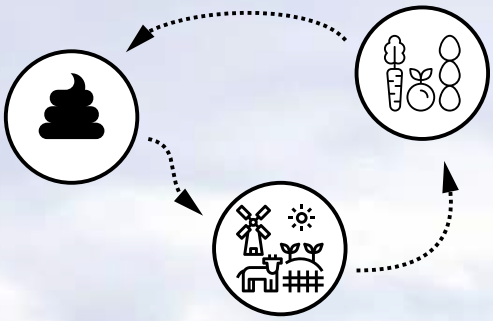
THE UNIVERSITY OF BRITISH COLUMBIA

Beneficial Recirculation of Nutrients and Organic Matter to Agriculture

Meeting the Needs of Farmers and Soils



Beneficial Recirculation of Nutrients and Organic Matter to Agriculture: Meeting the Needs of Farmers and Soils.

The research underpinning this report was conducted as part of the postdoctoral research visit of

Dr. Robin Harder

to the

Sustainable Agricultural Landscape Laboratory

at the

University of British Columbia.

This visit was supported by a mobility starting grant from

Formas - Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning

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2016-00859

and with project title

Recycling organic matter and nutrients from sanitation to farming systems to regenerate soil and land: identifying approaches that are feasible *and* preferable.

The work was supervised by

Dr. Sean Smukler

as part of the project

Organic Vegetable Nutrient Management in British Columbia

with funding provided by the

Organic Science Cluster 3.

organic SCIENCE CLUSTER 3
Connecting Environmental Sustainability with the Science of Organic Production | 2018-2023

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

We are grateful to the participating BC organic vegetable producers for their time and for sharing with us their stories, knowledge, and opinions.

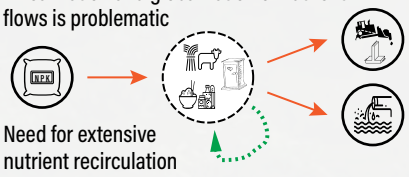
This study has been approved by the UBC Behavioral Research Ethics Board (UBC BREB H18-00140).

SUMMARY

In April 2018, we set out to learn from 10 organic vegetable producers in British Columbia about their perspectives on new and innovative fertilizer products rendered by the treatment of human excreta (i.e. urine and feces), wastewater, and other organic residuals. This report summarizes the findings from the interviews we conducted and is a part of a larger project designed to bring a greater understanding of various alternative nutrient sources, and improve their utilization.

PROJECT BACKGROUND AND SCOPE

Linearization and globalization of nutrient flows is problematic



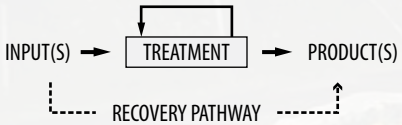
Need for extensive nutrient recirculation

The past century has seen a linearization and globalization of nutrient flows. Recirculating nutrients and organic matter contained in human excreta and other organic residuals to agriculture can make important contributions to a circular economy and is an integral part of radically rethinking how we manage nutrients and carbon along the entire food chain.

Human excreta is increasingly seen as a resource rather than a waste

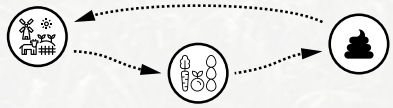
There is an ongoing shift from perceiving human excreta as waste towards recognizing its value as a resource. This shift is part of a broader trend towards more comprehensive resource recovery in the sanitation and wastewater sectors. Resources of interest include energy, water, nutrients, and carbon.

Research and development of innovative new nutrient recirculation solutions has intensified



The recognition of human excreta as a resource has led to the emergence of a range of new and innovative solutions that enable the recovery of nutrients and organic matter. A broad range of recovery technologies and products will potentially become available in the coming years.

Seeing human excreta management as a part of food systems can benefit soil and nutrient security



Human excreta management is still largely rooted in current sanitation and wastewater management approaches. Seeing human excreta management as part of food and farming systems has the potential to better guide human excreta management towards long-term global food, soil, and nutrient security.

Interviews with 10 organic vegetable producers in British Columbia

April 2018

10

Farms

How can alternative fertilizer products and soil amendments recovered from agricultural and urban residuals best support producers in their endeavours to grow healthy food and maintain long-term soil fertility and health?

CURRENT PERSPECTIVES ON FARM, SOIL, AND NUTRIENT MANAGEMENT

PERSPECTIVES ON FARM MANAGEMENT

Envision a farm that does things right and a farm that does things badly when it comes to managing nutrients and soil.

