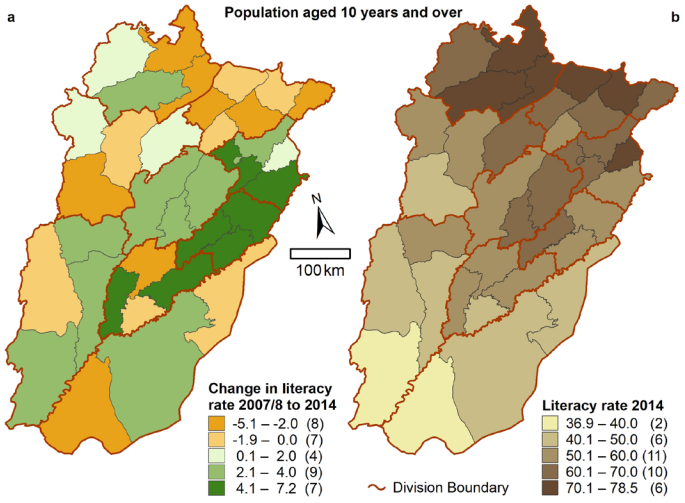

Figure 2
Population aged 10 years and over: a) change in literacy rate 2007/8 to 2014; b) literacy rate in 2014

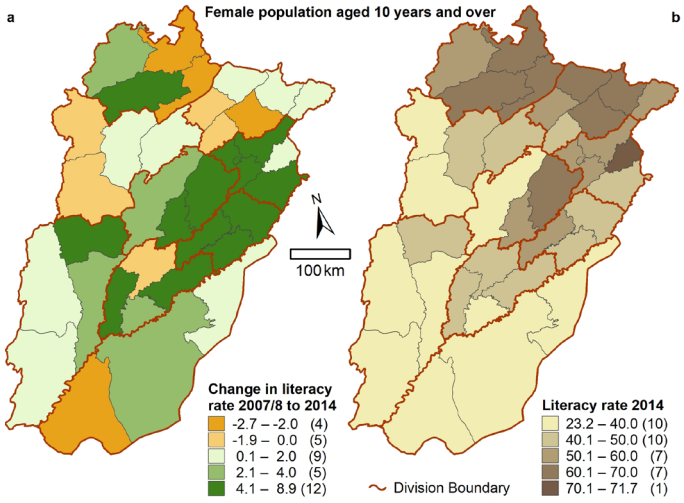

Figure 3
Female population aged 10 years and over: a) change in literacy rate 2007/8 to 2014; b) literacy rate in 2014

is presented in Figure 3b. It shows that, as with the total population, highest female literacy rates were registered in the relatively wealthy and more urbanized northern districts of Lahore (71.7%), Sialkot (69.6%), Rawalpindi (69.6%), Gujrat (68.4%), and Jhelum (65.5%). Generally lower rates were recorded in parts of central Punjab with lowest overall rates recorded in the southern districts of Rajanpur (23.2%), Rahim Yar Khan (29.6%), Lodhran (31.2%), Dera Ghazi Khan (31.3%), and Muzaffargarh (34.5%).

Literacy of population aged 15 to 24 years

Total population. As might be expected, increases in literacy for the population aged 15 to 24 years were greater than those for the population aged 10 years and over (Table 2). For example, literacy in Punjab increased by 2.6 percentage points rather than the 1.5 points of the population aged 10 years and over. Increases for major cities (+2.1), other urban (+0.4), and rural areas (+3.0) were also greater. At the district level, literacy increased in 25 of 35 (71.4%) districts (Figure 4a). This compares with increases in just 20 districts for the population aged 10 years and over, and provides one indication of the success of literacy programs directed at young children and youth in recent decades. As further evidence of this improvement, the average rate of increase in the 25 districts was 4.5 percentage points but only 3.6 percentage points in the 20 districts in which increases were recorded for the population aged 10 years and over. Of the 25 districts, greatest increases were registered in the northern districts of Kasur (+8.4) and Nankana Sahib (+7.4), the central district of Jhang (+7.9), and the southern districts of Rajanpur (+9.7) and Multan (+9.2). In contrast, greatest decreases were registered in the northern districts of Mandi Bahauddin (−4.9), Jhelum (−4.7), Gujranwala (−3.8), the central district of Khanewhal (−1.9), and the southern district of Rahim Yar Khan (−3.1).

Following the aforementioned changes, 75.9% of Punjab's population aged 15 to 24 years was identified as literate. Literacy rates remained highest in major cities (88.8%) and lowest in rural areas (70.2%) (Table 2). At the district level, highest literacy rates were recorded in Chakwal (93.3%), Rawalpindi (92.0%), Sialkot (90.1%), Gujrat (90.2%), and Jhelum (88.0%) all of which are located in the extreme north of Punjab (Figure 4b). Conversely, lowest literacy rates were registered in the southern districts of Rajanpur (52.8%), Rahim Yar Khan (52.9%), Dera Ghazi Khan (57.2%), Muzaffargarh (61.4%), and Bahawalpur (61.7%). However, despite their comparatively low rates of literacy, all but Rahim Yar Khan experienced an increase in literacy between 2007/8 and 2014 such that differences in literacy rates between them and the most literate districts narrowed over the study period.

