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Climate Change and Sustainable Living in Remote Communities

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***Abstract*— Climate warming in the Circumpolar World inflicts the greatest impact on the potential for sustainable living in remote northern communities. Attaining sustainable living is a process of reducing dependencies on outside influence for the supply of goods and services in all aspects of community life, and requires entrepreneurial action at the community level. The author builds on two prior publications, Malcolm 2010 [1] and Malcolm 2013 [2] to study the adaptation challenge, including entrepreneurism as a lead-in to policy innovation in both public and private sectors. Emphasis is placed on engineering best practices in the Arctic from a Canadian perspective.**

Keywords— climate; warming; circumpolar; remote; communities; permafrost; sustainable; dependency; methane; extreme; weather

I. INTRODUCTION

Fortunately, climate change impacts and adaptation (CCIA) in the circumpolar north does not depend upon a definitive proven link between greenhouse gas emissions and anthropogenic climate warming over regional scales. The weather and climate data on a regional basis, corroborated by the personal experience of warming impacts by long-time residents and indigenous elders in boreal and Arctic communities, are what we need to demonstrate that adaptation is vital. This paper lays out some of the important considerations to lead toward community sustainability.

I became very interested in the importance of sustainable living and how entrepreneurial skills can be encouraged in northern communities in Canada during conversations with engineers, scientists, and community residents on the poor track record of applying research results. The emphasis at the university and government research agency levels are always on doing more and more research. I began to consider that we must apply the research results that we already have to reduce community dependency on outside economic and social influence. Climate change is seen to impact all of the dependencies discussed by Malcolm 2010 [1]. Also engineering and innovation are certainly important to complement climate change adaptation, as discussed by Malcolm 2013 [2].

There is a considerable amount of information on warming trends in Arctic regions. In the Northwest Territories of Canada for example, this information is presently available on line at nwtclimatechange.ca under the “Impacts and Adaptation” drop down menu. We have seen the average annual temperature in the Mackenzie Delta region increase by several degrees Celsius over the past few decades. The impacts of northern climate warming on permafrost have become so serious that permafrost engineering has become a leading discipline in its own right. It is now evident that infrastructure design and construction in permafrost requires new building standards. Recent changes in building standards for infrastructure construction and maintenance in Arctic Canada have resulted in four new standards, including a standard for applying thermosyphons to building foundations in permafrost (*CSA S500: Buildings in Permafrost Supported on Thermosyphon Foundations*) They are available through the Canadian Standards Association (CSA). These standards follow a considerable amount of study by engineers in the public and private sectors, which led to the publication of a report entitled *True North: Adapting Infrastructure to Climate Change in Northern Canada* [3]. This report examined a broad range of climate change impacts and included a discussion of adaptation measures in Codes, Standards and Related Instruments, Insurance, and Disaster Management. This report is available on line on the Government of Canada Publications web site (publications.gc.ca).

II. REDUCING DEPENDENCIES FOR SUSTAINABLE LIVING

Let us look at sustainable living from a practical standpoint. Whenever we reduce a community dependency we work toward sustainable living. Malcolm 2010 outlined a number of dependencies experienced by remote communities, and encouraged local entrepreneurial action to work with these dependencies as follows: “Entrepreneurial businesses to encourage sustainable living can be built around virtually all aspects of our lives, including healing, music, crafts, and art as well as appropriate technologies, energy efficient building, cogeneration facilities, small-scale manufacturing, and food production using community greenhouse facilities” ([1] p.173). Although the paper considers circumpolar communities in particular, remote communities in India or wherever on Planet Earth experience similar challenges of dependency that need to be addressed.

Ten dependencies to be overcome when moving toward sustainable living were given in Malcolm ([1] pp.176-178) as follows:

- The energy we use
- Climate change impacts, our adaptation to them, and their effects on our lives
- Health and wellness
- Education
- Employment
- Housing
- Transportation
- Ecology and environment
- Policy and governance
- Appropriate technologies

From a practical perspective, these ten dependencies cannot be reduced or eliminated all at once. Attaining sustainable living is an on-going process, and reducing any one of the many dependencies leads a community in the right direction.