What does this farm do or not do?

THE 'GOOD' FARM

biodiverse, innovative, open to testing new approaches
avoidance of synthetic and chemical fertilizers

THE 'BAD' FARM

industrial approach, giant monocultures for global market
addiction to synthetic fertilizers and pesticides

GOOD PRACTICES

integrated animal-grass-crop production
cover cropping and sensible tillage practices
crop selection appropriate to season and region
regular field inspections and soil tests
thorough record keeping and equipment calibration
respects natural cues and the soil as living system

PESPECTIVES ON THE 'GOOD' SOIL AND NUTRIENT INPUT

Let us now consider a hypothetical situation where we do not take into account any aspects to do with organic certification, other legislation, user perception, etc. We focus solely on the quality of your soils and produce.

What makes a good soil? What makes a good nutrient input?

THE 'GOOD' SOIL

SOIL AS LIVING ECOSYSTEM

- high levels of organic matter
- healthy microbiome that breaks down organic matter and makes things available to plants
- good natural fertility and nutrient holding capacity
- balance between good drainage and the capacity to hold moisture
- clean smell and taste and adequate texture
- salinity levels that are not excessive

capacity to make things grow

THE 'GOOD' NUTRIENT INPUT

affordable

meets nutrient needs
- availability
- composition
- release characteristics

easy to apply

sustainable
- on-farm production
- sustainable supply chain
- resilient towards over-application

CURRENT SOIL MANAGEMENT AT THE FARMS

What do you do to maintain or improve the state of your soils? How satisfied are you with the outcomes?

PRACTICES TO MAINTAIN AND IMPROVE SOIL STATUS*

- 9 cover cropping
- 6 minimal tillage
- 5 compost and manure application
- 5 liming

SATISFACTION WITH THE STATE OF YOUR SOILS

- 3 satisfied
- 6 quite satisfied, could be better
- 1 not satisfied

*Other practices: mulching, crop-livestock integration, crop rotation, fallowing, soil testing, drainage, learn where the water is.

CURRENT NUTRIENT INPUTS AT THE FARMS

What are currently the main nutrient inputs to your farm? How do you decide which nutrient inputs to apply and at which application rates? Do you have any concerns regarding adverse impacts of certain inputs?

NUTRIENT INPUTS

KEY PRODUCTS

Vancouver Island	Lower Fraser Valley
fish meal feather meal boron	compost manure blood meal
compost, manure blood meal, bone meal guano, alfalfa meal ash, potash, seasoil	fish meal, feather meal bone meal insect frass micronutrient mix

OTHER PRODUCTS

DECISION FACTORS

soil and crop needs	soil testing, crop requirements
experience	own experience, other farmers
infrastructure	machinery

CONCERNS

health	dust
quality	salt, weeds, pathogens, strings, twines
sustainability	overapplication of nutrients, dependence on industrial livestock operations

PERSPECTIVES ON THE AVAILABILITY OF NUTRIENT INPUTS

Currently, do you feel you have good access to nutrient inputs? Do you have concerns regarding future availability?

PERCEPTION OF CURRENT AVAILABILITY

Vancouver Island	Lower Fraser Valley
sourcing is challenging producers are at the whim of suppliers	current availability of nutrient inputs is good

CONCERNS REGARDING FUTURE AVAILABILITY

nutrient scarcity	accessibility	regulations	planning	sustainability
P depletion and micronutrient scarcity	geopolitical issues and price increases	more stringent regulations on use of manure	lack of integrated thinking around nutrient flows	nutrient mining unsustainable in the long run

PERSPECTIVES ON NUTRIENT INPUTS

Are there any inputs or practices you do not currently apply (enough) but would like to apply (more)? Which inputs and practices that you are aware would you not consider applying at your farm and why?