Female population. Between 2007/8 and 2014, literacy increased by 4.6 percentage points in Punjab. Much of this increase was propelled by a substantial change in literacy in rural areas (+6.7) rather than in major cities (+0.7) and other urban areas (+1.5) (Table 2). Except in the case of major cities, rates of change exceeded those of the total population aged 15 to 24 years, and in all cases exceeded those of both the total and female populations aged 10 years and over. At the district level, increases in literacy were recorded in 28 of 35 (80.0%) districts (Figure 5a), with greatest percentage point increases occurring in the northern district of Kasur (+14.9), the central districts of Vehari (+14.2) and Layyah (+10.4), and in the southern districts of Multan (+11.5) and Muzaffargarh (+10.9). Conversely, decreases in literacy rates, although generally of lesser magnitude, were recorded in just 7 of the 35 (20%) districts. Of these, greatest decreases occurred in the northern districts of Mandi Bahauddin (−4.6), Jhelum (−3.5), Gujranwala (−3.2), Mianwali (−1.8), and Sargodha (−1.4). Collectively, these changes provide evidence of progress towards literacy and gender related goals but, as in the case of the total population, the reason why literacy rates declined in some northern districts is not easily explained.

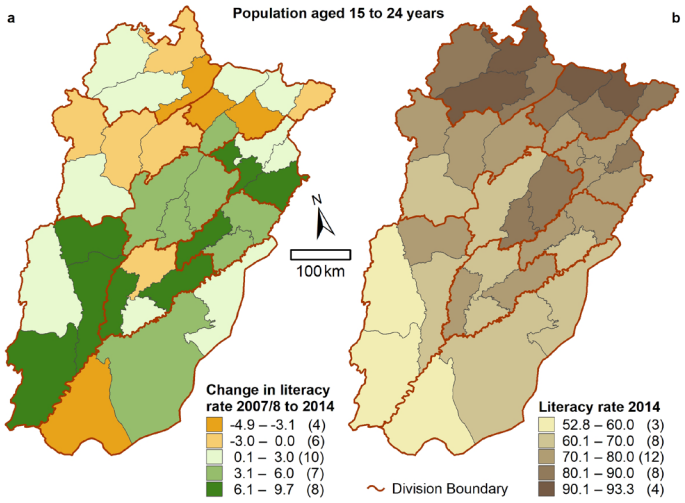

Figure 4
Population aged 15 to 24 years: a) change in literacy rate 2007/8 to 2014; b) literacy rate in 2014

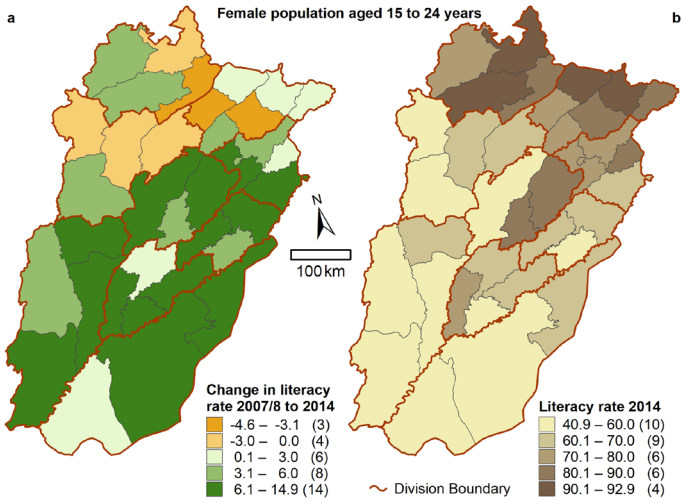

Figure 5
Female population aged 15 to 24 years: a) change in literacy rate 2007/8 to 2014; b) literacy rate in 2014

Following the aforementioned changes, 72.4% of Punjab's female population aged 15 to 24 years and over was classified as literate in 2014 (Table 2). Substantially higher literacy rates were recorded in major cities (89.2%) and other urban areas (84.6%), but the literacy rate in rural areas (64.7%) remained lower despite experiencing considerable gain between 2007/8 and 2014. At the district level, highest literacy rates were recorded in the northern districts of Sialkot (92.9%), Chakwal (91.5%), Rawalpindi (91.0%), Gujrat (91.0%), and Jhelum (87.0%) (Figure 5b). Despite the widespread improvement in literacy rates, a broad swathe of ten districts in southern and parts of central Punjab still registered literacy rates of less than 60.0%. They included Rajanpur (40.9%), Dera Ghazi Khan (46.4%), Rahim Yar Khan (46.6%), Lodhran (52.0%), and Muzaffargarh (53.2%).

Primary school net attendance rate (NAR)

All children. NAR measures the percentage of children of primary school age in receipt of primary or secondary school education. Historically, attendance in schools has favoured boys and, more generally, children living in large cities such as Lahore and Rawalpindi. Between 2007/8 and 2014, substantial percentage point increases in NAR were recorded in Punjab (+5.0), and in both rural (+4.9) and other urban areas (+4.9) (Table 2). Slightly lesser increase occurred in major cities (+3.4). At the district level, NAR increased in 31 of 35 (88.6%) districts (Figure 6a). Greatest gains were registered in the northern districts of Khushab (+21.0), Sargodha (+16.0), Kasur (+14.1), Sheikhupura (+12.3), and Nankana Sahib (+11.7), and more generally across all of northern Punjab. At the same time, most districts in central and southern Punjab also experienced gains although to a lesser extent. Decreases in NAR were comparatively modest, and were restricted to the central districts of Bhakkar (−3.8), Sahiwal (−2.3), and Okara (−2.0), and the southern district of Muzaffargarh (−2.1).

By 2014, 57.9% of children of primary school age were attending schools in Punjab (Table 2). Attendance levels in major cities (67.3%) and other urban areas (68.2%) remained higher than in Punjab as a whole, and considerably higher than in rural areas (53.7%). At the district level, NAR values still ranged dramatically across Punjab (Figure 6b). Highest NAR values were found in the extreme north of the province in the districts of Jhelum (80.3%), Chakwal (80.1%), Gujrat (75.2%), Attock (74.0%), and Sialkot (73.5%). Reasonably high values were also found in other northern districts, but values then decreased progressively through central into southern Punjab where particularly low values were registered in the predominantly rural districts of Rajanpur (31.7%), Dera Ghazi Khan (33.1%), Muzaffargarh (37.7%), Rahim Yar Khan (38.6%), and Bahawalpur (47.0%). Of these districts, only Muzaffargarh experienced a decrease in NAR between 2007/8 and 2014. Nevertheless, based on an objective of eliminating of regional disparities in educational opportunity, it is clear that much progress remains to be made in these districts.

