NAE Chapter 1

Setting the Stage

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Preface: Context and Goals of the IAASTD

i) Background

In August 2002, the World Bank and the Food and Agriculture Organization (FAO) of the United Nations initiated a global consultative process to determine whether an international assessment of the role of agricultural knowledge, science and technology (AKST) in reducing hunger, improving rural livelihoods and stimulating environmentally and socially sustainable economic growth was needed. During 2003, eleven consultations were held, overseen by a multi-stakeholder steering committee, involving over 800 participants from relevant governmental, private sector and civil society stakeholder groups. Based on these consultations and on an intergovernmental meeting in Nairobi (November 2004), the International Assessment of Agricultural Science and Technology for Development (IAASTD) was endorsed as a multi-thematic, multi-spatial, multi-temporal intergovernmental process with a multi-stakeholder Bureau co-sponsored by the World Bank, FAO, United Nations Environment Programme (UNEP), United Nations Education Science and Cultural Organization (UNESCO), United Nations Development Programme (UNDP), World Health Organization (WHO) and the Global Environment Facility (GEF).

The IAASTD builds directly on the recent global Millennium Ecosystem Assessment (MA), which revealed widespread degradation of the earth's capacity to support life. The overall lesson of the MA was that human use of global resources cannot continue on its current trajectory, because all of the earth's major ecosystems are in decline and approximately 60 percent of the ecosystem services examined are being degraded or used unsustainably. Unlike the MA, the IAASTD focuses explicitly on agricultural systems: the resources, actors and institutions involved in all stages of food, feed, biofuel, forest and fiber supply and use, from input production through waste disposal. Agricultural systems are the source of livelihoods for the majority of poor people in the world, and technologies used in these systems are important contributors to ecosystem degradation. The world's poorest people are most vulnerable to environmental degradation from exploitation and use of inappropriate technology. Better AKST can help to provide more sustainable livelihoods and allow agricultural systems to restore vital ecosystem services, or at least reduce the rate of degradation.

The IAASTD complements other recent assessments in addition to the MA that have provided information on possible future developments of aspects of agricultural production systems and their driving forces. These include: the Millennium Development Goal Task Force on Hunger; the Inter-Academy Council *Study on Science and Technology Strategies for Improved Agricultural Productivity and Food Security in Africa*; the Intergovernmental Panel on Climate Change (IPCC); the UN Food and Agriculture Organization's *World Agriculture: Towards 2015/2030*; the CGIAR International Water Management Institute *Comprehensive Assessment of Water Management in Agriculture: Guiding Policy Investments in Water, Food, Livelihoods and Environment*; the CGIAR Science Council Strategy and Priority Setting Exercise; UNEP's *Global Environmental Outlook*; and the World Bank's 2008 *World*

Development Report. These assessments use different approaches to address future agricultural changes, and usually employ either detailed projections accompanied by limited policy simulations or scenario analyses that consider a wide range of uncertainties in an integrated manner.

ii) Purpose of the IAASTD and its limitations

The IAASTD integrates scientific information on a range of topics that are critically interlinked but often addressed independently: agriculture, poverty, hunger, natural resources, environment and development. Knowledge gained from a historical analysis and insights from an analysis of plausible futures to 2050 forms the basis for assessing options for action on technology, capacity development, policies and funding.

An assessment is a critical, objective evaluation and analysis of information, including local and traditional knowledge, designed to meet user needs and support decision-making. It applies the judgment of experts to existing knowledge to provide scientifically credible answers to policy relevant questions, quantifying where possible the level of confidence. An assessment does not set goals or advocate specific policies or practices. It is policy relevant, but not policy prescriptive. It engages stakeholders early in the process in order to influence its focus, and is conducted by a large and diverse team of experts. In contrast to a review, an assessment is undertaken primarily to inform decision makers, rather than scientists, and conducted to achieve broad legitimacy for this purpose. It usually covers a broad and complex array of issues, and always contains a synthesis to reduce that complexity and clear indications of where expert judgment has been applied (Watson and Gitay, 2004).

The overall goal of the International Assessment of Agricultural Science and Technology for Development (IAASTD) is to help develop effective agricultural knowledge, science and technology (AKST) that will contribute to sustainable development, and improve access to it. It is presumed that adequate AKST can play a major role in achieving interlinked goals of sustainable development: eradicating extreme poverty and hunger by helping smallholder farmers, especially those from disadvantaged groups such as the marginalized, poor, and women, to improve their market competitiveness; creating employment among the rural poor; and making adequate amounts of healthy, safe food available to consumers. It also can contribute directly or indirectly to promoting equity across gender and social gaps, and to maintaining supporting, regulating, and cultural ecosystem services.

The IAASTD complements other global assessments by examining the role of AKST in sustainable development. By looking back on the past 50 years, it draws lessons about the conditions under which the impact of AKST on development has been positive for humans and ecosystems, and where, when and why impacts have been negative. By looking forward at plausible futures, it explores demands that are likely to be placed on agricultural systems in order to achieve goals related to hunger, nutrition, and

human health; poverty and livelihoods; and environmental and social sustainability. The result is an evidence-based guide for policy and management decision-making.

