Resources and Transportation in the Arctic in the Light of Climate Change

Research Presentation
by Alexander Strutzke
The Interdependency of Resource Mining, Transportation and Infrastructure with Natural Conditions and the Society in the Canadian North and Alaska. Chances and Risks of a Changing Climate.

Supervisor: Prof. Dr. Christian Opp, Philipps-University Marburg
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1. BACKGROUND
1.1 Philipps-University of Marburg
1.1 Philipps-University of Marburg

- Founded in 1527 by Landgrave Philipp the Magnanimous of Hesse
- About 23,000 students in 16 Departments
- No main campus – Department buildings are placed all over the city of Marburg
- Population of Marburg: 58,000
- „Other cities have a university – Marburg IS a university“
1.1 Philipps-University of Marburg
1.2 Motivation

- Exchange at the University of Saskatchewan (U of S) in 2004/05
- Master thesis at the National Water Research Institute in Saskatoon (NWRI, part of Environment Canada) in 2005/06
- Thesis topic: "Watflood in the Arctic – Application of a Hydrological Model in Arctic Basins with Different Land Cover Classes"
2. INTRODUCTION
2.1 Problem Statement

• Question: What is the interdependency of Transportation and Natural Conditions in the Canadian North and Alaska. How does climate change affect this interdependency?

• Problem: Versatile and very scattered literature. Interdisciplinary work-up hardly or not available.
2.2 Interdisciplinary Approach

Thesis

- Geography
- Economics
- Geology
- Environmental Science
- Social Science
- Political Science
- Biology
- Civil Engineering
2.3 Objectives

- Finding regularities and site-specific differences of climate change effects in the Arctic and Subarctic
- Raising awareness for the impact of climate change in the Arctic and Subarctic
- Recommendations for Arctic policies
2.4 Methodology

• Literature Review
• Remote Sensing (satellite images)
• Statistical Analysis, e.g.
  – Climate
  – Transportation
  – Mining
  – Infrastructure
• Surveys
• Geographic Information System (GIS)
2.5 Study Region

Bone (2009): Arctic, S. 3
2.5 Study Region

- Boarder Arctic/Subarctic: Treeline
- Arctic
  - Tundra vegetation
  - Continuous Permafrost
  - Summer mean temperature: 10 °C
- Subarctic
  - Boreal Forest
  - Discontinuous and sporadic Permafrost
2.5 Study Region

- Population: 1.47 million people live in Canadian Subarctic and Arctic
- 93% thereof live in Northern parts of the provinces, only 7% (ca. 115,000) in the Territories (Yukon, Northwest Territories and Nunavut)
- Indigenous population: Yukon ca. 25%, Northwest Territories ca. 50% and Nunavut ca. 85%
• Arctic and Subarctic are resource rich
  – Oil, Gas, Coal, Diamonds
  – Minerals (e.g. Uranium, Gold, Silver, Tungsten)
  – Potash, Timber, Sand and Gravel
  – Hydroenergy

• The North is a remote area
  – Streets and railways lead south
  – Air traffic is seasonally the only way of transportation
  – Some settlements exist only because of mines
3. IMPLICATIONS OF CLIMATE CHANGE IN THE ARCTIC
3.1 Temperature Change
3.1 Temperature Change

-30
-25
-20
-15
-10
-5
0
5
10
15
20
25

Temperatur in °C

GOOSE (NL)

Januar
Juli
Jahresdurchschnitt

Linear (Januar)
Linear (Juli)
Linear (Jahresdurchschnitt)
3.1 Temperature Change

The diagram shows the temperature change over the years for the months of January and July, as well as the annual average, for the ALERT (NU) site. The x-axis represents the years from 1983 to 2012, and the y-axis represents the temperature in °C. The graph indicates a general increase in temperature over the period, with slight fluctuations each year.
3.1 Temperature Change

YELLOWKNIFE (NT)
3.1 Temperature Change

FORT SIMPSON (NT)

Temperatur in °C

Januar
Juli
Jahresdurchschnitt

Linear (Januar)
Linear (Juli)
Linear (Jahresdurchschnitt)
3.1 Temperature Change

[Graph showing temperature changes over the years for Dawson (YT)]