Female children. Between 2007/8 and 2014, NAR values for girls aged 5 to 9 years increased by 5.0 percentage points, an amount equal to that for all children in the age group (Table 2). This change reflected slightly greater increases in rural (+5.3) and other urban areas (+5.2), but lesser increase in major cities (+1.9). At the district level, NAR values increased in 27 of 35 (77.1%) districts (Figure 7a). As in the case for all children, particularly large increases in NAR were recorded in the northern districts of Sargodha (+19.6), Khushab (+18.0), Kasur (+17.8), Sheikhupura (+14.2), and Nankana Sahib (+14.2). In comparison, decreases in the NAR were relatively modest and were largely confined to the southern districts of Rajanpur (−2.1), Muzaffargarh (−1.2), Dera Ghazi Khan (−0.5), and Rahim Yar Khan (−0.2), and to the central district of Bhakkar (−3.0). Some-

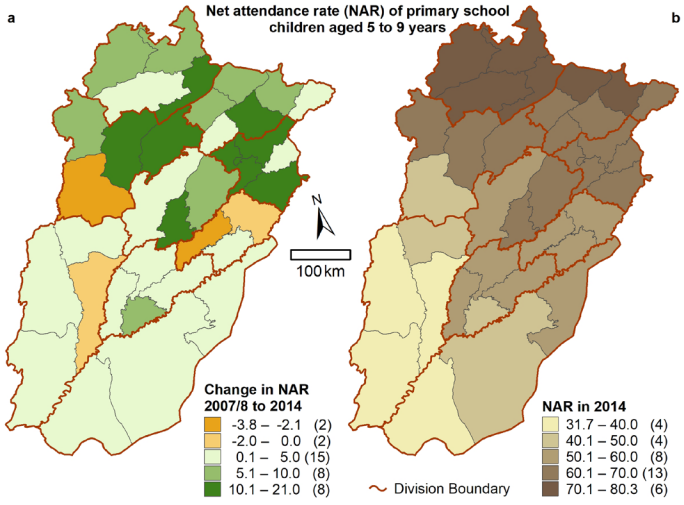

Figure 6
Net attendance ratio (NAR) of primary school children aged 5 to 9 years: a) change in NAR, 2007/8 to 2014; b) NAR in 2014

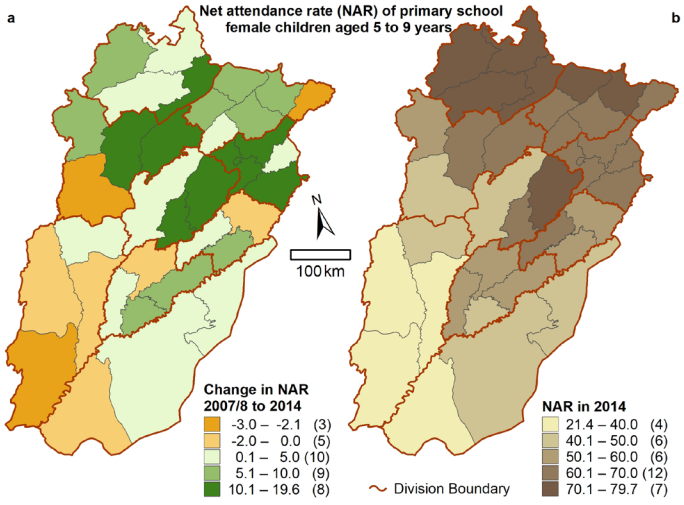

Figure 7
Net attendance ratio (NAR) of female primary school children aged 5 to 9 years: a) change in NAR, 2007/8 to 2014; b) NAR in 2014

what surprisingly, a decrease in NAR was also registered in the northern district of Narowal (−2.8).

By 2014, NAR values for females aged 5 to 9 years closely resembled those of all children of similar age (Table 2). Thus, in Punjab, 56.8% of females attended primary schools compared with 57.9 % of all children. Attendance rates were notably higher in major cities (68.0%) and other urban areas (68.9%), and correspondingly lower in rural areas (52.0%). At the district level, highest NAR values were registered in a band of districts in the extreme north of Punjab comprising Jhelum (79.7%), Gujrat (79.3%), Chakwal (78.9%), Sialkot (74.2%), and Rawalpindi (72.2%). To their south, NAR values generally declined throughout the province and reached their lowest values in the southern districts of Rajanpur (21.4%), Dera Ghazi Khan (32.2%), Rahim Yar Khan (33.4%), Muzaffargarh (36.0%), and Lodhran (44.8%). The comparatively low NAR values in these districts when combined with decreases in these values between 2007/8 and 2014 is cause for disappointment and concern.

Gender parity index (GPI)

GPI is a measure of the primary school attendance (percentage) for girls divided by that of boys. Indices greater than 1.0 indicate greater attendance levels by girls. Between 2007/8 and 2014, GPI increased only marginally in Punjab (+0.01). This change reflected an increase in GPI in rural (+0.02) and other urban areas (+0.01), but a decline in major cities (−0.05) (Table 2). The overall marginal increase masked a wide range of experiences at the district level where GPI indices increased in 20 of 35 (57.1%) districts (Figure 8a). Of these, greatest increases were recorded in the northern districts of Kasur (+0.14), Sargodha (+0.12), Gujrat (+0.09), and Nankana Sahib (+0.08), and in the central district of Sahiwal (+0.11). In contrast, districts that experienced greatest decreases in GPI were more scattered and comprised the southern district of Rajanpur (−0.28), the central district of Bahawalnagar (−0.12), and the northern districts of Narowal (−0.14), Gujranwala (−0.09), and Rawalpindi (−0.09).