III. Impacts of Climate Change on Community Dependency

Gradual reduction of one or more of the ten dependencies leads toward sustainability in a community. The reduction of dependency leads to better social and economic living standards in that community. One of the ten dependencies, that of CCIA, affects all of the other nine, as discussed in the following subsections. There are both positive and negative effects of climate warming in these dependencies.

A. The Energy We Use

Most remote communities in Canada's North depend upon imported diesel for electrical generation and transportation, and heating oil or propane for building heat. Although some hydro is used in Yukon and NWT, power generation in Nunavut is 100% diesel-generated [4]. As the climate warms heating energy is reduced, but infrastructure development challenges increase, with a probable increase in transportation energy requirements. Ice-road seasons are becoming shorter, leading to the costly construction of al-weather roads, and more air cargo transport.

Energy conservation, through better insulated buildings and district heating systems, for example, combined with small reactors to provide the thermal energy for both district heating and power generation can reduce the dependency on imported fossil fuels. Also, as the treeline moves north ([2] p.117) with increased Arctic warming, more local biomass will become available for building heat. Wood pellets are already filling a need for building heating requirements in some northern communities, both for houses and industrial buildings, and plans for regional wood pellet manufacture are in process.

B. Health and Wellness

Health and wellness at the community level is often closely connected to environmental and ecological health, a discussion that will be continued in Section 3.7. Community health depends upon food security, a real challenge in remote areas. Some communities, such as Yellowknife and Inuvik, are becoming very active in operating community gardens and greenhouses to encourage nutritional security.

Remote communities must import most of their doctors and nurses from southern locations for the staffing of community medical centres. Warming in coming decades in Canada's northern regions could make living conditions more temperate and encourage long term residence in the more remote communities. The following short discussion on education is also relevant to health and wellness.

C. Education

As climate warming increases in the remote northern regions and living conditions become more temperate, the education dependencies on imports of teachers and curriculum may be reduced. The three northern colleges, Nunavut Arctic College, Aurora College, and Yukon College are developing more and more collaborative arrangements to provide technical and professional education services to northern residents. The importance of local education and mentoring in indigenous communities to reduce dependency has also been stressed by Helin 2008 [5].

D. Employment

At the present time, business in remote regions must attract professionals and labourers from more populated centres. The combination of more temperate living conditions through climate warming and better education opportunities in remote communities may increase the economic benefit to some industry segments.

E. Housing

Standard housing is presently developed by contractors using southern designs, but new codes and standards are being developed to encourage design, construction, and maintenance that is appropriate to local conditions [3]. Climate change impacts on the construction and maintenance of buildings and infrastructure are mostly negative. The melting of permafrost greatly increases building costs. However, as the treeline moves north with a warming climate ([2] p.117) there may be an opportunity to manufacture building products with local forestry operations.

F. Transportation

Climate warming will have negative impacts on the transportation sector. With permafrost melting increasing with increased temperatures, it will be more and more difficult, expensive, and energy intensive to build stable roads and airport runways. The transportation sector in remote regions will continue to be dependent on imported fossil fuels for the indefinite future.

G. Ecology and Environment

Climate warming brings more and more invasive species and pathogens to northern flora and fauna in Canada's remote north. Such impacts of climate change are mostly negative [6]. However, warming temperatures will increase the potential for viable agriculture in the north. Wildlife are often affected negatively by climate warming through changing migration patterns and changing habitat and food availability. For example, a cursory online literature search reveals many entries that record the fact that climate warming brings freezing rain in winter, and this can prevent caribou from penetrating the snow cover to reach the lichen food source. Some caribou herds have been decimated in this way.

According to Hassol 2004 ([7] p.96): "Climate change is occurring faster than indigenous knowledge can adapt and is strongly affecting people in many communities. Unpredictable weather, snow, and ice conditions make travel hazardous, endangering lives. Impacts of climate change on wildlife, from caribou on land, to fish in the rivers, to seals and polar bears on the sea ice, are having enormous effects, not only for the diets of Indigenous Peoples, but also for their cultures."

