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Future Opportunities for Bioeconomy in the West Nordic Countries –

Executive Summary & Action Plan, Discussions and Conclusions, Overview of Opportunities Identified in the Report

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Arctic Bioeconomy
Focus on West-Nordic Countries

Future Opportunities for Bioeconomy in the West Nordic Countries

Executive Summary & Action Plan, Discussions and Conclusions, Overview of Opportunities Identified in the Report

A full length Matís report can be downloaded from http://bit.ly/bioeconomy-wn

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The Icelandic chairmanship program NordBio has also contributed to the project by initiating the mapping of waste as a source for value creation and by adopting identified opportunities in the West Nordic countries into the NordBio innovation program.

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Executive Summary

This project was initiated to prepare the West Nordic countries for active participation in Nordic and European initiatives in the field of Bioeconomy. This final report provides an overview of bioresources in the region, their utilisation and future opportunities based on green growth, providing good basis for strategic identification of beneficial projects in the region.

Compared to other Nordic countries, the bioeconomy of the West Nordic countries is a larger part of the GDP. The marine bioresources are the most important part and of common interests to the West Nordic countries which call for close cooperation within the region. A West Nordic Bioeconomy panel could be a platform for promoting common policy, to identify opportunities and set a common strategy for the region. The economies in the West Nordic countries can also be reinforced by developing industries further based on sustainable and responsible utilization of available resources. The aim should be to create multiple value streams from each resource, to improve processes and to develop and apply new technologies with the goal of minimising waste and maximising value.

The knowledge available in the West Nordic fishing industry has increased in the last decade and knowledge and technological transfer between the countries and increased cooperation would strengthen the West Nordic countries. It is important to maximise processing yields within the fisheries. However, substantial increase in value addition is likely to occur in synergy between fisheries and the biotechnology. Combining strong industry, such as the fishing industry, with research, development and innovation within the biotechnology sector will benefit the economy of the West Nordic countries as well as turn the region into an attractive area for young educated people.

Along with the fishing industry, the aquaculture is growing in Faroe Islands and Iceland and sharing knowledge and experiences will benefit both parties. The strong aquaculture industry in northern Norway is also an important partner for Iceland and Faroe Islands in further developing the aquaculture industries in the North West Region.

The macro-algae are growing in abundance in the coastal waters of the West Nordic countries and have promising properties for future utilization. The macro-algae can be used as biorefinery feedstock for bioconversions to platform chemicals, speciality chemicals and energy carriers (e.g. ethanol or butanol) and bulk carbohydrates, proteins and derivatives can funnelled into in various value streams.

Research into more efficient utilization of feed, feed health promoting factors and new possibilities in feed production should be given greater attention. It is also important to explore opportunities across different sectors of the bioeconomy as well as new innovative sources of biomass for feed.

Agriculture in the West Nordic countries is challenging due to harsh weather conditions. More emphasis should be on research on new crop variants, such as grain or berries and their adaptation to the West Nordic environment. There are also unexploited possibilities in using greenhouses to produce locally grown vegetables. Along with research on new crop variants, further research on revegetation, soil conservation and grazing pressure in the West Nordic countries is needed along with research on effects of climate change on the Arctic and the living conditions there.

Opportunities within the bioeconomy are likely to have an impact on the inhabitants of the area and help to reverse the trend of young educated people, especially women, moving from the rural areas to the larger towns, cities and other countries. A possible solution to increase opportunities for highly educated people in the West Nordic Region, is to create an interdisciplinary Centre of Excellence (CoE) focusing on issues related to the region such as bioeconomy, environmental issues, social issues, energy production and on solutions to increase added value of production based on local or regional bioresources. Further, tourism in the West Nordic countries can provide opportunities and jobs. By combining the unique nature, wildlife, fisheries, local food production and activities such as horse riding, hunting tours, recreational sea angling, salmon fishing etc., and tourism can add considerably to the income of the people in rural areas as well as in bigger towns and cities.

The key is a sustainable approach to all activities in the West Nordic countries, whether it is food production, transportation, bio-technology or tourism. There are large unrealised opportunities within the different sectors in the West Nordic countries. However, when each sector is operating separately in “its own silo”, the growth potential might be limited. If interdisciplinary cooperation is enhanced, the growth potential of the economy is far greater. Innovation, supported by strong infrastructure, is another key element in enhancing the bioeconomy, by exploring underutilized possibilities and growth opportunities within the West Nordic countries.

The initiatives supporting bioeconomy in the West Nordic countries whether local, regional or Nordic will have most impact if they can be paralleled with European and other international research and innovation programs. It is important for the West Nordic countries to promote common interests, provide inputs and influence agendas in international research and Pan-European innovation programs. Further, it is important to monitor calls under the H2020 and identify collaboration opportunities for innovation in the region. It is also important to use the supporting West Nordic infrastructure to strengthen development by promoting projects of regional interest to a larger European platform.