In 2014, Punjab recorded a GPI of 0.96, an index that slightly favoured boys (Table 2), and reflected GPI values for major cities (1.02) and other urban areas (1.02) being offset by a comparatively low GPI for rural areas (0.94). At the district level, 9 of 35 (25.7%) districts registered indices greater than 1.0 thereby indicating that more girls than boys were attending primary schools (Figure 8b). Most of these districts were located in northern Punjab where particularly high indices were recorded in Gujrat (1.11), Sahiwal (1.10), Faisalabad (1.08), Kasur (1.07), and Sheikhupura (1.07). A further 16 of 35 (45.7%) districts had GPI indices ranging between 0.91 and 1.00 indicating that an almost equal percentage of girls and boys were attending primary schools. In contrast, an extremely low index was recorded in the southern district of Rajanpur (0.51), with other relatively low indices identified in the southern districts of Rahim Yar Khan (0.77) and Lodhran (0.84), and in the central districts of Bahawalnagar (0.82) and Jhang (0.84).

In general, the data provide strong evidence of improving educational opportunities for girls in Punjab. Nevertheless, the very low and decreasing GPI of Rajanpur is cause for concern. Rajanpur is one of the least developed districts of Punjab. It is heavily dependent on agriculture with less than 15% of its population living in urban areas. The social and cultural norms of Rajanpur and other less developed areas usually favour boys allowing them to utilize family resources towards their education (Chaudry and Rahman 2009; Rehman et al. 2015). Some parents are reluctant to invest in their daughters due to the fact that girls are more likely to move out of the family after marriage whereas boys are expected to stay with their families to look after aging parents (Brown and Park 2002).

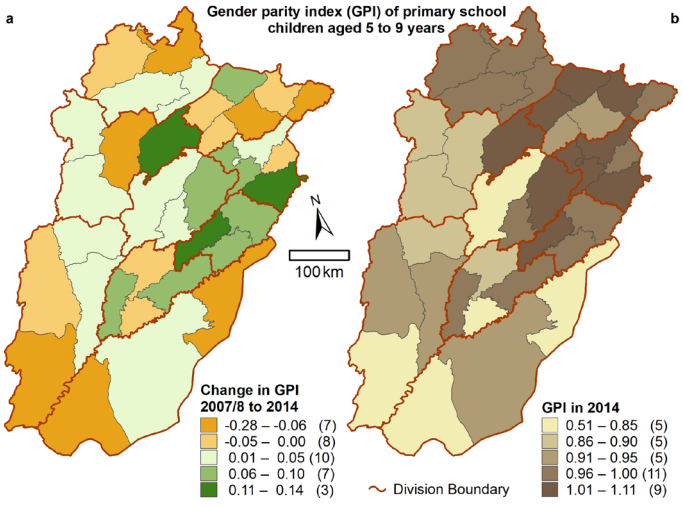

Figure 8
Gender parity index (GPI) of primary school children aged 5 to 9 years: a) change in GPI, 2007/8 to 2014; b) GPI in 2014

Attendance in private primary schools

Between 2007/8 and 2014, attendance by children aged 5 to 9 years in private primary schools in Punjab increased by 2.6 percentage points (Table 2). This fairly modest change masked substantial variation in experience across the province. Thus, whereas a major increase in enrolment was recorded in rural areas (+6.0), approximately equivalent decreases were recorded in major cities (−6.3) and other urban areas (−4.2). At the district level, attendance increased in 23 of 35 (65.7%) districts, with greatest increases occurring in the districts of Nankana Sahib (+16.7), Mandi Bahauddin (+12.3), Sheikhupura (+11.1), and Hafizabad (+9.4) to the northwest of Lahore, and in the central district of Bhakkar (8.8) (Figure 9a). Somewhat surprisingly, notable increases were also experienced in the southern districts of Muzaffargarh (+6.6), Bahawalpur (+6.2), and Rajanpur (+5.5). At the opposite end of the spectrum, greatest decreases occurred, unexpectedly perhaps, in the districts of Narowal (−9.4), Sialkot (−6.2), Gujrat (−4.5), and Gujranwala (−2.9) to the northeast of Lahore, but also in the southern district of Lodhran (−3.7). The variable experience of change particularly in rural areas and the districts to the north of Lahore is intriguing.

Arguably, the overall increase in private school enrolment represents a reaction to overcrowding and inadequate provision

of publicly funded education facilities especially in rural areas, and to the unavailability of a safe public transport system for children. Also, there is evidence that greater affordability and lower student-teacher ratios have contributed to increased attendance in private schools (Andrabi et al. 2008). This has led to greater acceptance of private schools and an increase in their number. At the same time, the increase in enrolment in some southern districts suggests that families in these relatively poor areas appreciate the importance of education in breaking the cycle of poverty, and have started investing in the education of their children.

By 2014, enrolment in private primary schools ranged widely across the province (Figure 9b). At the district level, only 8 of 35 (22.9%) districts recorded attendance rates greater than 50%, and all of these, as might be expected, were located in relatively prosperous northern Punjab. They included the districts of Lahore (71.0%), Sheikhupura (62.0%), Gujranwala (61.9%), Rawalpindi (60.2%), and Sialkot (56.7%). Despite some notable gains, enrolment in private primary schools remained low in most districts in southern and central Punjab with lowest overall enrolments occurring in Lodhran (22.4%), Mianwali (24.9%), Bahawalnagar (24.9), Rajanpur (26.6%), and Bhakkar (27.4%).