NUTRIENT INPUTS AND PRACTICES TO APPLY (MORE)

serenade | no-till | soil testing | make own compost | manure (chicken) | on-farm N fixation | cover crop integration | proactive application of micronutrients

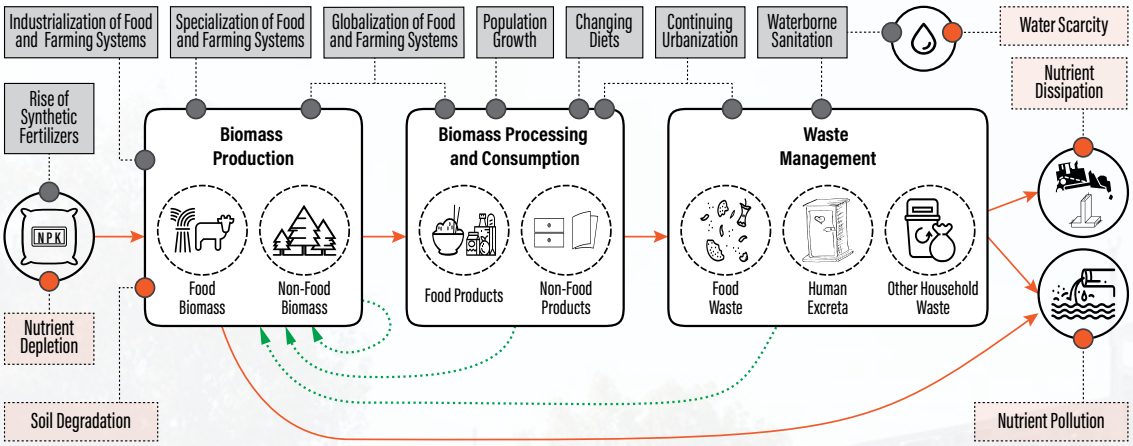
NUTRIENT INPUTS TO AVOID AND WHY

conventional fertilizers	humanure	municipal green waste	foliar sprays	unsustainably sourced nutrients
certification	public perception and food safety	plastic pollution	needs large infrastructure	not viable in the long run

BACKGROUND: WHY NUTRIENT RECIRCULATION AND WHAT ARE THE OPTIONS?

FROM LINEARIZATION AND GLOBALIZATION OF NUTRIENT FLOWS TO NUTRIENT RECIRCULATION

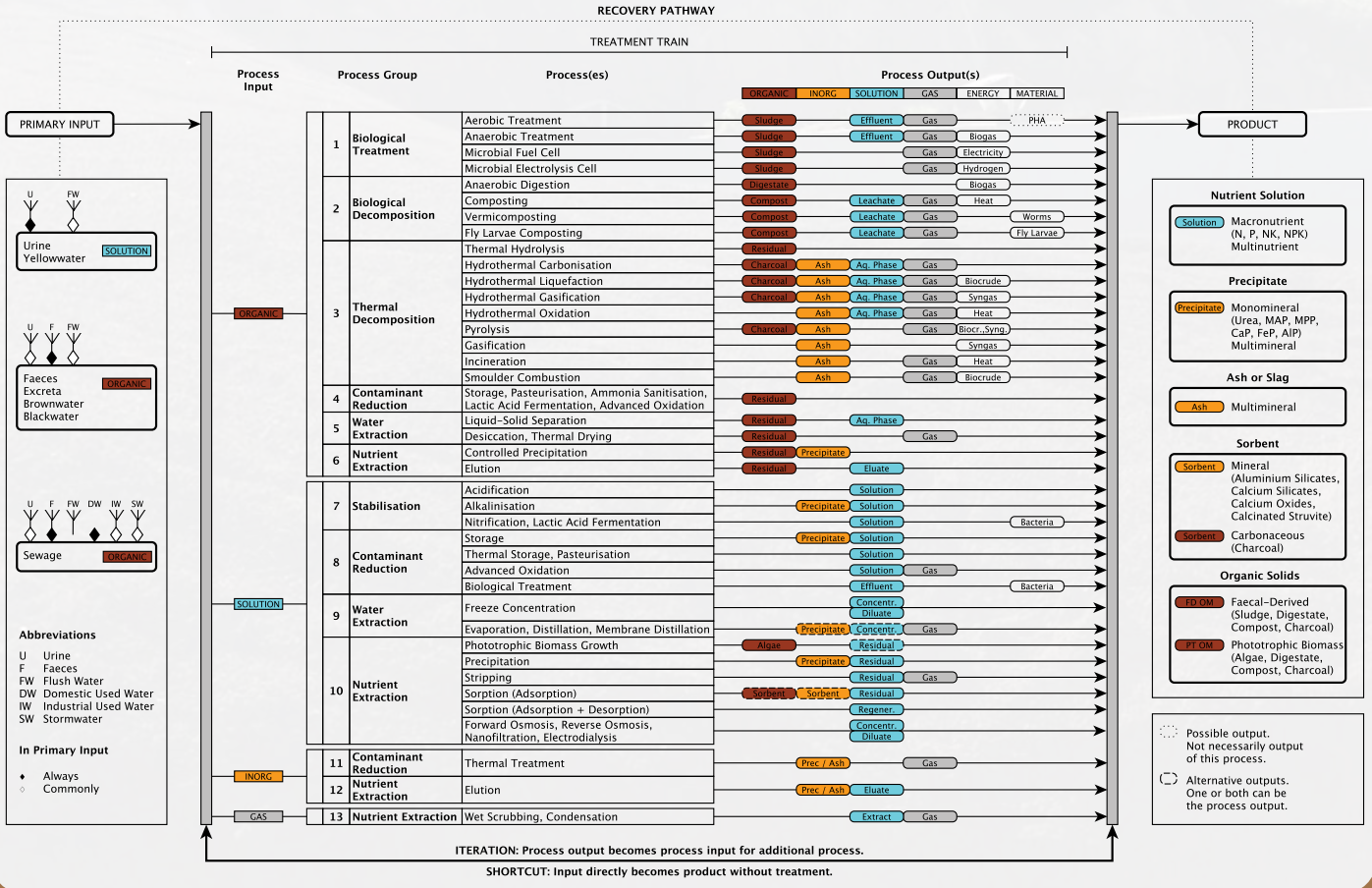
The past century has seen a profound alteration of nutrient flows. Together, a range of drivers (grey solid boxes) have led to a linearization and globalization of nutrient flows (orange solid arrows)and a suite of environmental problems (orange dotted boxes). Achieving global nutrient security clearly requires better nutrient management. This includes the recirculation of nutrients from human excreta and wastewater to agriculture (green dotted arrows).