An interview with Dr. dr. Christian Patermann.

Dr. dr. Christian Patermann describes the bioeconomy and its importance for the West Nordic Region and the unique features of the West Nordic Region. Further, Dr. Patermann, reflects on the importance of a West Nordic Bioeconomy panel in order to focus the strategy and priorities for the region as well as the importance of establishing a Centre of Excellence to optimise the research, technological and innovative activities in the region. The interview can be viewed at the following site: http://www.matis.is/drpatermann

Actions identified in the project as necessary and plan for their realization

Action 1. Create a West Nordic Bioeconomy panel

- West Nordic Bioeconomy panel/forum from academia, industry and commerce, non-governmental organizations (NGO's) and policy institutions will be formed to identify common key issues important for the West Nordic region, identify opportunities, advise industry, governments and the public and promote common key issues and policy. The creation of this West Nordic Bioeconomy panel is important for active and targeted participation in larger context such as the proposed Nordic Bioeconomy panel, the existing European Bioeconomy panel in Brussels and national bicoeconmy panels in Europe. Clear strategy and focus for the region is vital in working towards strengthening the bioeconomy, as well as opening up new opportunities for research and innovation in the region. Focus will be on wide cooperation with existing networks and infrastructures as well as representatives of the proposed Nordic Bioeconomy panel, national European Bioeconomy panels and the European Bioeconomy panel.
- A key action is to establish stakeholder platforms, complementing the advisory activities of the West Nordic Bioeconomy panel, to discuss industrial opportunities, infrastructure and support system to enhance value creation from bioresources as well as to discuss the balance between use and protection of bioresources and how to secure biodiversity.

- Opportunities provided with the Galway statement are currently being reviewed for possibilities to initiate a wider Arctic collaboration which can be of great importance for the Arctic bioeconomy. This could provide a valuable collaboration of the West Nordic Bioeconomy to the west (USA and Canada).
  - Application will be sent to NORA for support to initiate the West Nordic Bioeconomy panel and stakeholder platform before March 2. 2015.

Action 2. Establish an interdisciplinary CoE for the West Nordic region

- An interdisciplinary CoE will focus on the regions uniqueness, sustainability, energy and value streams, socio-economic aspects and rural development with active participation of all stakeholders. This CoE will link different expert groups and local/national knowledge centres together also through a virtual knowledge network/consortium. Comprehensive long term financing and political support is needed to realise this action.
  - To establish the CoE, an application will be sent to NordForsk on the current call for establishing Nordic Centres of Excellence in Artic Research (application deadline 4th of March, 2015).
    - 15th of December, concept paper (one-pager) will be finalised
    - 15th of January, consortium has been formed
    - 1st of February, 1st draft of application
    - 25th of February, final draft of application
    - 4th of March, submission of application

Action 3. Launching the project Arctic bioeconomy II – Biotechnology

- Special project focusing on opportunities in applying biotechnology for value creation in the West Nordic countries will be initiated. As one highly interesting aspect of the bioeconomy is the application of biotechnology to increase value from biomass and produce high value products from biomass, including products and chemicals now produced from fossil based resources. Further, in the North there is plentiful available space for dedicated cultivation of biomass as ingredient for biorefineries. The development

of next generation biomass resources to supplant fossil based feedstocks may be one of the most important tasks of today's industrial biotechnology.

The project will look at feasible biorefinery feedstocks available in the region and opportunities to create multiple value streams from such resources. Emphasis will be on utilizing (1) waste streams from traditional industries, such as the fish industry and agriculture, applying new technology with the goal of minimizing waste and maximizing value, (2) underutilized natural resources, including macro-algae and wood/plant based biomass and (3) micro-algae biomass that can be cultivated specifically for specialized biorefineries. Further, climate conditions and unique geological aspects of the region make the high North a valuable source of unique extremophilic organisms for a wide spectrum of biotechnological application this project will strive to explore these opportunities.

This project is founded on the project Arctic Bioeonomy (Future opportunities for bioeconomy in the West Nordic countries), taking further the mapping of bioresources by exploring the opportunities that can be realised by applying new technology.

- Application for funding has been submitted and approved by Ag-Fisk
- Application for funding has been submitted and approved by the NMR Arctic Co-operation Programme.
- Application for funding will be submitted to NKJ and SNS
- Cooperation will be sought from Nord-Gen and SNS

Action 4. Program focusing on "The Blue Bioeconomy"

- Marine bioresources are the most important biological resources of the West Nordic countries, as fisheries contribute extensively to the GDP in all three countries. In order to have a positive impact on value creation in the West Nordic countries, investment in research, innovation and technology along with strengthening the fish stocks is needed. The aim of the action should be to create a blueprint on how to maximize opportunities in the Blue bioeconomy in the West Nordic countries. Cross-national collaboration between institutes and industry in the area will be increased by this action.