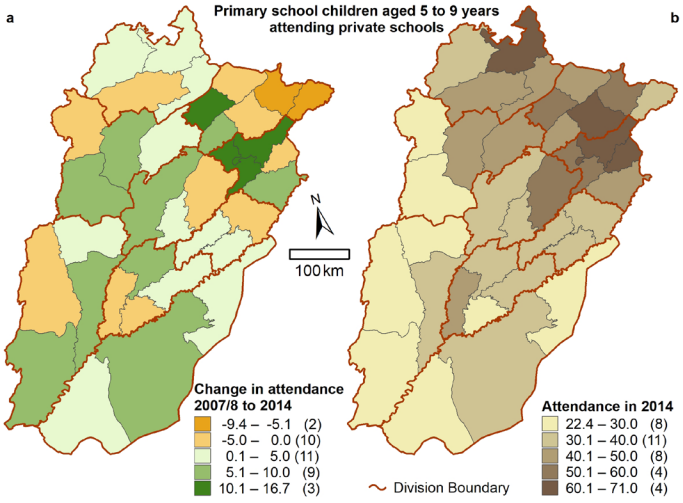

Figure 9
Primary school children aged 5 to 9 years: a) change in attendance, 2007/8 to 2014; b) attendance in 2014

Literacy and educational opportunity in relation to wealth

The preceding discussion has suggested that comparative wealth is a factor in explaining literacy levels and educational opportunity in Punjab. Provincial level data for 2014 provides evidence of very strong relationships in which literacy and education variables are strongly related with wealth (Table 3). For example, among the population aged 10 years and over, a literacy rate of 86.1% is recorded for persons belonging to households in the highest wealth quintile. Literacy levels then decrease by quintile until reaching 28.2% for persons in the lowest wealth quintile. Expressed alternatively, this means that persons in the highest wealth quintile were over three times more likely than persons in the lowest quintile to be classified as literate. A similar relationship is identified for the female population aged 10 years and over except that in this case females in the highest wealth quintile were over five times more likely to be identified as literate. This pattern of relationships is then repeated for both the total and female populations aged 15 to 24 years, and for NAR, GPI, and private primary school attendance.

In most of the aforementioned relationships the range in values between the highest and lowest wealth quintile is striking. Despite this, between 2007/8 and 2014 positive rates of change tended to be greater for the lowest, second, and middle quintiles than for the fourth and highest quintiles. Moreover, rates of change were usually greater for females than for the total population and, by inference, greater than those for males. These observations indicate a reduction in disparity. An example of this is provided by change in private primary school attendance. In this case, children of families in the lowest, second, and middle quintiles recorded percentage point increases of 7.1, 3.2 and 2.6 respectively, whilst those in the fourth and highest quintiles recorded increases of 3.0 and 0.6. It is known that economic conditions play a crucial role in childhood education and that chil-

Table 3
Literacy and educational opportunity in relation to wealth quintiles in 2014

	Literacy Rate of Population Aged 10 Years and Over		Literacy Rate of Population Aged 15 to 24 Years		Primary School Net Attendance Rate (NAR) of Population Aged 5 to 9 Years		Primary School Gender Parity Index (GPI)	Private Primary School Attendance
	Total	Female	Total	Female	Total	Female		
	% [C]	% [C]	% [C]	% [C]	% [C]	% [C]	Index [C]	% [C]
Quintiles								
Highest	86.1 [0.5]	81.4 [0.3]	95.5 [0.7]	95.7 [0.3]	74.9 [3.5]	75.6 [2.7]	1.02 [-0.02]	79.8 [0.6]
Fourth	73.1 [0.8]	66.3 [2.3]	88.6 [1.7]	88.2 [1.6]	71.0 [6.7]	72.1 [6.4]	1.03 [-0.01]	59.4 [3.0]
Middle	63.0 [1.7]	54.0 [4.2]	80.2 [2.6]	78.7 [6.7]	66.8 [7.0]	67.1 [7.2]	1.01 [0.01]	39.8 [2.6]
Second	49.5 [3.4]	37.1 [5.1]	66.3 [6.4]	58.9 [10.9]	55.4 [6.3]	54.1 [6.9]	0.96 [0.03]	24.6 [3.2]
Lowest	28.2 [1.6]	16.0 [2.5]	41.1 [5.1]	27.6 [8.5]	33.8 [2.7]	29.0 [3.4]	0.76 [0.05]	16.5 [7.1]

[C] = Perecentage point change from 2007/8 to 2014. Highlighting denotes greater percentage point change for females.
Source: SBJ (2009, 2016)

dren of poor families are the least likely to be enrolled in schools (Boutayeb and Helmert 2011). Despite this, these data suggest that in Punjab relatively poor families are at least as committed as wealthy families to improving the educational opportunities of their children.

In sum, the relationships between literacy and educational opportunity on the one hand and wealth on the other are strong and remarkedly consistent. Although major disparities are still evident, and particularly for persons in the lowest wealth quintile, there is considerable evidence of advancement for persons belonging to all wealth quintiles, and in many instances, improvement has been greatest for persons belonging to the lowest, second, and middle quintiles, and particularly for females in these quintiles.

Conclusion

MICS reports for Punjab provide an important source of data for monitoring change in literacy and education indicator variables. Analysis shows improvement in literacy among youth and young adults, and in primary school attendance at both provincial and district levels. Most notably, indicators pertaining to female literacy and school attendance have shown greater improvement than corresponding indicators for the population as a whole, and, by inference, for males. This finding points to the successful application of literacy and educational initiatives in the promotion of female education in a conservative society. Nevertheless, gender disparity persists and is typified by comparatively low literacy and school attendance rates in rural Punjab, and particularly by rates in the southern districts of Rajanpur, Rahim Yar Khan, and Dera Ghazi Khan, which continue to lag behind districts in the relatively prosperous and more urbanized north.