The IAASTD is guided by four overarching questions:
(1) What are the challenges that can be addressed through AKST?
(2) What are the likely positive and negative consequences of AKST?
(3) What are the enabling conditions required to optimize the uptake and diffusion of AKST?
(4) What investments are needed to help realize the potential of AKST?

iii) Structure of IAASTD

The IAASTD consists of a Global and five sub-Global assessments, of which the North America/Europe report is one. The other regions are:

(1) Central/West Asia and North Africa (CWANA,
(2) East and South Asia and Pacific (ESAP),
(3) Latin America and the Caribbean (LAC) and
(4) Sub-Saharan Africa (SSA).

Each report addresses historical and current perspectives, future scenarios, and options for action. Each report includes an executive summary and summary for decision makers. A synthesis report integrates the key findings from the Global and five sub-Global assessments, and focuses on eight topical issues: biofuels, climate change, human health, markets and trade, management and availability of natural resources, traditional knowledge innovation, transgenics and women in agriculture.

The IAASTD's governance structure is a geographically balanced multi-stakeholder Bureau comprising 30 government representatives and 30 representatives from civil society (nongovernmental organizations, producer groups, consumer groups, private sector entities and international organizations). This structure ensures ownership of the process and findings by the full range of stakeholders. Over 400 world experts, working in all stakeholder groups but acting in their individual capacities, assisted in the preparation of the IAASTD. Additional experts and governments were involved in the peer review process. The IAASTD was subjected to two rounds of expert and government peer review and approved at a plenary of governments in January 2008. The IAASTD was conducted throughout as an open, transparent, and representative process, while maintaining the requirements of a formal assessment.

Key Messages

Different political and socioeconomic histories during the 20th Century have driven very different paths of agriculture and agricultural knowledge, science and technology (AKST) across North America and Europe (NAE) that are now converging around a common agenda. Agricultural systems in NAE are mainly temperate; and agricultural resources (environmental, social, infrastructural, financial, etc.) are relatively abundant per capita. Public education through the secondary-school level, a high average standard of living and income compared with other sub-global regions, labor mobility, well-established AKST assets and infrastructure, and widespread access to technological innovations are attributes common to much of NAE. Political and cultural aspirations are increasingly consistent across the region.

Until the 1980s agriculture and food systems across NAE primarily sought to produce abundant, cheap food, while from the 1980s onwards in Western Europe new social demands called for a more multifunctional agriculture, requiring agriculture to simultaneously produce food and fiber, provide environmental services, conserve resources and biodiversity, provide livelihoods and support the quality of rural life. These demands are being heard in North America as well, although political responses have been weaker. Agricultural development post-World War II resulted in large areas being dominated by intensive food production, generating food surpluses, alongside other areas characterized by extensive land management and land abandonment. Increasing productivity of agriculture in Western Europe and North America came with environmental and social costs that were questioned, once food supplies were considered secure. In Western Europe, the subsidy of food production has largely given way to payments for social and environmental benefits, while consumer demand has increased for food produced and supplied so that it contributes to animal welfare and social justice (such as through Fair Trade), and for local provenance. Environmental protection in agriculture has been ensured through increasing regulation. In North America, subsidies have been largely decoupled from agricultural production but still contribute to production of surpluses and serve to maintain the current power structure in the food system. Consumer demand for local and social value-added goods is rising in this part of the region as well. Thus, in North America and Western Europe, policies and regulations have moved from ensuring food security to a more multifunctional view of agriculture. Agricultural value chains, currently dominated by multinational corporations responding to economic signals, are becoming more socially and environmentally responsive.

The main drivers of changes in AKST in NAE over the past 50 years have been shifts in policies, regulations, and markets. Knowledge and technological progress outside agricultural systems have been as or more influential than factors internal to agriculture. In particular, technological advances in transportation and communication that allowed the globalization of food supply have been

critical. Changes in international property regimes, especially the development of Intellectual Property Rights, have influenced how benefits of AKST are distributed.

NAE regional activities have significant consequences globally for meeting the development and sustainability goals because of its potential agricultural surpluses (a product of good agricultural land, and the mix of technologies, practices and policies in place); its large volume and variety of imports; and its many actors and networks that dominate food chains, fuel chains and AKST (including Intellectual Property Rights and patents). Businesses within NAE have a powerful impact on consumer demand in the rest of the world and extract commodities, genetic resources and labor from other regions. NAE countries house the greatest diversity of *ex situ* genetic resources collections of the world. Many advances in AKST were generated and initially used in NAE, so this region shows the impacts of specific AKST over the longest time period and thus provides illustrative lessons on its application and resulting positive and negative (intended and unintended) consequences.

NAE AKST has played a major role in the development of the world's agricultural systems.

- The international contribution of NAE AKST was established in some regions with great success for increasing food security, but the technology transfer approach had severe consequences for sustainability in some other regions. Factors that increasingly limit technology transfer from NAE to developing countries include regulatory policies like Intellectual Property Rights, biosafety protocols and trading regimes. In addition, most technologies developed in NAE are not appropriate for poor farming communities.
- The indirect effects of NAE agriculture, diet, policies and food systems on other areas of the world have distorted markets and reduced the potential for food and water security in many areas of the world.