- Three year chairmanship program focusing on the Blue bioeconomy led by the Faroe Islands will be initiated in 2015, focusing on the West Nordic region. The project will focus on four main themes: pelagic fish, white fish, algae and aquaculture.
- Close collaboration will be between the innovation part of the Icelandic chairmanship program 2015-2016, and the Faroese program and the Arctic bioeconomy project I &II, to create synergy.

Further Recommendations:

Establishing a research centre on new crop variants and land reclamation.

- More emphasis should be on research on new crop variants, such as grain or berries and their adaption to the West Nordic environment. There are also unexploited possibilities in using greenhouses to produce locally grown vegetables for domestic use in Greenland and the Faroe Islands. Along with research on new crop variants. Further research on land reclamation, re-vegetation, soil conservation and grazing pressure in the West Nordic countries is needed along with research on effects of climate change in the Arctic.

Adapting legislations regarding biodiversity research

- Laws and regulations regarding access and benefit sharing of geothermal biotopes in Iceland have been in place since 1999. Protection on benefits from biodiversity research should be expanded to cover the many different and unique biotopes for the region and put into legislation in Greenland, Iceland and Faroe Islands.

Streamlining and synergising Nordic research with European funding bodies

It is important to streamline and synergize research efforts for better use the large variety of funding opportunities in Europe. Further, it is important to monitor calls e.g. SC2 and SC5 under the H2020 and identify collaboration opportunities for innovation in the region. It is also important to use the West Nordic funding bodies to strengthen and promote projects of West Nordic regional interest that will lead to synergic effects with European and pan-European funding bodies.

Discussions and conclusions

Regional policy and strategy setting

The bioeconomy in the West Nordic countries is a large part of the GDP compared to the other Nordic countries. Their production and export is mainly limited to primary production. However, this also opens up possibilities for growth and added value creation for the economy of the West Nordic countries by strengthening secondary industries and service sectors. The common interests of the West Nordic countries are apparent. They call for close cooperation of the countries in putting their common interests on the agenda both in Nordic and other international collaboration and strategy settings. A clear and focused strategy for the West Nordic region with specific priorities is vital for effective participation in international forums on bioeconomy. Therefore, a West Nordic Bioeconomy panel would be a forum for realizing such a strategy as well as a platform for promoting common policy, to identify opportunities, advice industry, governments and the public as well as set a common strategy for the West Nordic region with policy- research-, commerce, NGO´s and industry partners alike. This would help maintain and strengthen the bioeconomy in the region, as well as opening up new opportunities for research and innovation in the region. Focus should be on wide cooperation with existing networks and infrastructures as well as representatives of the proposed Nordic Bioeconomy panel, other national European Bioeconomy panels and the European Bioeconomy panel. Current forums such as NORA and the Arctic Circle have a good infrastructure and could be used to raise the topic of bioeconomy with theme specific meetings. A key action would be to establish stakeholder platforms, complementing the advisory activities of the West Nordic Bioeconomy panel, to discuss industrial opportunities, infrastructure and support system to enhance value creation from bioresources as well as to discuss the balance between use and protection of bioresources and how to secure biodiversity.

The environment in the West Nordic is very vulnerable to pollution and effects of climate change, both due to its cold climate and rapid warming. Therefore, an extra care has to be taken when resources are utilized in order to prevent adverse effects. The unique circumstances in the West Nordic, the vast open areas, the wildlife and the harsh environment, are both strengths and weaknesses when the opportunities in the West Nordic are discussed. Unspoiled and unmatched nature and biological diversity, unique to the region, are clear attractions in addition to the rich natural resources. Green growth is vital for value creation established on efficient and sustainable use of resource, therefore, policy making in the West Nordic region focusing on green growth is highly important and must be transparent and co-operation oriented.

Environmental weaknesses on the other hand lie in the vulnerability and threat from human activities, both global and local. Therefore, the sustainable use of resources and protection of the environment are key issues in the West Nordic countries. It is important to establish stakeholder platforms to discuss industrial opportunities, infrastructure and support system to enhance value creation from bioresources as well as to discuss the balance between use and protection of bioresources and how to secure biodiversity.