Source: *Harder et al. 2020. Reframing human excreta management as part of food and farming systems.*

RECOVERY OF NUTRIENTS AND ORGANIC MATTER IN SANITATION AND WASTEWATER MANAGEMENT

Over the past decades, a wealth of technologies that aim to facilitate the recovery and reuse of nutrients and carbon contained in human excreta, wastewater, and other organic residuals have unfolded.



Source: *Harder et al. 2019. Recycling nutrients contained in human excreta to agriculture: Pathways, processes, and products.*

BROAD CATEGORIES OF NUTRIENT-RICH PRODUCTS

Recycled fertilizers rendered through treatment of human excreta, wastewater, and other organic residuals can be grouped into five broad categories.

NUTRIENT SOLUTIONS

Example: Aurin

Nutrient solutions contain nutrients but are devoid of suspended organic matter. Some nutrient solutions can be used as fertilizers while others can be used as input for the production of fertilizers. Nutrient solutions that can be derived from human excreta or wastewater include concentrated urine and ammonium sulfate.

PRECIPITATES

Example: Struvite pellets

Precipitates range from slurries consisting of individual precipitated nuclei, which can be filtered and dried to obtain a powder, to larger crystals or granules. Common precipitates derived from human or wastewater include struvite (MAP) and potassium struvite (MPP), as well as, calcium, aluminum, and iron phosphates.

ASHES

Example: Ash pellets

Ashes and slags generally are not considered a product of direct use for agriculture unless subjected to additional treatment. Thermochemical treatment for instance renders calcinated ash that is potentially useful for agriculture. More commonly, ashes and slags are the starting point for the recovery of other fertilizer products such as struvite or the production of synthetic fertilizers.

SORBENTS

Example: Granular zeolite

A wide range of sorbents has been investigated to extract one or several of the macronutrients NPK from liquid streams. Sorbents can be broadly divided into two subgroups: carbonaceous and mineral sorbents. The main carbonaceous sorbent is charcoal. Key mineral sorbents include calcinated struvite as well as aluminum silicates, calcium silicates, or calcium oxides.

ORGANIC SOLIDS

Example: Biosolid compost

Fecal-derived organic solids include a wide variety of products that contain organic matter originating from feces or biomass produced during treatment of fecal-derived organic matter. Biological decomposition renders digestate or compost (including vermicompost and fly larvae compost), thermal decomposition renders charcoal.

Example: Dried ground algae

Phototrophic algae and cyanobacteria can be grown in urine and other liquid streams such as treated effluent, anaerobic digester supernatant, or the aqueous phase after hydrothermal liquefaction of feces. Algal biomass is a promising product potentially useful as plant fertilizer or animal feed.