1.1 Introduction

The development and implementation of agricultural knowledge and technology have delivered real benefits to farmers, processors, and consumers worldwide. Global agricultural productivity has kept pace with increases in population: while world population grew from about 2.5 billion people in 1950 to 6.5 billion in 2005, the total cultivated area remained almost constant and the proportion of the world's population suffering from hunger diminished. Yet the absolute number of people suffering from chronic hunger had risen to approximately 854 million by 2001-2003 (820 million in the developing countries, 25 million in the transition countries and 9 million in the industrialized countries) since the global agreement to halve hunger by the year 2015 was made at the Rome World Food Summit in 1996; and overall progress toward that goal has been minimal (Skoet and Stamoulis, 2006). The vast majority of hungry people are poor and rural, depending on small-scale farming, fishing, and gathering food, fuel and fodder from forests. A large proportion is in areas that are especially vulnerable to environmental degradation and climate change (FAO, 2005).

Most countries in North America and Europe do not have large numbers of hungry and impoverished people, but food insecurity is still present in all of them. For example, although the United States has the highest Gross Domestic Product of NAE countries, 11% of the U.S. population were food-insecure in 2005, meaning that they lacked access at all times to enough food for an active, healthy life for all household members; and 3.9% suffered from "very low food security", meaning that they had multiple indications of reduced food intake and disrupted eating patterns (Nord et al., 2006). Food insecurity in NAE is more frequently a consequence of poverty and government policies than lack of AKST.

However, countries within NAE that were under Soviet influence and have been torn by war and economic or political instability over the last few decades have much more serious problems with food insecurity. In addition, advances in agricultural productivity have been uneven, and subsistence farming still predominates in parts of Eastern Europe. The FAO estimates that rates of food insecurity are six percent at most in countries that have recently acceded to the European Union and in Romania; but levels are higher in the Balkans and some of the countries in the Commonwealth of Independent States (Skoet and Stamoulis, 2006; Figure 1.1). Armenia had the highest prevalence of undernutrition of the countries in transition in 1993-1995 at 52 percent. This dropped to 29 percent by 2001-2003, according to the most recent data from the FAO Undernutrition in Armenia has been aggravated by conflict, large numbers of refugees and displaced persons, and drought.

[Insert Figure 1.1 Prevalence of undernourishment in countries in transition, 2001-2003].

In NAE, policies and investment in science and technology have led to surplus production of many crops and the overconsumption of foods that lead to poor health. The three leading causes of death in the

U.S.—heart disease, cancer and stroke—are diet-related; adult-onset diabetes, which is closely correlated with obesity, ranks sixth (NCHS, 2006a). The percentage of adults between 20 and 74 years that are overweight was 66.0 percent in 2001-2004, with 32.1 percent obese. During the same time period, 17.5 percent of children between the ages of 2 and 17 were overweight (NCHS, 2006b). For adults and children, the proportion of the population that is overweight and obese is significantly correlated with sex, race and ethnicity (NCHS, 2006b). Average life expectancy in the U.S. is expected to fall over the next few decades as a result of the rising incidence of obesity and associated health problems (Olshansky et al., 2005). Obesity and diet-related diseases are rising throughout NAE, although not as rapidly nor to the levels currently in the U.S. For example, the Canadian Community Healthy Survey estimated an obesity rate of 23.1% among Canadians 18 and older in 2004 (Tjepkema, 2006); and 26% of Canadian children between the ages of 2 and 17 were overweight or obese (Shields, 2006). The Regional Office for Europe of the World Health Organization reports that the prevalence of obesity has tripled in many countries in the region since the 1980s and continues to rise, with obesity already responsible for 2-8% of health costs and 10-13% of deaths in different parts of the region.

The globalization of food supply has increased competition across the world and, combined with overproduction of many crops and low commodity prices, reduced profitability for most producers. Agricultural resources and most stages of input production and commodity processing, distribution and retail have become concentrated into fewer, much larger enterprises at an accelerating pace over the past century. Financial rates of return are not high enough for many small- and mid-scale farmers in North America and Europe to maintain an adequate standard of living and invest for the future without substantial subsidies or off-farm income. Increased productivity has also brought environmental costs through habitat transformation and the pollution and mining of precious natural resources such as oil, soil and water. The consequences on production of mining natural resources are seen most vividly in the abrupt decline of marine fishery stocks (Pauly and Alder, 2005). Perhaps the most dramatic illustration of environmental consequences is the hypoxic zone extending into oceans from the mouth of all major rivers in industrialized countries, caused by run-off of excess nitrogen applied as fertilizer to agricultural systems (Schlesinger et al., 2006). The full environmental costs associated with substantial gains in human well-being and economic development are only now becoming apparent (Tegtmeier and Duffy, 2004; Millennium Ecosystem Assessment, 2005; Sumelius et al., 2005; Foster et al., 2006).

Awareness of these environmental costs and their implications for future generations has given strength to demands for a more multifunctional agriculture, promoted through policy incentives and supporting the production of ecosystem goods and services beyond provisioning food and feed, water, fuel, fiber, and forest products. In multifunctional agricultural systems, producers would be compensated for their roles in maintaining supporting ecosystem services such as nutrient cycling and soil formation; cultural services such as aesthetic, spiritual and educational value; and regulating services such as climate and flood

regulation and water purification (Aldington, 1998; OECD, 2001; Boody et al., 2005). The diversion of acreage from food and feed grains into ethanol production in NAE has contributed to renewed interest in balancing demands on agricultural resources, as concerns about food security and food prices in NAE are resurgent.