Rural development and infrastructure to support innovation, centre of excellence

Opportunities within the bioeconomy are likely to have an impact on the inhabitants of rural areas and help to reverse the trend of young people, especially women, moving from the areas to the larger towns, cities and other countries. People seek education away from the rural areas and often do not return due to lack of job opportunities, isolation and other problems that small communities are facing in the West Nordic countries. This results in brain-drain from these areas, social disruption in age and gender and fewer productive members in the societies. By increasing the number of jobs for educated people in the secondary sector with innovation, research and further processing of raw materials from the primary sectors, there is a possibility of altering this trend and creating more value in the economy. A possible solution to increase opportunities for highly educated people in the West Nordic Region is to gather a strong group to create an interdisciplinary Centre of Excellence (CoE) focusing on issues related to the region such as bioeconomy, environmental issues, social issues, rural development, energy production and on solutions that lead to added value of production from the region through the entire value chain. The CoE would be located in the West Nordic Region, however in order to fully benefit this vast geographical area the CoE would apply information technology (IT) solutions to link different experts and local/national knowledge centres together through a virtual knowledge network/consortium. The CoE should include stakeholders from all sectors and would cooperate with experts from the other Nordic Countries as well as other countries involved in the bioeconomy and Arctic research. The partners in the CoE would also share infrastructure e.g. pilot plants and laboratory instruments, which in turn would lead to faster transfer of knowledge and implementation of new techniques in the region. To maximise the impact of the CoE, it´s partners will act as local “ambassador” that will involve local stakeholders (e.g. industry, farmers) in order to overcome barriers regarding the acceptance of this new methodology and way of thinking e.g. by increasing the level of understanding and create incentives to attract primary industries in their region.

The CoE would therefore have multiple impacts and would turn the region into an attractive area for highly educated people as well as support and promote the economy of the area with research and innovation, create derivate jobs and increase the possibilities available in the area.

The Blue Bioeconomy

Marine bioresources are the most important biological resources of the West Nordic countries, as fisheries contribute extensively to the GDP in all three countries. In order to have a positive impact on value creation in the West Nordic countries, investment in innovation and technology along with strengthening the fish stocks is needed. The knowledge available in the West Nordic fishing industry has increased greatly in the last decade. Increased knowledge and technological transfer between the countries and increased cooperation is highly recommended and would strengthen the West Nordic countries in the field. New technology is constantly being implemented in the fishing industry and while the Icelandic fishing industry is a frontrunner when it comes to utilisation and value creation, there is a room for improvement. New technology developments in the blue bioeconomy should take into account effects on rural development. Obstacles need to be identified and overcome and effort needs to be invested to increase the growth of the industry in the region at large. An action plan should be formulated to create a blueprint on how to make the most out of the opportunities in the Blue bioeconomy in the West Nordic countries. Institutes working on research and development in the area should receive more support to be able to better support the industry and anticipate future opportunities and developments. Cross-national collaboration between institutes and industry in the area should be increased.

It is important to increase processing yields within the fisheries. However, substantial increase in value addition and creation of new innovative products is likely to occur in synergy between fisheries and the biotechnology. This applies to the agricultural sector as well. Furthermore, utilizing bioresources for e.g. protein production, isolation of bioactive compounds and produce ingredients and products for the pharmaceutical, health industry and cosmetics could multiply the value creation from raw materials. A clear strategy for R&D and commercialization of high value marine products via biotechnology should be established to increase the likelihood of success and make the most out of available marine bioresources. Combining strong industry, such as the fishing industry, with research, development and innovation within the biotechnology sector will benefit the economy of the West Nordic countries as well as turn the region into an attractive area for young educated people. Priority should be put on establishing a central marine raw materials biorefinery and demonstration plant to speed up commercialization efforts in the region.

Along with the fishing industry, the aquaculture is growing in Faroe Islands and Iceland and sharing knowledge and experiences is highly encouraged as it can only benefit both parties. The strong aquaculture industry in northern Norway is also an important partner for Iceland and Faroe Islands in further developing the aquaculture industries in the North West Region. Knowledge transfer to Greenland will be important to establish an aquaculture industry there. Aquaculture is an ascending industry globally and with accessibility to the vast ocean in the West Nordic Region, the countries have extensive opportunities within this industry. The unique features of each country should be exploited to maximize and diversify aquaculture opportunities (e.g. geothermal heat in Iceland can open up opportunities for new species). Significant focus should be put on research into future feed sources for aquaculture, for example utilizing new raw materials (macroalgae, insects, plants etc), as well as disease control. Spatial planning should also be given special attention to harmonize the needs of the industry, environment and citizens.