The study has examined data for two points in time, 2007/8 and 2014, and has identified a record of predominantly positive changes in literacy and school attendance rates. Despite this, some districts have experienced little or no improvement, and seemed locked in a condition of marked disparity. Future research should identify the socio-economic and socio-cultural conditions or public policy failings that might explain continuing disparities, and indicate what policy initiatives are needed to redress them. Also, analysis of data for additional years is recommended to determine whether progress towards MDG and SDG targets is maintained. Achievement of targets will require further elimination of gender and regional disparities which are rooted in socio-cultural norms and income inequalities.

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Across the Division

Brandon University

The Department of Geography and Environment had some staff changeover this past year. Dr. Kristen Lowitt, who was on a 5-year term, left for a tenure-track position at Queen's University. We enjoyed having Kristen on faculty and wish her well in the future. The department was then happy to welcome Dr. Julie Chamberlain into the position on a 3-year contract. Julie's research area is critical race urban geography in Germany and Canada. She will be teaching introductory and upper-level cultural geography courses. In other news, Dr. Derrek Eberts and Dr. Christopher Malcolm, along with Dr. Doug Ramsey in the Department of Rural Development, were awarded a SSHRC Partnership Engage Grant to study the effects of COVID-19 on tourism and recreation in southwestern Manitoba. Dr. Rachel Herron was successful in obtaining a CIHR Project Grant to study safe places for ageing and care. In the fall, Dr. Alex Koiter was selected to the Beef Cattle Research Council Mentorship Program. The COVID-19 pandemic, of course, affected our year. Dr. Peter Whittington was the invited keynote speaker for the Flow Country Workshop in Thurso, Scotland. Unfortunately, the conference was cancelled. Dr. Herron secured a SSHRC Connection grant to host the Mental Health on the Prairies Conference and Community Gathering. COVID-19 forced postponement of the conference until a later date. In late September, the department was scheduled to host the PCAG's annual conference in Virden, but had to cancel the event. We now hope to host the conference in September 2021.

Lakehead University

The year 2020 can only be described as a year of patient coping with the fallout of the COVID pandemic. For that reason, we have very little news to report. We have not experienced any personnel changes—planned or unplanned—for which we are grateful. Our student numbers remain relatively steady. Teaching geography courses online presented its own unique challenges, some of which we have met through creative use of video laboratories, multimedia editing, and teaching alternatives that improve students' understanding of the spatial and temporal aspects of the field through online mapping and visualization. Not surprisingly, field and lab work have still been severely affected in many courses by the distancing rules. The department has been awarded a multi-year grant to perform assessments of hydrological function and climate change vulnerability on the Neebing River in Thunder Bay. This research forms part of a multi-institutional collaboration through the Ontario Ministry of Environment, Conservation, and Parks. Also, we have received additional funding allowing us to maintain our long-standing relationship with the North Shore of Lake Superior Remedial Action Plan dedicated to the restoration of the degraded habitats in the Great Lakes Basin Ecosystem.

University of North Dakota

The University of North Dakota's Geography and GISc Department is still operating somewhat successfully during 'Living in the Time of COVID-19: Second Wave.' However, it is being done with a mix of many online courses and limited face-to-face classes. Unfortunately, the 2019–2020 academic year saw the passing of a longtime adjunct faculty member, Dr. Robert Seidel. He was an enthusiastic supporter of PCAG's meetings held in Devils Lake and Rugby when this campus hosted those conferences. Meanwhile, the department's new office manager, Ms. Pamela F. Nielsen, is successfully covering duties with the Anthropology Department as part of local budget cutbacks and staff restructuring. Although there are projected budget and staff reductions in the near future, the department's current ratio of operation cost/revenue generation is such that other units in the College of Arts & Sciences are being underwritten to some extent by the geographers. These colleagues hold four tenure lines (Dr. Greg Vandeberg, Dr. Paul Todhunter, Dr. Enru Wang, and Dr. Douglas C. Munski) and one non-tenure teaching assistant professor (Dr. Mbongowo Mbuh). As part of the general curricular changes being encouraged on campus, the department now is tasked with overhauling its graduate online GIS certificate and its MS program plus preparing for better integration with proposed data science-oriented curriculum collaborations across colleges. Wrapping up this news is the question of whether congratulations or commiserations are in order, but effective July 1, 2020

Dr. Munski began a three-year term as chairperson. Thus, he is set better to continue to represent this campus on the PCAG Executive Committee. He also will be an increasingly stronger advocate for cross-border cooperation even if it must be in a virtual environment.

University of Regina

During the academic year 2019/20, the Department of Geography and Environmental Studies celebrated the convocation of 23 graduates comprising four BA in Geography, one BSc in Geography, four BA in Environmental Studies, one Bachelor in Geographic Information Science (BGISc), one BA combined major in Economics and Geography, four BSc in Environmental Geosciences, seven minors in Geography, and one PhD in Geography.

In September 2019, the department hosted PCAG's 2019 Annual Meeting in cooperation with Saskatchewan Polytechnic's Geomatics and Surveying Engineering Technology Department in Moose Jaw. The conference was very well attended and featured some excellent student presentations. And the food was great!

Due to the outbreak of COVID-19, the department was forced to adapt to new ways of teaching. Courses for the winter term switched to online/remote teaching in mid-March 2020 and some courses planned for Spring 2020 (e.g., a field trip course to Berlin, Germany) were cancelled in compliance with public health advisories.