The sociocultural costs of current trends in agriculture, due in part to scientific and technological investments, are also tremendous concerns in NAE, as well as other regions of he world. Larger and more industrialized farms; rural depopulation and loss of human capital because people can no longer make a living through food production and young people no longer want to become farmers, fishers or ranchers; increasing distance between food producers and consumers, dissociation with food production or lack of awareness among many consumers of how their food was produced; and the breakdown of communities and traditions based on agricultural or fishing livelihoods are leading to sociocultural disruption of unparalleled scope in rural North America and Europe (Lobao, 2000; Stofferahn, 2006). Most agricultural input industries and food processing, distribution and retail are becoming highly concentrated, with resultant shifts in power dynamics in food systems (MacMillan, 2005; Ollinger et al., 2005; Arda, 2006; ETCGroup 2006; Murphy, 2006). The particular form of concentration is important: interlinked networks of powerful international companies have expanded their reach upwards and downwards in the chain of production through strategic mergers with input companies such as seed suppliers and biotechnology firms involved in seed production and through financial arrangements with global retailers. The outcome has been global value chains or value networks that control what is to be produced, how, and by whom (Gereffi et al., 2001). While many people celebrate these changes as signs of progress or an inevitable transition to a globalized economy, they create undeniable hardship for people who are left out of the benefits of globalization.

Across the region, agriculture is in flux as regulators seek to limit or reverse environmental damage caused by agriculture, migration and other demographic shifts change the complexion of rural areas, and consumers and citizens become more concerned about diet-related health issues and social externalities of agriculture. Agriculture seems to be more “consumer-driven”, with increasingly differentiated markets responding to new desires. Markets are opening up for products that promote social and environmental quality, denoted in the marketplace with labels such as “Fair Trade Certified”, “organic” and “dophin-safe”. The consequences of greenhouse gas emissions on global climate change have led to new attention on “food miles”, or the distance that food travels from point of production to point of consumption, and interest in consuming foods producing locally. Enthusiasm for local foods is also fed by the desire to preserve unique foodways, cultures and landscapes associated with agricultural production; this has resulted in the defense of geographic indicators to demarcate foods’ point of origin.

There is an emerging agenda for agricultural knowledge and technology that fosters economically, environmentally and socially sustainable farming and food systems; public benefits via the food value chain; and equity between producers within the region and with those elsewhere in the world. Yet exactly how will this "new agenda" for agricultural knowledge be implemented, and who will benefit from it? Are social and environmental standards merely expiation for some NAE consumers' sense of guilt over being born in privileged circumstances; or are they the vanguard of a new, more humane and environmentally beneficial agriculture? Will profits from the global food and agricultural system be increasingly concentrated in the hands of a few business owners and CEOs, mainly in NAE? Will people whose livelihoods and quality of life are affected by changes in the farm and food system have a voice in planning and implementing those changes? Will they be able to choose which kinds of technology are used to produce their food and other products? Will the rift continue to grow between incomes and quality of life in NAE and those in developing regions, where a majority of severely impoverished people depend on agriculture?

The unintended consequences of new technology in NAE, and technology transfer from industrialized to developing countries, have become better known since the days of the Green Revolution. Distrust of new products and technology has displaced earlier optimism that agricultural productivity and production could keep growing indefinitely, without negative side-effects. Revelations of government or business cover-ups of harmful impacts (such as from cigarettes and other tobacco products), the emergence of new health hazards related to agricultural production practices (such as bovine spongiform encephalopathy or "mad-cow disease") and accidental contamination of the food supply (such as dioxin contamination of grain products and *E. coli* contamination of leafy greens) have contributed to loss of faith that global hunger and poverty can be eradicated through technological fixes through governmental intervention.

The status of ecosystem goods and services and social factors in NAE gives a preview of some of the unintended consequences of the application of contemporary AKT. Because AKST that is being introduced to other areas often has been applied already in NAE, unintended negative effects may be apparent. Some examples of negative consequences of the agricultural development path that dominates NAE are genetic erosion and vulnerability to disease that accompanies widespread monocultures; the effects of massive deforestation (and reforestation in some areas, as agriculture has been abandoned); and effects of synthetic agricultural chemicals on water quality, biodiversity, and related ecosystem services. The consequences of the "Western" diet that food technology has made possible and aggressive marketing has made omnipresent are apparent in NAE, as in other parts of the world. Additionally, the loss of traditional knowledge is apparent in many parts of NAE where indigenous populations were decimated long ago. For example, in North America 90-95% of the indigenous population was killed; so indigenous models of agriculture and resource use are scarce and can only be understood through laborious archaeological investigation. Traditional knowledge such as the acequia

systems of irrigation in the Southwestern US developed slowly, and resulted in agricultural systems that were sometimes maintained for centuries, much longer than current agricultural systems dependent on fossil fuels seem likely to last.