Underutilized resources and new opportunities

The West Nordic region has a variety biological resources for sustainable and responsible utilization. The major resources include waste streams, such as those found in the fish industry, wood, grasses and crop residues. Production of micro-algae is also a feasible option. However, macro-algae may be the resource which has the highest potential for utilization. Macro-algae grow in abundance in coastal waters of the West Nordic countries and their high carbohydrate content make macroalgae an attractive source of sustainable biomass. Macro-algae can be used as biorefinery feedstock and the proteins and protein derivatives funnelled into in various value streams. Macro-algae are cultivated off shore in the Faroe Islands and Iceland has promising prospects for algal biomass production, as geothermal energy can be used in the production at relatively low costs. Production of bioenergy and valuable chemicals from macro-algae, along with other sources of biomass, is an important direction of research for the West Nordic countries. An important aspect of focusing on biorefineries is that they can aid in reducing the use of fossil resources. Fossil resources are only partially used as fuel and for combustion where large part is used in the chemical industry as raw material for producing vital and commonly used products, such as plastic, solvents, pharmaceuticals, etc. Chemicals from biorefineries could substitute this to a large extent or even completely in the future. In order for production of valuable chemicals to become realistic, new refining and conversion technologies are needed along with development of effective processing enzymes. Iceland has established a good reputation in the field enzyme biotechnology and metabolic engineering of potential biorefinery microorganism for processing and further bioconversion of macroalgal polysaccharides into added value products.

Research on better utilization of feed and new possibilities in feed production should also be given greater attention. It is important to explore opportunities across different sectors of the bioeconomy as well as new innovative sources of biomass for feed, such as using the black soldier fly to produce protein or to grow fungus, rich in single sell protein from wood waste streams.

The economies in the West Nordic countries can be reinforced by further developing industries based on sustainable and responsible utilization of available resources. The aim should be to create multiple value streams from each resource, to improve processes and to apply new technology with the goal of minimising waste and maximising value.

Opportunities within and across sectors

Linking different pillars of the bioeconomy presents great opportunities where industry and research can benefit from knowledge and advances across sectors. It is impossible to address sustainability without including the bioeconomy on a brought scale, which makes it a key factor in R&D as well as in running a successful business in all sectors.

The West Nordic bioeconomy is, and will continue to be, resourced based rather than processed based. It does not mean that there are no opportunities in processed based economy in the region, but the big opportunities in the near future are in resource utilisation. The region have huge opportunities in marine biomass, access to clean and relatively inexpensive energy and water, which can to a point provide opportunities in various sectors.

However, a number of issues need to be considered carefully when dealing with the resource based bioeconomy. Socio-economic sustainability is one of three pillars of sustainability but is often neglected, for example the widespread use of subsidies in fisheries and agriculture.

Many of the bio-economic resources in the Nordic countries are highly vulnerable to change, e.g. due to climate change and to natural fluctuations. This has serious consequences for the economies that rely on these resources. De-risking and identification of potential obstacles with a systemic approach is needed. Such work requires interdisciplinary expertise with the broadest possible scope. An interdisciplinary centre of excellence (CoE) is therefore needed to bring together as much knowledge as possible. This CoE should work across sectors and look at all opportunities as well as associated risks.

There are some sectors in the West Nordic bioeconomy that present obvious opportunities where the region has some advantages over other regions in the world. There are for example enormous opportunities in algae, which can be seen as agriculture of the oceans. There are definite opportunities in using experience from land-based agriculture when dealing with some of the issues that will arise

when harvesting and cultivation of algae will commence on large scale in the area. This applies for issues such as property rights which will become a controversial issue.

Agriculture in the West Nordic countries is challenging due to harsh weather conditions, at least compared to agriculture in warmer climate. The West Nordic countries on the other hand benefit from having to use less amounts of pesticides, as pest infestation in the agriculture is limited because of colder climate and therefore residues are less likely to be present in the production. More emphasis should be put on maintaining and claiming this benefit of Nordic agriculture and food production, especially in the West Nordic countries. Another advantage of the West Nordic agriculture is the short supply chain from producer to customers. This characteristic is also valuable and should be supported and combined with increased tourism in the region. If farmers are able to provide food and other supplies in their nearest environment, carbon footprints are reduced, contributing to the protection of the environment as well as the strengthening the region´s image and its food production.

More emphasis should be on research on new crop variants, such as grain or berries and their adaption to the West Nordic environment. There are also unexploited possibilities in using greenhouses to produce locally grown vegetables for domestic use in Greenland and the Faroe Islands. Along with research on new crop variants, further research on re-vegetation, soil conservation and grazing pressure in the West Nordic countries is needed along with research on effects of climate change on the Arctic and the living conditions there.

Tourism in the West Nordic countries can provide opportunities and jobs for the inhabitants if the sector is managed in a sustainable way by a supporting infrastructure. However, the environment is vulnerable and an appropriate infrastructure to tourism would be of great value to the societies in the West Nordic countries. An increase in tourism, as Iceland has experienced in recent years, can have a negative effect on the nature if the infrastructure is lacking, such as transportation, trails and access points in the nature, sanitary facilities, hotels, restaurants, and other servicing facilities. By combining the unique nature, wildlife, fisheries and agriculture and activities such as horseback riding, hunting tours, salmon fishing etc. with the hospitality of the local people, tourism can add considerably to the income of the people in rural areas as well as in bigger towns and cities. Further, tourism can help to create world wide net of consumers looking for clean high value food products exported from the region as well as ambassadors motivated to preserve the Arctic for the future. The key is a sustainable approach to all activities in the West Nordic countries, whether it is food production, transportation, bio-technology or tourism.