FUTURE POTENTIAL FOR FERTILIZERS FROM ALTERNATIVE SOURCES

RECYCLED FERTILIZERS DERIVED FROM HUMAN EXCRETA AND WASTEWATER

Together with the producers, we discussed different alternative nutrient inputs. We asked the producers why they would or would not consider using certain alternative nutrient inputs on their farms.

OVERALL RESPONSE

Producers were very aware of the need to at some point use recycled fertilizers derived from - among other sources - human excreta and wastewater.

No clear preference for one type of recycled fertilizer. Rather, it seemed that the full range of potential recycling fertilizers could be useful.

KEY HINDRANCES

- acceptance and public perception
- regulations and standards
- lack of trust in waste management

KEY CONCERNS

- quality and pollutants ····· pathogens, antibiotics, medicines, hormones, metals, salts
- smell
- similarity to mineral fertilizers

PRODUCTS THAT SPARKED PARTICULAR INTEREST

biochar

urine-derived liquid products

algal biomass

KEY OPPORTUNITIES

- more precision in nutrient application
- reducing nutrient flush to oceans
- increased future nutrient availability
- concentrated, custom-made products

OUTLOOK

How have the interviews informed our research? What is coming next?

We were delighted by the interest producers showed in knowing more about potential future recycling fertilizers. The interviews highlighted that it is difficult for producers to find the information they would need to assess how alternative nutrient inputs could be beneficial for their farms. The producers also expressed concerns about contamination, as well as, public perception and acceptance of nutrient products derived from human excreta and wastewater. Taken together, this has motivated us to take the initiative to further collect and synthesize available best knowledge from research and practice, and to put more effort into sparking and supporting public debate on human excreta and nutrient management.

CO-CREATION OF A KNOWLEDGE BROKERING AND PUBLIC ENGAGEMENT TOOLBOX

Help various actors navigate and interpret evidence on nutrient recirculation in a structured, intuitive, and engaging manner. Includes information on the characteristics of recycled fertilizers that specifically caters to knowledge needs of producers.

Knowledge Brokering and Public Engagement Toolbox

Scattered Knowledge, Limited Impact, Low Acceptance, Slow Implementation

1 - 'Living' Database

Transparent, comprehensive, up-to-date and updateable, open-access.

Covers technical details on different nutrient and carbon recovery and reuse solutions, the usefulness of different recycled fertilizers for different biomass production systems, as well as safety and legal aspects.

2 - Planning and Decision-Support Interface

Visually attractive and intuitive web-based user-interface.

Targets actors in infrastructure planning, municipal waste and urban water management, food and farming systems, public health, etc.

3 - Public Engagement Material

Communication materials designed to engage a broad and diverse audience on the topic of human excreta management, as well as, nutrient and carbon recovery and reuse solutions.

Educational short films, fact sheets, newspapers articles, policy briefs, infographics, etc.

Consolidated Knowledge, Amplified Impact, Enhanced Acceptance, Accelerated Implementation

Project duration: 2020 - 2023. Financial support: Kamprad Family Foundation.

THE INTERVIEWED PRODUCERS AND THEIR FARMS

10
Farms

5+5
Lower Fraser Valley
Vancouver Island

PRIMARY LAND USE
organic vegetable production

SECONDARY LAND USES
7 farms with:
fruits and berries
farm animals
wetland restoration
set-aside fields

2 to 30 years of farming experience
2 to 120 years since the farm was established