Food system trends in NAE often foreshadow changes in other regions; this pattern is important for the IAASTD to the extent that these trends affect a country's ability to meet development goals. In this respect, the most important trends concern the rise and fall of power in different agricultural sectors. People in NAE trying to earn their livelihoods in production agriculture face poor prospects of sustainable livelihoods at present; their income is derived largely from subsidies rather than crop or products prices, and subsidies are under attack. Subsidies are increasingly linked to agroenvironmental performance. In contrast, people involved in management tiers of agribusiness have seen dramatic rises in wealth and power. For example, five of the inheritors of the Wal-Mart fortune were among the top thirty wealthiest people in the world in 2006 (Kroll and Fass, 2007). Wal-Mart's Supercenters sell more groceries than any other retailer in the United States, and Wal-Mart has moved rapidly into other countries in NAE and other regions. Institutional shifts in NAE agriculture may presage similar shifts in developing countries as well. As the influence of traditional agricultural interest groups and state governments wanes, the power of organizations dominated by the private sector and civil society is waxing. These power shifts accompany a transition from state government to governance of food systems, and the emergence of a new set of players in food politics.

A careful assessment of AKST in NAE should help to illuminate lessons applicable in regions that have not extensively adopted the technologies pervading NAE. Early judicious investment in appropriate types of AKST, in conjunction with policies and other processes to support multifunctional agriculture, is likely to reduce the probability of irreparable loss of resources and resource quality, as well as the need for larger investments of AKST later. It is possible to draw tentative conclusions about the attributes of AKST that are most likely to enhance resilience and sustainability of global agroecosystems, based on experience in NAE.

1.1.1 Geographic scope of the assessment

The North America/Europe sub-global assessment covers Canada and the United States in the Western Hemisphere.

[Insert Figure 1.2 Map of North American countries included in NAE].

It includes Russia and most Eastern European countries and the westernmost countries of the Eurasian continent.

[Insert Figure 1.3 Map of Russia and Eastern European countries Included in NAE]

NAE uses geographic rather than political boundaries, other than the recognition of sovereign states. Therefore, "Western Europe" is used in this report to refer to the westernmost countries in Europe, rather than to states that formally affiliated with the European Union at a particular date, so countries within this designation have differing political histories. Similarly, the countries included in "Eastern Europe" vary widely in many sociodemographic factors relevant to the generation and application of AKST.

[Insert Figure 1.4 Map of Western European Countries Included in NAE]

1.1.2 Conceptual framework

1.1.2.1 Key definitions

The following terms and concepts are used throughout the NAE assessment in the ways defined:

Agriculture, for the purposes of the IAASTD, is considered to be a system based on the extraction of biological products and services from an ecosystem, innovated and managed by people. It thus includes cropping, animal husbandry, fishing, forestry, biofuel and bioproducts industries, and the production of pharmaceuticals or tissue for transplant in crops and livestock through genetic manipulation ("pharming"). It encompasses all stages of production, processing, marketing, and waste disposal.

Development of concern to the IAASTD is often called **"*sustainable development*",** defined by the World Commission on Environment and Development (1987) as "meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs".

A ***driver*** is any natural or human-induced factor that directly or indirectly causes a change in an ecosystem. Types of drivers (with definitions from the Millennium Ecosystem Assessment [2005]) include:

- ***Direct*:** A driver that unequivocally influences ecosystem processes and can therefore be identified and measured to different degrees of accuracy.
- **Indirect:** A driver that operates by altering the level or rate of change of one or more direct drivers.
- ***Exogenous***: A driver that cannot be altered by the decision-maker.
- ***Endogenous***: A driver whose magnitude can be influenced by the decision-maker. The endogenous or exogenous characteristic of a driver depends on the organizational scale. Some drivers (e.g., prices) are exogenous to a decision-maker at one level (a farmer) but endogenous at other levels (the nation-state).

An ***ecosystem*** is a dynamic complex of plant, animal, and microorganism communities and their nonliving environment interacting as a functional unit (Millennium Ecosystem Assessment, 2005). The term ***agroecosystem*** is sometimes used to refer to an ecosystem managed for agriculture.

Institutions are the rules that guide how people within societies live, work, and interact with each other. Formal institutions are written or codified rules. Examples of ***formal institutions*** would be the constitution, the judiciary laws, the organized market, and property rights. ***Informal institutions*** are rules governed by social and behavioural norms of the society, family, or community (Millennium Ecosystem Assessment, 2005).

Knowledge comprises cognitive capability skills, training and learning. Knowledge—in whatever field—empowers those who create and possess it with the capacity for intellectual or physical action (ICSU 2003). Information and knowledge are not synonymous: information only becomes knowledge when it is applied.

Scenarios are depictions of alternate plausible futures, typically developed through the joint involvement of decision-makers and scientific experts, and they link scientific information to decision-making processes. They do not attempt to predict the future but instead are designed to indicate what science can and cannot say about the future consequences of alternative plausible choices that might be taken in the coming years (Millennium Ecosystem Assessment, 2005).

Science is a system of knowledge covering general truths or the operation of general laws, especially as obtained and tested through scientific methods.

A ***system*** is a high-order, multiple-loop, nonlinear feedback structure (attributed to J. Forrester, in Richardson, 1991) operating together to achieve a common goal

Technology can be defined as simply as “a piece of equipment or a technique for performing a particular activity” (Intergovernmental Panel on Climate Change, 2001). It is used in this way in the IAASTD, but also in its common sense of ”means and methods of producing goods and services, or the application of science to production or distribution, resulting in the creation of new products, new manufacturing processes, or more efficient methods of distribution” (USINFO, 2006).