- Temperature in °C
- Linear (Januar)
- Linear (Juli)
- Linear (Jahresdurchschnitt)
3.2 Implications for Natural Conditions

- Thinning sea-ice in the Arctic sea
- Smaller sea-ice distribution
- Earlier melt of snow and ice
- Melting of permafrost → increasing active layer
- Treeline moves northwards
- Plants migrate northwards
- Animals (e.g. Caribou) follow their food
3.3 Implications for People

- Hunters (e.g. Inuit, also polar bears) face changing conditions. Hunting on thinning sea-ice is more dangerous.
Melting permafrost endangers buildings and infrastructure (1)
3.3 Implications for People

Melting permafrost endangers buildings and infrastructure (2)
3.3 Implications for People

Mining of resources is easier, open-pit-mining time increases
Iceroad-time decreases. Heavy load transportation more difficult
3.3 Implications for People

New transportation possibilities with ships through an ice-free Northwest passage
3.3 Implications for People

Cruise ships in the Arctic
4. INTERDEPENDENCY OF NATURAL CONDITIONS AND TRANSPORTATION
4.1 Definition

- Transportation of goods takes place in two directions:
  - North ➔ South: In the Northern regions raw materials are mined (e.g. oil, gas, gold, diamonds, sand and gravel) and transported south for further processing. Destinations: Southern Canada and USA
  - South ➔ North: machinery, food, construction materials, workers and tourists are transported into Northern regions. Destination: small “islands” in Northern areas where resources exist, that are economically worth to mine
4.2 Nature → Transportation

• Huge geographic area (7.6 million km² in Canada are part of the Arctic/Subarctic)
  • Very few settlements, small population
  • Far away from the South
  • Cold climate
  • Permafrost
  • Wilderness

• Transportation of goods is expensive due to long distances and missing infrastructure
  • Building on permafrost is more complex and expensive. Risk of destruction due to melting permafrost.
  • Isolation and climate challenges lead to expensive employees
Mining produces waste

- Example (1): Fracking and oil sand production leave huge amounts of contaminated water
- Example (2): Hydroenergy projects change the course of rivers and landscapes

Pipelines disturb migration patterns of animals (e.g. Caribou)

Burried pipelines thaw permafrost
4.3 Transportation $\rightarrow$ Nature (2)

- Transportation changes the indigenous population that lived before independently from outside influence in the Arctic.

- Resource towns exist only as long as the mine exists. If the mine closes (destroyed) ghost towns remain.

$\rightarrow$ No sustainability, no diversification.
5. EXAMPLES
Sea-ice distribution summer minimum 16.09.2012
Source: NASA (http://svs.gsfc.nasa.gov/vis/a000000/a003900/a003998/)
5.1 Sea-ice distribution

Sea-ice distribution winter maximum 28.02.2013
5.1 Sea-ice distribution

Sea-ice distribution summer minimum 1979-2012
Source: NASA (http://svs.gsfc.nasa.gov/vis/a000000/a003900/a003991/)
5.1 Sea-ice distribution

- Seasonal sea-ice distribution decreases continuously
- Sea-ice cover gets thinner
- Vicious circle: Dark (ice-free) water absorbs more solar energy and melts the adjacent ice faster
- Ice melt starts earlier in the season, freezing starts later
- Implications:
  - Shipping the Northwest and Northeast passage is possible at times
  - Shipping of resources is easier
  - Access to resources in the Arctic Ocean
  - Political conflict about borders in the Arctic Ocean
  - Different natural habitat for animals and humans
5.1 Sea-ice distribution

- Where are the borders in the Arctic?
- Who owns the shipping routes at and around the (ice-free) North pole
- Who owns the resources in the Arctic Ocean?
- The Arctic Council is searching for answers to these questions.