There are opportunities within the different sectors in the West Nordic countries. However, when each sector is operating separately in “its own silo”, the growth potential might be limited. If

interdisciplinary cooperation between different sectors is enhanced, the growth potential of the economy is far greater. This interdisciplinary cooperation could include transfer of knowledge and best practices, between sectors. An example is the high utilization yield of raw material accomplished within cod fishing in the Icelandic fishing sector where knowledge of production of by-products could be transferred to other sectors. Further, research and development in combining e.g. aquaculture and horticulture, forming a semi-closed system where waste/by-products from one production are used as feed/fertilizer in the other production. Research and development are essential in pushing the entire bioeconomy further and should be supported across sectors, e.g. by governmental support, industrial investment and/or competitive research funds. Innovation, supported by strong infrastructure, is another key element in enhancing the bioeconomy, exploring underutilized possibilities and the economic benefits and growth opportunities within the West Nordic countries.

How to create synergy between (West) Nordic and EU H2020 funding

The initiatives supporting bioeconomy in the West Nordic countries whether local, regional or Nordic will have most impact if they can be aligned with European and other international research and innovation programs. It is important for the West Nordic countries to promote common interests, create synergies, provide inputs and influence agendas in international research and Pan-European innovation programs. The West Nordic countries should therefore put emphasis on active participation in preparing research agendas in H2020 through their national representatives in program committees, Standing Committee on Agricultural Research (SCAR) and other pathways open to the West Nordic countries. The West Nordic countries should encourage and assist the Nordic funding bodies in aligning their research policy with European policies in order to create synergies. The West Nordic countries should also find ways within the Nordic- and European cooperation to enforce regional programmes such as the Nordic Atlantic Cooperation (NORA) and the Northern Periphery and Arctic Programme (NPA). It is also very important for the West Nordic countries to participate actively in the European Bioeconomy Panel as well as the proposed Nordic Bioeconomy Panel and suggested West Nordic Bioeconomy Panel. This will ensure that the common interests of the West Nordic countries are clear and on the agenda in global and regional context.

Further, it is important to monitor calls e.g. SC2 and SC5 under the H2020 and identify collaboration opportunities for innovation in the region. It is also important to use the West Nordic funding bodies to strengthen and promote projects of West Nordic regional interest that will lead to synergic effects with European and pan-European funding bodies. Cooperation on research topics will e.g. increase the competitiveness and economic benefits for the West Nordic Region as well as European research

area in general. Opportunities provided with the Galway statement should be utilized for initiating a wider Arctic collaboration which can be of great importance for the Arctic bioeconomy. In addition, the West Nordic countries need to collaborate on other issues of common interest such as the utilization of abundant and unique bioresources in accordance with the United Nations' Convention of Biological Diversity. This includes genetic resources unique for the region such as terrestrial and marine extremophiles and invertebrates of various marine habitats. Laws and regulations regarding access and benefit sharing of geothermal biotopes in Iceland have been in place since 1999. Protection on benefits from biodiversity research should be expanded to cover the many different and unique biotopes for the region and put into legislation in Greenland, Iceland and Faroe Islands.

Overview of opportunities identified in the report (page numbers are referring to the A full length Matís report)

West Nordic Bioeconomy panel, p. 12

The common interests of the West Nordic countries are apparent as they distinguish themselves from the other Nordic countries when it comes to economic dimensions concerned with evaluation of the bioeconomy. West Nordic bioeconomy panel could have the mission to identify opportunities and to suggest a sound strategy for the West Nordic region in order to maintain and strengthen the bioeconomy in the region, as well as to communicate that strategy. It could serve as consultation venue and strategy forum, put common interest of the West Nordic countries more explicitly on the agenda of the Nordic Bioeconomy Panel, to be further feed into the European Bioeconomy Panel, setting EU strategy in the field. Furthermore, it could open up new opportunities for research and innovation in the region.

Arctic Centre of Excellence, p. 15

An interdisciplinary Centre of Excellence (CoE) focusing on issues related to the region such as bioeconomy, environmental issues, social issues, energy production and on solutions to increase added value of production of the region would benefit the rural development of the region. The CoE wold increase cooperation between the Nordic countries as well as with experts from other countries involved in Arctic research. The CoE would have multiple impacts, as it would turn the region into an attractive area for highly educated people as well as support and promote the economy of the area with research and innovation, create derivate jobs and increase the possibilities available in the area.

