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A knowledge-based bio-economy

It is necessary to develop a knowledge-based bio-economy in order to solve many of the world's most pressing problems. Renewable biomass must increasingly become the raw material for food, health products, textiles, energy generation and industrial goods.

Life is believed to have existed on Earth for 3.5 billion years – an incomprehensible length of time. The origin of mankind is debated, but according to the United Nations' Determinants and Consequences of Population Trends, modern Homo sapiens first appeared around 50 000 years BC.

We have become very numerous in a very short time

It is estimated that 8 000 years BC there were about 5 million people on the planet and that this number had increased to 300 million by the time of the birth of Christ. By 1200 AD, this number had grown by 50 per cent, to about 450 million. In 1850 the population was estimated at 1.2 billion, a number which doubled in a hundred years to about 2.5 billion in 1950. From that point, it was to take just 45 years before the population doubled again, with the number passing 5.7 billion in 1995. Today, the population of the world is estimated at about 6.5 billion.

Throughout most of this period, known as the *Holocene epoch*, mankind lived in a hunting-based, nomadic culture. In the course of 10 000 years we gradually moved towards a sedentary culture based on arable and livestock farming. Only in the past 150 years have we moved away from this to enter the *Anthropocene epoch*, in which the activities of people exert a greater impact on the environment than natural factors and their variations. The Industrial Revolution at the beginning of the 1800s is recognised as the event during which human activities started to create imbalance in the ecosystem. To put this into perspective we can say that:

If human beings have been on the Earth for a total of one hour, it is only in the last seven seconds that they have created ecological imbalance.

The cause of this imbalance is to be found not only in population development as such, but also in the fact that we have constantly striven to reach the top of Maslow's hierarchy of needs. This has called for greater access to resources and has resulted in greater consumption. Some of us have been successful in acquiring such resources, while others have not had the same opportunities. As a result of the differences in access to resources, the 6.5 billion inhabitants of the Earth occupy different levels in the hierarchy of needs. A growing number, about one billion people in 2010, are starving and even their physiological needs are not satisfied.

In addition to climate change, migration, poverty and energy needs, pressure on foodstuff resources and loss of biodiversity currently stand out as global challenges. For some time we have realised that to tackle these challenges we must desist from creating an additional imbalance in relation to the natural environment. The solution is to use our knowledge of nature and its processes to reverse the development. We must develop a knowledge-based bio-economy.

The knowledge-based bio-economy in Europe

A growing demand for sustainable supplies of food, raw materials and fuel, as well as scientific advances in, among other things, modern biotechnology, has been the driving force for the development and growth of a knowledge-based bio-economy (KBBE) in Europe in recent decades. The term bio-economy entails sustainable production and processing of renewable biomass as a raw material for various foodstuffs, health products, textiles, industrial products and energy generation. It is anticipated that this will provide a new basis for, and a play a significant role in creating, renewed economic growth.

The knowledge-based bio-economy is also expected to be one of the solutions for meeting global challenges. The starting point for the EU's objective of developing a knowledge-based bio-economy for Europe has been a desire to improve its competitiveness in the global arena. This demands excellence in life sciences and technology, as a foundation for innovation and future industrial development. The aim is to develop a smarter, more sustainable and less vulnerable foundation for future economic development in Europe.

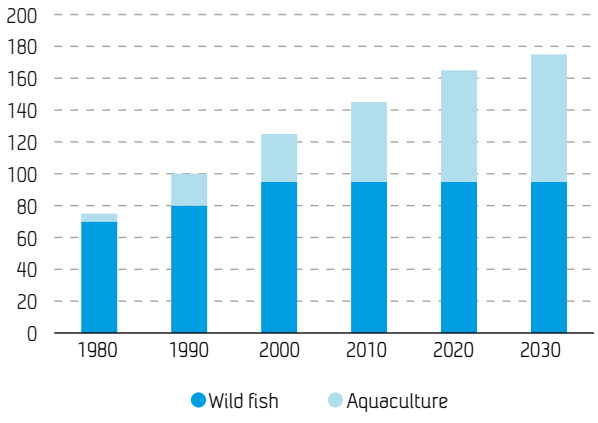
It is estimated that the European bio-economy currently represents a market worth more than 2000 billion Euros, that it employs 21.5 million people and that it has a highly optimistic starting position as regards growth potential. Besides contributing to future economic growth, the bio-economy will be able to make positive contributions towards maintaining human welfare which is currently threatened by global challenges. Examples are the aging population, urbanisation and population growth, increasing pressure on fresh water resources, limited availability of fossil fuels, climate change, the need for safe, healthy foodstuffs, and the prevention of infectious diseases.

Based on the accessibility of biological raw materials and the knowledge of how to exploit these in a sustainable manner, Norway already plays an important role in the development of a knowledge-based European bio-economy. This applies particularly in the marine science sector, in which Norway has long-standing traditions with regard to the management, harvesting and processing of wild fish. We have also developed unique expertise in the field of aquaculture, as a result of the industrialisation of salmon production. With the knowledge base which it has accumulated, Norway will be able to make significant contributions with regard to the exploitation of marine resources in the production of food.

Continued global growth in aquaculture

In recent decades, global production growth in the agricultural sector has been approximately 2 per cent (Duarte et. al 2009). Urbanisation, shortage of agricultural land and not least shortages of water have resulted in the stagnation of this production. Genetically modified plant and animal strains can contribute to increased production of agricultural raw materials. These developments will raise major ethical issues which will demand caution. The markets and society as a whole must provide their approval.