Chairmanship May 2013-2015: Canada
5.1 Sea-ice distribution

- Shorter seaway through Northwest Passage and Northeast Passage compared to seaways through Panama Channel and Suez Channel
- Northwest Passage was ice-free for the first time in 2007
- Both routes were ice-free at the same time in 2008
- Commercial shipping has already been started in the Northeast Passage
5.2 Tibbitt to Contwoyto Winter Road

**First year constructed** 1982  
**Original purpose** supply the Lupin Gold Mine at Contwoyto Lake, NU  
**Length** 600 kilometres with route being 87% over lake ice  
**Width** 50 metres on lakes, narrower on portages (12-15 metres)  
**Ice thickness** Engineer proven to support light vehicle loads at 70 cm increasing to full highway truck loads as the ice thickens, often exceeding 107 cm  
**Speed limits on ice**: Loaded trucks 25 km/hr with some areas 10 km/hr; empty trucks 60-70 km/hr on “Express Lanes” – which are return (southbound lanes) built on larger lakes
5.2 Tibbitt to Contwoyto Winter Road

- Construction starts shortly after Christmas each year
- 5-6 weeks around the clock construction to open end of January
- Road opens for 8-10 weeks
- Main transported good is Diesel fuel
- When the ice reaches 107 cm it is thick enough for a “super B tanker” fully loaded with 50,000 l of fuel, each tank weighs about 42 tonnes
### 5.2 Tibbitt to Contwoyto Winter Road

<table>
<thead>
<tr>
<th>Year</th>
<th>Operating Period</th>
<th>Days</th>
<th>Total Tonnes Hauled (northbound)</th>
<th>Number of Truckloads (northbound)</th>
<th>Number of Backhauls (southbound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>Jan 26 – Apr 16</td>
<td>81</td>
<td>256,915</td>
<td>7735</td>
<td>433</td>
</tr>
<tr>
<td>2003</td>
<td>Feb 1 – Apr 2</td>
<td>61</td>
<td>198,818</td>
<td>5243</td>
<td>883</td>
</tr>
<tr>
<td>2004</td>
<td>Jan 28 – Mar 31</td>
<td>64</td>
<td>179,144</td>
<td>5091</td>
<td>165</td>
</tr>
<tr>
<td>2005</td>
<td>Jan 26 – Apr 5</td>
<td>70</td>
<td>252,533</td>
<td>7607</td>
<td>243</td>
</tr>
<tr>
<td>2006</td>
<td>Feb 5 – Mar 26</td>
<td>50</td>
<td>177,674</td>
<td>6841</td>
<td>469</td>
</tr>
<tr>
<td>2007</td>
<td>Jan 27 – Apr 9</td>
<td>73</td>
<td>330,002</td>
<td>10,922</td>
<td>818</td>
</tr>
<tr>
<td>2008</td>
<td>Jan 29 – Mar 31</td>
<td>63</td>
<td>245,585</td>
<td>7484</td>
<td>890</td>
</tr>
<tr>
<td>2009</td>
<td>Feb 1 – Mar 22</td>
<td>50</td>
<td>173,195</td>
<td>4847</td>
<td>530</td>
</tr>
<tr>
<td>2010</td>
<td>Feb 4 - March 21</td>
<td>46</td>
<td>120,020</td>
<td>3508</td>
<td>429</td>
</tr>
<tr>
<td>2011</td>
<td>Jan 28 - March 31</td>
<td>63</td>
<td>239,000</td>
<td>6832</td>
<td>530</td>
</tr>
<tr>
<td>2012</td>
<td>Feb 1 - March 31</td>
<td>60</td>
<td>210,188</td>
<td>6551</td>
<td>648</td>
</tr>
</tbody>
</table>
5.2 Tibbitt to Contwoyto Winter Road

Tibbitt to Contwoyto Winter Road
Operation Days

- 2002: 81
- 2003: 61
- 2004: 64
- 2005: 70
- 2006: 73
- 2007: 63
- 2008: 50
- 2009: 50
- 2010: 46
- 2011: 63
- 2012: 60

Graph shows the number of operation days for the Winter Road from 2002 to 2012.
5.2 Tibbitt to Contwoyto Winter Road

Tibbitt to Contwoyto Winter Road
Total Tonnes Hauled Northbound
6. CONCLUSION
6. Conclusion

• The impact of Climate change on transportation and infrastructure in Arctic and Subarctic areas is much more severe than in other areas of the world

• Climate change will continue. We need strategies to adapt to it

• Climate change has positive and negative effects on transportation. Which ones predominate in the future has yet to be determined
7. Acknowledgement

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- My supervisor Prof. Dr. Christian Opp
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- My family, especially my wife Marzi
Thank you! Questions...?