Value chains are multinational enterprises or systems of governance that link firms together in a variety of sourcing and contracting arrangements for global trade. Lead firms, predominantly located in industrialized countries and comprising multinational manufacturers, large retailers and brand-name firms, construct these chains and specify all stages of product production and supply (Gereffi et al., 2001).

1.1.2.2 Value chain approach

The concept of alternate global value chains has been a useful framework in the NAE IAASTD to pull together three of the important trends in agriculture: the shift toward a more multifunctional valuation of the goods and services from agroecosystems, the shift toward a more consumer-driven agriculture, and the shift in power dynamics toward integrated global values chains. Each of these trends has an implicit tension, which could be interpreted as the effects of a paradigm shift in agriculture; the tensions are reflected in AKST and possible future options.

To illustrate alternate agricultural value chains in the context of globalization and the rising demand for multifunctionality in NAE, IAASTD participants used axes similar to those used by the Millennium Ecosystem Assessment in its construction of future scenarios. The vertical axis ranges from "fragmented" to "globally integrated", and the horizontal axis ranges from "responsive to economic signals only" to "responsive to multifunctional signals". Note that the horizontal axis depicts not only the addition of new public values, but also the growth of new markets, such as for carbon sequestration and water purification

[Insert Figure 1.5 Quadrants and typical products from alternative agricultural value chains].

Each quadrant of this diagram represents a value chain, with corresponding AKST applied throughout the agricultural system that enables it to function; the typical end product of that value chain is indicated in Figure 1.5. These value chains co-exist in time and space, although those in Quadrant I dominate the global agricultural system at present. Figure 1.6 shows typical producers, retailers and intermediaries within each quadrant

[Insert Figure 1.6 Typical producer, retailer and intermediary types in alternative agricultural value chains].

1.1.2.3 Conceptual diagrams

AKST is knowledge, science and technology pertaining to agriculture

[Insert Figure 1.7 Meaning of agricultural knowledge, science and technology].

It is influenced by and draws from other kinds of knowledge and technology in important ways. For example, advances in transportation and communications technology have been key to the globalization and integration of global value chains. Likewise, AKST is influenced by and influences all stages and sectors of agriculture.

The conceptual diagram developed by the IAASTD participants depicts how the indirect and direct drivers of change affect development goals. Note that AKST is a subset of science and technology, which is only one of several indirect drivers of development goals.

[Insert Figure 1.8 Conceptual diagram of IAASTD]

The development goals against which the IAASTD assesses past AKST are:

(1) Decreased hunger and poverty
(2) Improved nutrition and human health
(3) Enhanced livelihoods and equity
(4) Environmental sustainability
(5) Sustainable economic development

These goals are interlinked, in addition to being connected with food systems, agricultural products and services, and the factors contributing to AKST.

1.1.2.4 Drivers of change

The direct drivers of AKST highlighted in the conceptual diagram are food demand and consumption, the availability and management of natural resources, land use, climate change, energy and labor. These drivers of change are influenced in turn by a set of indirect drivers, including demographics; economics and international trade; the socio-political context; the broader context of science and technology; education, culture and ethics; and the bio-geophysical environment. The next subchapter (Section 1.2) introduces the current status of these direct and indirect drivers of change in AKST in the NAE region, and most of Chapter 2 examines the complexities of how AKST has interacted with these factors over the past 50 years.

1.1.3 Structure of the report

This chapter (Chapter 1) is designed to introduce the entire NAE assessment, and lead to Chapter 2. Chapter 2 will examine the consequences on the development goals of the past 50 years of generation, introduction and application of AKST. This will lead into Chapter 3, which will introduce scenario-building as a method for analyzing the consequences of different options in AKST congruent with different alternative future developments in the region. Chapter 4 will draw from the lessons summarized in Section 2 of the past generation and application of AKST, to explore options for future investment, policies, education and training, and funding

[Insert Figure 1.9 Roadmap for NAE sub-Global assessment]

1.1.4 Cross-cutting thematic issues

Each sub-Global assessment deals with the past 50 years of AKST in relation to the development goals specified in the original mandate to conduct the IAASTD. However, certain cross-cutting themes emerged in all of the assessments that deserved special attention because of their importance to meeting

the development goals, their contentiousness, or the lack of adequate attention to them in previous assessments. These themes are:

- Bioenergy
- Climate change
- Human health
- Natural resource management
- Trade and markets
- Traditional and indigenous knowledge
- Transgenics
- Women in agriculture and shifting gender relations

The Global and sub-Global assessments contributed experts on these issues to develop key messages and integrate their treatment across the reports.

1.1.5 Interface with the Global Assessment

The sub-Global assessments including NAE were developed simultaneously with the Global Assessment by different working teams, which gave limited opportunities to coordinate the findings. However, representatives of the different assessments met together twice and shared their plans. Each sub-Global assessment has a slightly different structure to accommodate the particular issues that contributors thought needed the most attention. The Global Assessment is longer and more comprehensive than any of the sub-Global assessments, but does not go into detail on individual regions other than to illustrate points via case studies or vignettes. There is a separate Synthesis Report which combines the major points of all of the reports (Global and sub-Global), and highlights findings from the cross-cutting thematic issues.