A transition from the production of beef to that of poultry and pork may also contribute, but will not be sufficient to satisfy future needs for protein and fat. An ever-increasing proportion of these nutrients must be obtained from marine-based production through harvesting and aquaculture.



The illustration below shows the FAO's figures for the development of world fish production (in millions of tonnes). If we consider the production of food based on catches of wild fish and fish-farming, an interesting picture emerges. The world's total fish production is currently approximately 145 million tonnes, of which 100 million tonnes is wild fish and the rest is produced by aquaculture. Global production of wild fish has stagnated and to some extent dropped in the past 10-15 years because of over-fishing and unsatisfactory management. Norway, in collaboration with Russia, among others, has succeeded in managing its fish stocks in a balanced manner and represents an honourable exception.

Global fish-farming production in the last decade has shown an average growth of 7.5 per cent, which is approximately the same rate of growth as in Norway. With modest growth in agriculture, production of marine-based foodstuffs must increase to satisfy demand for protein and fat, with the entire marine food chain being exploited in an integrated manner. If we cannot catch more wild fish, this demand must be satisfied by increased aquaculture production. This means that the total aquaculture production on a world basis must increase from about 45 million tonnes today to about 80 million tonnes in 2030 (FAO, 2008).

One of the greatest global challenges between now and 2050 will be achieving sustainable food production to feed 9.5 billion people. With its natural advantages, industrial experience and expertise, Norway should adopt a leading role. Existing fish-farming production in Norway represents only 1.7 per cent of world production. We should make it our goal to increase this contribution to 3.5 per cent in 2020, which corresponds to increasing our production from about 900 000 tonnes today to 2.4 million tonnes in 2020, in other words a 2.5-fold increase. This calls for an annual growth until 2020 of 10.3 per cent, which is 2-3 percentage points higher than the current growth rate.

There will of course be many challenges connected with achieving this in a sustainable manner, environmentally, economically and socially. One prerequisite for continued growth is that we succeed in solving the problems we have today and develop a strategy for the future development of operations while protecting the environment and ensuring efficient and integrated resource management. Knowledge-based solutions must be found to the challenges of the aquaculture industry with regard to salmon lice, escaping fish and the fouling of nets.

The entire marine food chain must be exploited to satisfy world food demands

Population statistics published by the UN's Food and Agriculture Organization indicate that by 2050 there will be 9.5 billion people in the world, compared with 6.5 billion today. In order to feed this population, world food production must be increased by 70 per cent. In reality, the number of people suffering from starvation increased by about 100 million between 2008 and 2009, and currently lies at about 1 billion. A programme commenced under the auspices of the World Bank in 1990, when the corresponding figure was 800 million, aimed to halve the number by 2015. In reality, the trend has been in the opposite direction.

The biomass production of the planet (plants and animals in the sea and on land), which creates the basis for food production, is divided equally between sea and land. Expressed in calories, we obtain 98 per cent from land-based production and only 2 per cent from the sea. When we consume agriculturally produced food, we exploit

Group		Annual production in 2004 (Million metric tons)	Production growth rate 1994-2004 (% pr. year)
Land	Agriculture (non-food items excluded)	7000	2,0 +/-0,1
	Livestock (meat)	260	2,6 +/-0,1
Aquatic	*Cultured*		
	Freshwater animals	26	7,3 +/-0,4
	Marine animals	20	7,4 +/-0,3
	Marine plants	14	7,5 +/-0,5
	Wild harwest		
	Fisheries	96	0,1 +/-0,2
	Aquatic plants	1,4	0,5 +/-0,6

mainly plants which are on the lowest trophic level of the food chain. When we consume food from the sea, on the other hand, we are entering at level two or three in the food chain. For each rise of one level in the food chain, the usable potential is reduced by a factor of ten.

The figure below (Duarte et. al 2009) shows that total world food production is approximately 7 billion tonnes. If we consider what is produced on land, the ratio between plants and animals is about 6:1. If we consider food produced by aquaculture, the ratio is 1:3, and if we consider catches of wild fish and harvesting of marine plants, the ratio is 1:53.

In other words, if we aim to increase the contribution of the sea to the world's food demands, we must focus not on fish alone, but must also consider how we can harvest at lower trophic levels. Norway has technological expertise which can contribute to this type of development. The harvesting and exploitation of krill and copepods, the development of multitrophic aquaculture in which fish, shellfish and algae are produced in the same system and the cultivation of macroalgae for human food consumption are fields which must be prioritised. The world's largest aquaculture species (4.6 million tonnes per year) is a plant, the Japanese kelp, which is harvested for human consumption. It will also be appropriate to make the production cycle in the sea independent of that on land, by releasing land areas which are currently used in the cultivation of feedstuffs for fish farming, and use them for the direct production of human foodstuffs.

With a strong biomarine cluster embracing producers, suppliers, research and education, Norway is the most advanced nation in the world with regard to the sustainable exploitation of marine resources. By placing further focus on this field, Norway will consolidate its position as a contributor to meeting the foodstuff requirements of an increasing world population.

Recommendations

- Norway must develop an integrated strategy for a knowledge-based marine bio-economy.
- Norway must in future contribute to meeting the world's increased food requirements through a sustainable expansion of Norwegian aquaculture production.
- Expertise and technology must be developed to obtain competitive advantages for Norwegian industry in the fields of new marine industries such as marine bioprospecting, production of macroalgae and harvesting at lower trophic levels in the food chain.

Sources:

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