Operations research (OR) has a branch of study related to community development. Midgley and Reynolds 2004 have been concerned with environmental planning and management at the community level. In particular they have suggested the use of community-developed indicators so that the level of sustainability can be measured quantitatively [8]. As communities seek to adapt to climate change impacts on their infrastructure, their renewable resources, and their human health, quantitative measurement indicators are necessary to show success and suggest areas for further improvement. Waltner-Toews and Kay 2005 have written an interesting paper on applying OR to ecosystem sustainability and health from a remote community development perspective [9]. They developed an Adaptive Methodology for Ecosystem Sustainability and Health (AMESH) that has shown some success in local communities in several countries, including Nepal, Kenya, and Peru as well as Canada. Such methodologies are helpful in providing a framework for researchers to develop and apply OR knowledge while working directly with community stakeholders in a sustainable living framework.

H. Policy and Governance

Changes in government policy and changes in models of governance are necessary in remote regions to reduce dependence on policy that is dictated by federal government departments and agencies that are far-removed from the remote communities being governed. Sustainability depends upon more sensitivity to local climate conditions through local governance, policy, and decision-making.

The Adaptive Methodology for Ecosystem Sustainability and Health [9] provides a framework for community decision-making through appropriate governance models. The challenge here is to learn to apply the AMESH research results to practical community development challenges in climate change adaptation scenarios.

I. Appropriate Technologies

The influence of climate change on engineering and technology is discussed in more detail in Section 4. Changes are already underway in Arctic regions to reduce dependency on southern building codes and standards for example [3]. The required equipment and training is usually not available to support advanced technologies in small remote communities. In remote areas a lower level of technology usually increases service reliability and ease of maintenance.

IV. Engineering Innovation and Best Practices

In the remote north of Canada, engineers are faced with permafrost degradation, slumping of ice-laden landforms, changes in timing of freeze-up and spring melt, and increased melting of river and sea ice among the many aspects of global change. However, engineering practices in Canada's remote north are already responding to climate warming [3]. Over the past decades permafrost engineering has gone from being a side issue to being a popular area of study and practice. The Government of the Northwest Territories has responded to the special challenges of northern construction through published updates from time to time of its guidelines for good building practice [10].

Advanced technologies often do not meet remote community needs because of severe weather and climate impacts, and due to a lack of equipment and training for maintenance in those communities. Although climate change in Canada's Arctic implies increasing average temperatures, it is accompanied by increasing variability, with increasing instances of extreme heat and extreme cold [2]. For example, computer-controlled drive trains in modern passenger vehicles are designed for temperate climates and do not respond well to extreme cold. In most remote communities it is difficult to find anyone who is capable of even the simpler tasks of computer maintenance. The increased costs of building infrastructure and installing new equipment in remote communities now often give rise to design principles that look for the cost-optimal solution, and to life cycle costing and appropriate risk management and assessment.

One area of advanced technology that may catch on in remote communities is in the area of agriculture and food production. Community gardens and greenhouses are becoming more and more popular over the past few years. Research programs are underway in partnerships of colleges, universities and space agencies to design, build, and operate automated growth chambers for fruit, vegetable, and herb production. Although such equipment points to maintenance difficulties, broad community acceptance could give rise to wireless monitoring and calibration from a central location along with trained personnel to keep systems operating.

V. CONCLUSION

Climate warming and increasing extreme events result in social, economic, and technological challenges for remote communities. These challenges are often exacerbated by inappropriate policy, governance, and technological solutions that are imported from more moderate climes. There is an urgent need to encourage sustainable living in remote communities through the reduction of dependency in all areas, and through the mentoring of entrepreneurs in these communities to replace the import of goods and services.

New approaches to engineering design and construction are being applied to the challenges of climate change impacts in remote Arctic communities. New building codes, standards and related instruments, along with the sharing of best practices, enable engineers to assist communities to work toward future sustainability.

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