1.2 Description of the Region

1.2.1 Social, political and economic development relevant to AKST

It is thought that people first entered the region via the Near East, spreading northwestwards into Europe and eastwards into Asia some 40,000 years ago, and into North America across the Bering Strait land bridge between 15,000 and 9,000 years ago (Dixon, 2001). While waves of nomadic migration, conquest and trade resulted in intermittent actions among the Eurasian cultures, sea level rise cut all but the most tenuous links with North America until European exploration and colonialism began in the 15th century. The subsequent migrations into North America were essentially economic, involving well over 12 M people from Europe (Gibson and Lennon, 1999) and an estimated 500,000 slaves imported from Africa (n.b. the population grew to around 4M by 1860 (US Census Bureau, 2002)). As the United States grew in area and economic power, the indigenous peoples were greatly reduced in numbers and largely

displaced by the end of the 19th century. Indigenous food systems based largely, but not entirely, on hunter-gathering were replaced by arable agriculture and extensive grazing. Simultaneously, Russia expanded its political control from eastern Europe to the whole of mainland north Asia and Alaska (sold to the US in 1867). At the turn of the century, the region was politically and economically dominated by major powers linked by trade and diplomacy. However, the Russian Revolution, the economic and agricultural depressions of the 1920s and 1930s and the 2nd World War polarized the region into the largely communist Eastern Europe and USSR and the largely democratic and capitalist Western Europe and North America. This polarization helped shape the development and current status of agriculture and AKST.

1.2.1.1 Political and economic changes since 1945

In the first decades of the 20th Century, NAE countries dominated the global economy, but WWII left Europe in crisis and the US as the dominant global economic power. Millions had died during the war, after which there were millions more refugees and major food shortages while millions of prisoners were held in gulags across Siberia, including victims of cultural and scientific purges. The USSR had occupied countries in eastern Europe to provide a buffer zone, creating an “iron curtain” dividing Germany, and enclosing Czechoslovakia, Hungary, Bulgaria and Romania as border countries of the Warsaw Pact. Despite also being communist, Yugoslavia was never part of the Eastern Bloc, and Albania broke away in the 1960s, aligning instead with China. The US supported the economic recovery of Europe, dispensing $12,500 million to 16 participating countries during 1948-1951 through the Marshall Plan. The Soviet Union refused to participate and ordered the countries within its sphere of influence to do likewise: as a result, the political divide was reinforced by a marked economic divide (Davies, 1996; Judt, 2005; Roberts, 1999).

The Organization for Economic Co-operation and Development (OECD), established to manage the recovery funds for western Europe, insisted that recipients increase production, remove tariff barriers and make contributions of their own. Governments were democratic (except for Spain, Portugal and Greece), promoting a more market economy. Economic recovery was rapid, despite the loss of cheap raw materials and captive markets as Britain, The Netherlands, France, Belgium and Portugal decolonized from around the world. By the 1951, of those countries that had received support, only Germany had failed to exceed pre-war production levels. In Eastern Europe, economic development was fostered through the Council for Mutual Economic Assistance (Comecon). Founded by Stalin in 1949, it promoted central command planning, militarization and heavy industry. The strategy changed in the 1960s, and specialized tasks were allocated to each member country, and emphasis was placed on the dissemination of modern science and technology. The Communist party controlled production through rigid output figures required by sector and by commodity. Private enterprises were mostly taken over by the state, as was agricultural and forest land, except in Poland and Yugoslavia. Popular uprisings and

attempts at political reform were repeatedly suppressed by the Warsaw Pact, notably in East Germany in 1953, in Hungary and Poland in 1956 and in Czechoslovakia and Poland in 1968 (Davies, 1996)..

New international structures were established by the WWII Allies in the post war years. The United Nations (UN) and the World Bank were founded in 1945 to promote economic development and the avoidance of conflict, with the UN agencies Food and Agriculture Organization (FAO), United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) created shortly afterwards. International agriculture research stations were established during the 1960s following initiatives form the Rockefeller Foundation, to become the first centers of the new Consultative Group on International Agricultural Research (CGIAR) in 1971.While the proposed International Trade Organization did not take shape, the discussions led to the General Agreement on Tariffs and Trade negotiation rounds and ultimately the World Trade Organization (WTO) in 1995.

The US economy flourished during Second World War and the 1950s, and consumption increased, reflecting a new prosperity and confidence. Foreign investment into Canada doubled during 1945-55, with progressively greater involvement from the US as opposed to Great Britain, and by the mid-1960s two thirds of Canadian export went to the US. The discovery of oil and gas as well as sources of iron ore and other raw materials helped to expand industrial production (Sautter, 2000). Economic growth and political confidence declined in both the US and Canada during the 1960s and 1970s, but both were restored in the 1980s. The US economy has grown at an average of 3.4% between 1050 and 2005 (Johnston and Williamson, 2006).