Organic waste as a resource for innovation, p. 32

The project *Organic waste as a resource for innovation* is an ongoing cooperation project between Umhverfisstofnun (The Environment Agency of Iceland) and Matis, funded by the Nordic Council of Ministers. In the first part of the project, mapping of organic waste in Iceland, Greenland and the Faroe Islands will be carried out, focusing on by–products and waste from the fishing industry and slaughtering. Fishing industry is the largest industry in the three countries but agriculture is also important since it promotes sustainability in the countries. Iceland, Greenland and the Faroe Islands all have in common that they are remote islands where the nations are highly dependent on import of supplies. Mapping of organic waste and by–products is therefore important and can encourage innovation and sustainable economy of the nations.

Importance of fisheries for the West Nordic countries, p. 64

Wild fish stocks are by nature renewable resources, provided they are sustainably utilized. For nations like the West Nordic countries that depend heavily on fisheries there is a need to maximise the sustainable yield (MSY) of the fish stocks to boost the value creation as well as productivity throughout the value chain in the fish industry. This calls for new thinking, focusing on multiple value streams development and implementation of new processes and technology including biotechnology.

“Maximum sustainable yield is a broad conceptual objective aimed at achieving the highest possible yield over the long term (an infinitely long period of time)” (ICES, 2011)).

Cooperation in fisheries between the West Nordic Countries, p. 75

The knowledge available in the West Nordic fishing industry has increased in the last decade and knowledge and technological transfer between the countries and increased cooperation would strengthen the West Nordic countries.

Opportunities in combining fisheries and biotech, p. 75

Opportunities in fisheries of the West Nordic Region depend on robust fish stocks and investment in innovation and technology to improve yield and increase quality of the products. Combining strong industry, such as the fishing industry, with research, development and innovation within the biotechnology sector will benefit the economy of the West Nordic countries.

Future development in Greenland fisheries, p. 70

Altogether, fishing in recent years has been moderately growing in Greenland both in regards to production volumes and income. In general, however, there is a need for reform to combat overcapacity, low productivity in some parts of the sector and a strong need to modernise the fishing

fleet, which is today in large parts composed of older and relatively small vessels. This calls for long-term, stable and attractive framework conditions for the Greenlandic fishing industry. Distribution of licenses is one tool. Another possible tool is to develop a taxation structure that supports a healthy economy and treasury and at the same time enables the sector to continue to develop.

Opportunities in aquaculture in Iceland, p. 82

When looking at the Faroes prosperity in salmon farming, there is no doubt that Iceland could learn from its neighbour and partly build its future wellbeing on aquaculture. The Faroe Islands have managed to build a successful industry which is already contributing more to the economy and export than catch fisheries and is more profitable. For Iceland, the fish farming is not only an expectation for future economic growth but it could also be extremely important for strengthening regions in the North West and East of Iceland, regions that are currently suffering economic and social problems with reduced population. Iceland could look to the Faroe Iceland´s success in salmon farming considering value creation, job creation and rural development.

Opportunities in feed production for Aquaculture, p. 78

Pre-feasibility studies by Matis have shown that the black soldier fly (*Hermetia illucens*) (BSF) represents a promising option for the production of feed protein, with growing interest in its use. The aim of the project was to answer questions related to optimal raw material use for the Black soldier fly larvae as ingredient for fish feed and potential raw material reduction. Results so far have shown that the larvae can be grown on different substrates but with variable efficiency. By taking advantage of available nutrients and water, the larvae can reduce the amount of feedstuff by 50-95%, making the benefits of their use substantial in relation to resource utilization and environmental impacts.

Fish feed from wood, p. 79

Increased demand for fish and fish products has led to increased research of protein resources for fish feed. Fish meal has been one of the main sources but is expected to fall short of demand in the near future. To meet this shortage protein-rich microorganisms (i.e. Single cell protein) have been used to produce protein from wood. Microbial biomass from cultivated residual streams from wood-based biorefineries in Sweden were collected and used for production of fish feed in feed trials for Tilapia. Fishes fed with such feed where fishmeal had been substituted with single cell protein, shoved similar or better growth than fishes fed with control feed containing fishmeal (Alriksson et al., 2014).

Biotech opportunities in the West Nordic countries, p. 85

A mapping and opportunity analysis focusing on biotech opportunities in the West Nordic bioeconomy will be a highly important addition to the conclusive mapping and opportunity analysis of biorecourses and the utilization in the West Nordic conducted within the project reported herein.

Challenges and opportunities in macroalgae, p. 83

Cultivation, harvesting and bulk processing technologies of macroalgae are being established in various Nordic projects, but processing of marine polysaccharides to high added value products has not been developed to industrial bulk state. This provides unique while challenging commercial opportunities for the Nordic countries, especially the West Nordic countries. The utilization of macroalgal biomass has been limited by lack of appropriate cost-effective pre-processing technologies including bio refinery processing enzymes and fermentative bio refinery organisms.