Several department members received funding for a variety of research projects. Among them were the following: Dr. Vanessa Mathews was awarded a SSHRC Insight Development Grant for a project on the effects of craft beer on small towns in Ontario; Dr. Julia Siemer received funding as co-applicant from the Community Engagement and Research Centre (CERC) for a GIS study on healthy food accessibility in Regina; and Dr. David Sauchyn (PARC) received several grants, including funding from NSERC, the International Institute for Sustainability Development, and the Saskatchewan Water Security Agency.

The department is continuing to work on implementing the redesign of its academic offerings and curriculum, based on recommendations that resulted from its most recent unit review. With regret, the department has lost a valued member, Dr. Kyle Hodder, who has taken on a new position at Queens University in his native Ontario. The department is also sad to announce the sudden passing of Dr. Hansgeorg Schlichtmann, Professor Emeritus, in May 2020.

University of Winnipeg

The past year has been both challenging and immensely rewarding for the Department of Geography at University of Winnipeg. While the global pandemic has altered the way we deliver our courses and conduct our research, it has not delayed the overall operations of our department. In June, the Department of Geography along with the Department of Environmental Studies' application for a new graduate program titled Environmental and Social Change was approved. Implementation and planning are underway for admission of our first students in September 2021. The graduate program will offer the following degrees—Master of Science, Master of Arts and Master of Environment (a first of its kind on campus). To quote the application—"The three-credential structure reflects the interdisciplinary focus of the programs: while students would choose one of the three degree routes for their specialization, all students would participate in training activities in and out of classes and laboratories designed to bridge social and natural science with humanities research." The department would like to give special thanks and recognition to Dr. Nora Casson (Geography) and Dr. Ryan Bullock (Environmental Studies) who tirelessly drove the process forward ultimately resulting in its success. We are looking forward to our first graduate students this coming fall. Please email mesc@uwinnipeg.ca for further information on the graduate program.

Additionally, the department has been at the heart of several major funded research projects. Dr. Patricia Fitzpatrick (Co-Investigator and Manitoba Lead) was part of a team awarded a Social Sciences and Humanities Research Council of Canada Partnership Grant (2019–2026) of $8.8 million ($2.5 million from SSHRC) titled "Community Appropriate Sustainable Energy Security (CASES)." Dr. Marc Vachon in collaboration with West End Biz was awarded a summer student grant to research and develop a West End Mural tour which focuses on architecture, culture, and the role of public art, place making, and social space. Dr. Gina Sylvestre has been working with Connor McFarlane, a Selkirk High School student, on historical research examining the leadership of Chief Peguis pre- and post-European contact. These are only samples of the accomplishments of our faculty, many of whom have been successful in obtaining research funding over the last year.

Last but not least, the Department of Geography would like to extend its warmest thanks to Brian McGregor (Instructor) and Weldon Hiebert (Cartographer) for their many years of service and offer them our best wishes on the occasion of their recent retirements. We wish them all the best in their future endeavours. We also want to welcome Dr. Sheika Henry (Instructor) who has been hired for a

1-year limited term appointment. Dr. Henry's research interests include using big data to analyze geomorphic surface processes, hazard, risk and vulnerability assessment, climate variability and change, and vector borne diseases. Her work involves the application of GIS, remote sensing, and statistical analysis in aiding decision support systems.

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About the Authors

John Lehr is a Senior Scholar in the Department of Geography at the University of Winnipeg, where he was formerly a Professor. His research interests focus on the role of ethnic and religious groups in settling the Canadian West. With Yossi Katz he is the author of *Inside the Ark: The Hutterites in Canada and the United States* (University of Regina Press 2014).

Herve Lahamy is an instructor in the Geomatics Engineering program at Saskatchewan Polytechnic. Prior to his PhD studies at the University of Calgary, Herve worked for 10 years at the National Surveying and Mapping Agency of Benin Republic. His research interests include accuracy analysis of surveying technologies and 3D point cloud processing.

Christian Larochelle is a 2019 graduate of the Geomatics Engineering and Surveying Technologies Diploma program at Saskatchewan Polytechnic. He is currently employed as a junior party chief for Caltech Surveys Ltd. and continues to study and expand his knowledge in various surveying methods and technology.

Brian McGregor is a former instructor in the University of Winnipeg's Department of Geography where he taught cartography, GIS, statistics and physical geography. He holds an MA from Queen's University and a diploma in GIS from the College of Geographic Sciences. He has published articles in *Canadian Ethnic Studies*, *Great Plains Research*, *Manitoba History* and *Prairie Perspectives* applying GIS to a variety of historical and contemporary issues.

Abdul Raouf is an instructor in the Geomatics Department of Saskatchewan Polytechnic, Moose Jaw Campus. He has 30 years of post-PhD research and teaching experience. In the past, he has worked at the European Space Agency (ESA), and the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO). His expertise includes integrated use of remote sensing and GIS for land-use planning, disaster monitoring/mitigation, and environmental management.

Tayyab Shah is a Geospatial Research Manager with the Canadian Hub for Applied and Social Research, University of Saskatchewan. He is a broadly trained geographer with over 15 years professional and research experience in geospatial science. His interdisciplinary research lies at the intersection of geospatial technologies and health/environmental geography.

Rizwan Shahid is a Geographic Information Scientist at Alberta Health Services and an Adjunct Assistant Professor at the Department of Geography, University of Calgary where he is co-lead of the Geographies of Health and GIS Analysis Research Group.

