IMPLICATIONS OF INCREASING DEMAND FOR FRESHWATER USE FROM THE WATER FOOTPRINT OF IRRIGATED POTATOES

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INTRODUCTION

- Global scenarios for future water supply and demand suggest that future demand for freshwater use will increase significantly due to rising food demand, rapid urbanization, industrial development and climate change, and it could exacerbate freshwater scarcity problems unless appropriate action is taken to improve irrigation efficiency and water use efficiency (Ercin and Hoekstra 2014).
- A study of current and future water use in Alberta projected that freshwater use in the South Saskatchewan River Basin (SSRB) in Alberta, Canada will increase 53% from the current use of 1.98 km3 to the future use of 3.04 km3 by 2030, mainly due to irrigation demands (AMEC 2009).
- This study assessed the impact of future water use on the water footprint of irrigated potato production in Alberta and identified potential mitigation strategies to alleviate future water deprivation potential.

WATER STRESS INDEX

- The water stress index (WSI) developed by Pfister et al. (2009) was used to calculate the regional water stress characterization factor relevant to the SSRB in Alberta. The WSI was adjusted to a logistic function ranging from 0.01 to 1 using a ratio of total annual freshwater withdrawal to hydrological availability (WTA).
- Hydrological availability, current and future water use of the SSRB were obtained from AMEC's Water Resource Management Model (WRMM) to calculate the WTA of the SSRB (AMEC 2009).
- The calculated WTA was adjusted using variation factors of monthly and annual precipitation of four water sub-basins in the SSRB. Monthly, as well as the annual precipitation normal (1961-1990) were obtained from the AgroClimatic Information Service (ACIS), Alberta Agriculture and Rural Development (ARD).
- The water stress indices were calculated for current water use and future water use scenarios by using the WTA for both scenarios and the variation factor.

WATER FOOTPRINT

- Green and direct blue water footprints of irrigated potato production for six locations from three irrigation districts were calculated using the water footprint assessment method and the crop water requirements from the Alberta Irrigation Management Model (AIMM) (Hoekstra et al. 2011).
- The AIMM calculated daily evapotranspiration values over a growing season (May 15 to September 30, 2011) using daily climate data and crop coefficients and reference evapotranspiration of Penman-Monteith equations developed by Allen et al. (1998).
- Indirect blue water footprint for crop inputs and field operation were calculated by adapting the US potato production data from the ecoinvent database.
- Fertilizer production was modified using the Alberta/Canada electricity grid mix. Fertilizer application rates were obtained from ARD's fertilizer recommendations for irrigated potatoes.
- Pesticide use was calculated from the 2011 Potato Crop Weed and Pest Control Guide, Prince Edward Island Department of Agriculture.
- The indirect blue water footprint was calculated by IMPACT 2002+ version 2.2 method in SimaPro 7.3.3.

SENSITIVITY ANALYSIS

The following sensitivity analyses of the future blue water footprint were conducted to identify potential mitigation strategies for alleviation of freshwater deprivation potential:

- Combination of 4.3% increase in conveyance efficiency and 15% increase in application efficiency;
- 10% increase in potato yield; and
- 20% increase in potato yield.

Table 1. Parameters used for calculation of irrigation water requirement of irrigated potato production

Irrigation district	St. Mary	St. Mary	St. Mary	Taber	Taber	Bow River
Location	Seven Persons	Bow Island	Grassy Lake	Fincastle	Barnwell	Enchant
Potato yield (tonne/ha)	41	41	41	41	41	41
Conveyance efficiency (%)	93.7	93.7	93.7	93.7	93.7	93.7
Irrigation application efficiency (%)	80	80	80	80	80	80
Evapotranspiration (mm)	486	435	441	484	478	437
Precipitation (mm)	133	155	295	187	260	172
Irrigation water requirement (mm)	353	283	146	297	218	265
Conveyance loss (mm)	9	7	4	8	6	7
Irrigation application loss (mm)	71	56	29	59	44	53
Total irrigation water requirement (mm)	433	343	179	364	267	325

Table 2. Water footprint of irrigated potatoes (per hectare and per kg of potato)

Irrigation District	St. Mary	St. Mary	St. Mary	Taber	Taber	Bow River
Location	Seven Persons	Bow Island	Grassy Lake	Fincastle	Barnwell	Enchant
Green WF (m^3/ha)	1330	1550	2950	1870	2600	1720
Direct blue WF (m^3/ha)	4458	3536	1844	3751	2753	3347
Total WF (m^3/ha)	5788	5086	4794	5621	5353	5067
Green WF (L/kg)	33	38	73	46	64	42
Direct blue WF (L/kg)	110	87	45	92	68	82
Indirect blue WF (L/kg)	15	15	15	15	15	15
Total WF (L/kg)	158	140	133	153	147	139

Table 3. Water stress index-weighted blue water footprint of irrigated potatoes (L/kg) for two water use scenarios

Irrigation District	St. Mary	St. Mary	St. Mary	Taber	Taber	Bow River
Location	Seven Persons	Bow Island	Grassy Lake	Fincastle	Barnwell	Enchant
WSI=0.2078 current water use	26	21	13	22	17	20
WSI=0.5981 future water use	75	61	36	64	50	58

Table 4. Sensitivity analyses for irrigation efficiency and potato water use efficiency (blue water footprint L/kg)

Irrigation District	St. Mary	St. Mary	St. Mary	Taber	Taber	Bow River
Location	Seven Persons	Bow Island	Grassy Lake	Fincastle	Barnwell	Enchant
Baseline	75	61	36	64	50	58
Increased irrigation efficiency	65	53	32	56	43	51
10% yield increase	69	56	34	59	46	54
20% yield increase	56	46	28	48	38	44

CONCLUSIONS

- Increased water use of irrigation could lead to additional pressure on freshwater resources and in a greater blue water footprint of irrigated potato production.
- A regional water stress index is a relevant characterization factor to measure local water scarcity in the region. Therefore, the WSI could be used to assess the impact of different scenarios of water use and supply on regional water deprivation potential.
- Integrated management of freshwater resources combining strategies for increasing irrigation efficiency and improving water use efficiency will be an effective way to reduce the blue water footprint of irrigated crop production and to alleviate increase pressure on freshwater resources.

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