PESPECTIVES ON FARMING

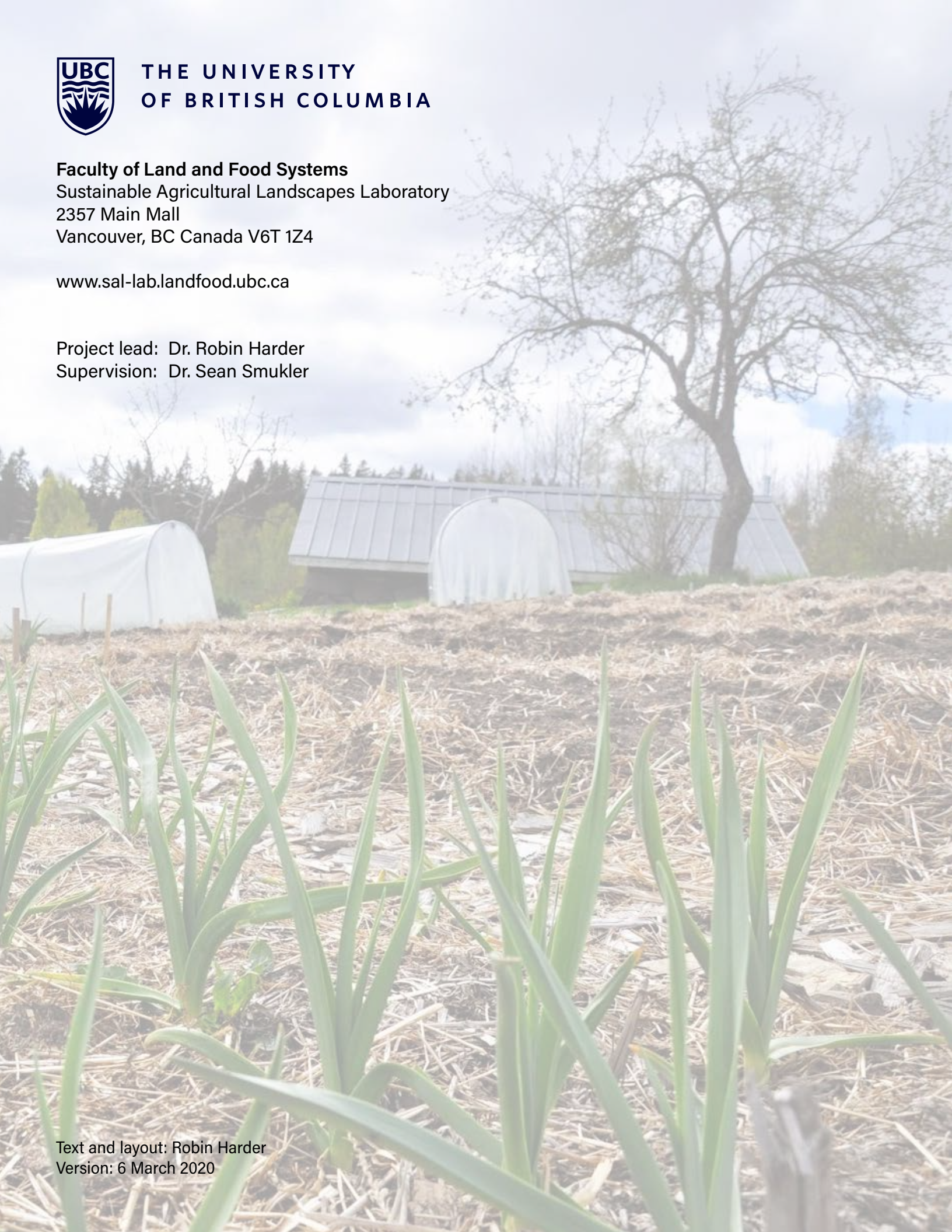
What are the main goals and objectives you have in farming and why do you continue to farm?
Which do you think are the most important factors that allow you to continue farming your land in the future?

REASONS AND MOTIVATION FOR FARMING

9 of 10 producers mentioned	WORK AND LIFESTYLE ASPECTS	6 of 10 producers mentioned	COMMUNITY AND ENVIRONMENTAL ASPECTS	5 of 10 producers mentioned	FINANCIAL AND PERSONAL ASPECTS
7 good work	love / passion for the work gratifying / satisfying work enjoy the work	5 food production	feed the community produce highest quality of food for community	4 make a living	to make a living can make a living
5 good lifestyle	work where you live living in healthy environment good environment for children	2 community education	educate community connect people to the land	3 capital lock-in	well invested can't just walk away
4 flexible work	flexibility be your own boss do other things off-season	2 environmental stewardship	environmental aspects sustainability aspects regenerate the soil	3 family tradition	in the genes grew up with it

KEY FACTORS TO CONTINUE FARMING

ACCESS TO LAND	ACCESS TO INPUTS	FINANCIAL VIABILITY	ENVIRONMENTAL VIABILITY	PERSONAL VIABILITY
availability of reasonably priced land	access to irrigation water	market access	good soil	physical health
partnership with First Nations	access to nutrients	community support through purchasing products	viable pest management	capacity to work
	less off-farm inputs		supportive climate	doing more with less



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