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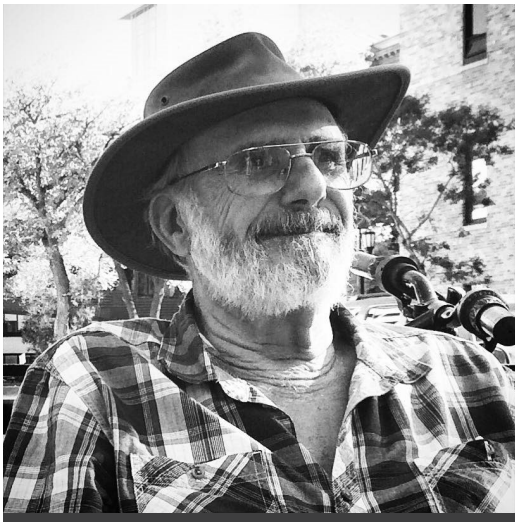

Henry John Selwood
22 November 1936–31 August 2020
Source: Katherine McLennan

Henry John Selwood 1936–2020

My friend and colleague, Henry John Selwood (always known as John), passed away on August 31, 2020.

John was born in London, England, where he received his early education. At age 16 he joined the Royal Artillery Regiment as a musician. He played the clarinet and bassoon in the Royal Artillery Band. According to John he and the army seldom saw eye to eye, and he spent a considerable time on *jankers* (KP), often for "dumb insolence." After four years' service, he left the army to join his parents who had emigrated to Canada a couple of years earlier. In Winnipeg, John completed his education at Gordon Bell High School. He then entered the University of Manitoba to study commerce. After two years he took a year off to work as a Bridge Inspector for the Manitoba Provincial Highways Branch. On his return to the University of Manitoba he switched to a major in geography. After completing his BA, he obtained an MA from McGill, before enrolling in the PhD program at the University of Western Australia. In 1969, John returned to Canada to become a member of the University of Winnipeg's Geography Department.

John loved Australia, returning often to work on completing his PhD, which he obtained in 1982, and afterwards to collaborate on research projects with colleagues at Perth's three universities. John's research initially had an urban focus but increasingly turned to recreation and tourism. He published on subjects as diverse as pet cemeteries, the sex trade, food tourism, urban transportation, and the role of the Hudson's Bay Company in land development. He authored or co-authored over 60 papers, 20 book chapters, and two monographs. He contributed many entries to encyclopedias, and co-edited collections of papers presented at PCAG meetings. He presented over 115 papers at academic conferences around the world.

John was always a strong supporter of the CAG, serving on the National Executive and as President of the PCAG from 1990 to 1992 and 1998 to 2002. He received both the John H. Warkentin Award for Scholarly Contributions to the Geography of the Interior of Western Canada, and the John E. Welsted Award for Service to Geography in the Western Interior.

John was never comfortable teaching large first year classes, preferring small seminars where one-to-one interaction was possible and where his bone-dry, often sardonic, sense of humour was more readily appreciated. He was a firm believer in the value of field trips and experiential learning. His field trips to North Dakota and Brandon acquired a reputation for introducing students to sites not listed in *Baedeker*!

John loved classical music. From 1983 to 1992 he served on the board of the Winnipeg Bach Festival, where he served a term as President, and was a member of the boards of the Harpsichord Association of Manitoba, the MusikBarock Ensemble, and the Winnipeg Youth Orchestra.

He leaves to mourn his passing his daughters Carol and Lynn, Katherine his wife and partner of 33 years, and many friends in Canada and Australia. John will be missed.

John C. Lehr
University of Winnipeg

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Hansgeorg Schlichtmann
29 April 1938–31 May 2020
Source: Esther Schlichtmann

Hansgeorg Schlichtmann 1936–2020

Hansgeorg Schlichtmann (known to colleagues as Hans) was born in East Prussia and grew up in Hannover, West Germany. After studying geography at the universities in Göttingen and Tübingen, Hans received his degree of DPhil in geography in 1967 from Eberhard-Karls-Universität, Tübingen. From 1966 to 1970, he worked as a research officer at the Federal Research Institution for Geography and Planning in Bonn. In 1970, he accepted a teaching position from what was then the University of Saskatchewan, Regina Campus.

After arriving in Regina, Hans taught geography and cartography and was quickly promoted to the rank of full professor. After his retirement from the University of Regina in 2005, he became Professor Emeritus. Hans continued to be an active researcher working on his projects and publications and attending conferences during his retirement.

Hans's areas of professional interest were cultural geography, historical geography, geography of settlements and, more recently, cartography (with emphasis on cartosemiotics). His research in cartosemiotics stands in the semiotic tradition of continental Europe. In the International Cartographic Association, he served as chairman of the Working Group on Map Semiotics (1995–1999) and as vice-chairman of the Commission on Theoretical Cartography (1999–2007). In the former capacity he edited *Map semiotics around the world* (1999). He co-edited the discussion-paper series *Kartosemiotik/Картосемиотика* (1994–1995) and was co-editor of the successor series *Diskussionsbeiträge zur Kartosemiotik und zur Theorie der Kartographie* (2012). In 2011, he published *Cartosemiotics: A Short Dictionary*, the first dictionary of the field written in English.

Throughout his career, Hans was a teacher and a scholar with very high standards; always thorough and uncompromising. He was highly respected by his students as well as by his colleagues. Colleagues and students who got to know him better experienced his inner warmth, compassion and mentorship.

Hans was a rather private man, not too fond of social gatherings and seemed often difficult for his students to approach. But when students showed genuine interest in his assistance, he would move the earth for them and explain anything to the greatest detail. His recall of facts and literature on an array of subjects—even beyond geography—was legendary. The students who dared break through his sheath of inscrutability to waylay him on his way home after his long hours in the library or office were richly rewarded. When they bought him a round at the campus bar, they got a glimpse of his kindness, wry humour and gentle nature.

Dr. Hans Schlichtmann passed away unexpectedly on May 31, 2020. Hans is survived by his wife Ingeborg, his daughter Esther (Christian) and two grandchildren, Nicholas and Brookelyn.

Ulrike M. Hardenbicker
University of Regina

Editor's note: Parts of this entry are included with permission of the journal *SemiotiX*.