New technologies needed, p. 92

To realize the transition from petroleum refineries to biorefineries new refining and conversion technologies are needed due to the vast differences in the composition and properties of petroleum and lignocellulose. Second generation biomass contains large quantities of recalcitrant polysaccharides, e.g. cellulose in plants and alginate in seaweeds. For a versatile multi value stream biorefineries fermentative organisms capable of producing a variety of added value chemicals including biofuels need to be developed as traditional organism do not suffice. For complete degradation to fermentable monosugars efficient enzymes need also to be developed as well as cost effective enzyme production organisms.

Opportunities in West Nordic countries agriculture, p. 49

The most promising opportunities in agriculture in the West Nordic countries are to emphasise the clean air and water when growing vegetables and producing meat from sheep and reindeer, i.e. the clean and healthy production the farmers in the West Nordic countries can provide in a sustainable way.

Greenhouses in West Nordic countries agriculture, p. 48

The use of greenhouses in Greenland and Faroe Islands to produce vegetables for domestic use is a possibility in order to increase production of vegetables in areas not suited for outdoor cultivation. The early sowing in the greenhouses can positively affect the vegetables production and is worth further research.

Opportunities in vegetable production, p. 47

Large portion of consumed vegetables in Iceland are imported. About 45% of overall fresh vegetables were imported in 2010, 13,660 tons with value of over 93 million DKK. Consumers in Iceland prefer and opt for Icelandic vegetables over foreign. As such, the opportunity to increase domestic production is relatively large. There is a need to examine further use of vegetables in other food products such as tomatoes in salsa sauces, horticulture value chain and storage methods (Þorkelsson *et al*., 2012).

The salad and berry production in Iceland has been increasing in recent years, and there is still a great opportunity for further increase. It has been publicly stated by the Icelandic Association of Horticulture Producers (Bjarni Jónsson, managing director), that a long term strategy is needed for the business framework of the horticulture sector, including electricity price strategy. A well-executed supportive strategy would result in a great increase in production, increased food security and self-sufficiency.

Opportunities in agriculture in Greenland, p. 41

Although residents of Greenland have historically not placed much importance on agriculture, the climatic conditions of the land for agriculture are improving in the southern region. This has allowed farmers to expand the production of existing crops. However some negative effects have been seen in relation to drought in most areas. Cattle ranging has also recently started in Greenland and there seems to be possibilities both in Nuuk area and South West Greenland, which could reduce and minimize import of beef and other products from cows.

Opportunities in sealing in Greenland, p. 56

With the right publicity and marketing effort, the sealing in Greenland could make good livelihood for the Inuit hunters and draw the attention of the fashion industry to the furs as a valuable material and sustainable living of the Inuit in harmony with the nature. The meat and other products from the seals can also ensure food security in underdeveloped countries as a protein supplement.

Hunting tours in the West Nordic countries, p. 59

Hunting tours in the West Nordic countries are already popular therefore combining the hunt with sustainable use and by protecting areas in the countries must be a focus point. Many species of seal, reindeer and musk-oxen in Greenland are currently underutilised and can be sustainably hunted to a larger extent. Hunting trips with tourists can provide the Inuit a living as guides and help the natives to utilise the wild species found in their surroundings. Birdlife in Greenland is also rich. Birding for tourists is also an unutilised area that needs to be focussed on in the coming future.

Tourism in the West Nordic countries can provide opportunities and jobs, p. 95

By combining the unique nature, wildlife, fisheries, local food production and activities such as horse riding, hunting tours, recreational sea angling, salmon fishing etc., tourism can add considerably to the income of the people in rural areas as well as in bigger towns and cities.

Opportunities in Greenland's tourism, p. 99

The current global spotlight on the Arctic and on Greenland should be able to foster a positive trend as regards the number of tourists in Greenland in the coming years, not least when compared to the current low number of guests from abroad staying overnight (37,160 in 2012). By comparison, Iceland had 800 thousands visitors in the same year, i.e. 22 times as many, even though Iceland's number of inhabitants is only about 5.6 times higher and the country's geography is significantly smaller (Rambøll Management Consulting, 2014).

Opportunities for reindeer husbandry, p. 61

Combining reindeer husbandry and tourism sustainably is a feasible way to increase value and raise society's awareness regarding the lifestyle of the reindeer herders.

Further utilisation of side products of the reindeer is also a good approach to increase the sustainability and income for the reindeer herders. The reindeer's fur is highly valuable if used in the fashion business with focus on the cultural and sustainable way of producing the skins.

Valuable data information for reindeer herders, p. 62

Information is important both up and down the value chain. Information to the herder/farmers is valuable for them to manage their resources. Information for the distributers and consumers can also be very valuable, for example traceability and/or origin information. Further work has to be put in gathering and distributing information for them to be useful and serve their purpose.