The post-war economies of western Europe had already been linked by the Marshall Plan, and further integration began when Belgium, France, Italy, Luxembourg, the Netherlands and West Germany established the European Economic Community in 1958, intended to lead to economic and, ultimately, political union. Denmark, Ireland and the UK joined in 1973 (a referendum in Norway rejected membership), with Greenland withdrawing in 1985. Greece, Spain and Portugal joined in the 1980s, by which time they were governed by democracies. Further expansion took place in 1994, leaving only the neutral Switzerland, Norway and Iceland as major western European countries outside what had become the European Union (EU). The early focus of the European Economic Community was on the Common Agricultural Policy (CAP) and common policies for coal and steel. Over time, a much wider range common policies were developed, addressing (for example) culture, consumer affairs, competition, the environment, energy, transport and trade. Political union was progressed by introducing new institutions, including a Parliament, a Court of Justice and a commitment to monetary union.

In Eastern Europe, economic growth and development was largely managed through Five-Year Plans. But these were not uniform, nor did they provide consistent benefits. Hungary introduced limited market

mechanisms into a system still controlled by the state, and encouraged agricultural enterprise by relaxing controls on compulsory deliveries and land ownership. By the mid 1960s Hungary was relatively prosperous, as was Yugoslavia, where private ownership of land and enterprises was maintained, along with freedom of international trade and travel. Elsewhere, Five-Year Plans gave the illusion of continuing quantitative success even when growth rates slowed and targets failed to be met. Not until the early 1980s did it become obvious that the Soviet Union was lagging economically behind the West. Uncontrolled military spending (consuming over 30 % of the Soviet GDP) and the diminishing domestic economic returns could not be maintained, politically or economically (Davies, 1996).

Political change was heralded by the emergence of the Solidarity non-socialist trade union in Gdansk in 1980 and the appointment of Mikhail Gorbachev as general secretary of the Communist Party of the USSR in 1985. Communist regimes started to loose power; in 1989 the Berlin Wall came down and in 1990 East Germany committed to unity with the West, while the communist federal government of Yugoslavia gave way to largely nationalist democracies in the constituent republics. There followed a wave of establishment of independent states: Czech Republic, Slovakia, Serbia, Slovenia, Croatia, Bosnia-Herzegovina, Macedonia. Most major republics of the Soviet Union asserted their sovereignty in 1990-91, with Estonia, Latvia, Lithuania and Ukraine declaring full independence. While most of these transformations were peaceful, many thousands of Bosnians, Croats, Serbs and Albanians were killed during the wars of 1991-2001, while conflicts continue in the Caucasus (Judt, 2005).

The model of a free market, democratic, consumer-based economy was adopted across most of the region, as the new governments embraced the attributes of Western Europe and North America. Some of these countries joined the EU (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia in 2004, along with Cyprus and Malta, with Bulgaria and Romania joining in 2007), giving the EU a combined economy second only to the US. EU political integration deepened significantly when a new single currency, the Euro, was circulated in January 2002 for twelve EU states. In practice the cost of running the Union is met by net contributions from six member states: the UK, France, Sweden, Austria, the Netherlands and Germany (Judt, 2005).

1.2.1.2 Social and demographic changes since 1945

North America had not been touched physically by the war, but Europe had been devastated, with millions killed (an estimated 27 M in the USSR), millions more homeless and in extreme poverty. Western European states developed comprehensive welfare systems, learning lessons from the depression in the interwar years. Countries varied in the resources they provided, and the methods used to pay for them, but they all provided social services (in particular education, housing, medical care, subsidized public transport) as well as social security to provide assistance in case of illness, unemployment, accident and old age (Judt, 2005; Roberts, 1999).

Post-war development in the US was driven by its economy. By the 1950s, the US was producing half of the world's goods. Standards of living soared, and new, consumer-based lifestyles evolved, with a greater emphasis on private enterprise. Refrigerators, washing machines and other consumer goods became regarded as necessities rather than as luxuries. Television ushered in the information age, providing the general public with almost instantly accessible information about what was going on in the country and the rest of the world as well as about what to buy, wear and how to behave. As individual wealth increased, many people moved out of the city centers into the suburbs to avoid crime, congestion and high taxes and to find better schools for their children (Hamby, 2005). Life here was family-centered with men going out to work while women looked after the house and the children. Americans have moved to the suburbs. This lifestyle increasingly relied on cars (over 60 million of them by the mid-1950s, and resulted in a relatively high per capita energy use. By contrast, 39.5 million American lived below the poverty line, with African Americans, American Indians and farming households particularly affected. Racial segregation led to the civil rights movement in the 1950s and 60s, to be followed by campaigns promoting peace, women's rights and the environment. Their development was closely associated with pop and rock music, that proclaimed a radical, English-language culture across the radio waves of much of the region (Jones, 2005).

Standards of living also rose in Western Europe and Canada, driven by economic growth and supported by much greater levels of welfare provision. Although food rationing only ended in 1951 in Germany and 1954 in the UK, by 19XX, Western Europeans ate better, lived longer and healthier lives, were better housed and clothed than ever before (Judt, 2005). The population of the Soviet Union recovered from the losses during WWII, rising from 178.5 million (1950) to 262.4 million (1974). Child mortality was reduced not only in the Soviet Union (where it fell from 81 per thousand in 1950 to 25 in 1970) but across Eastern Europe (e.g. in Yugoslavia, child mortality fell from 118.6 per thousand in 1950 to 55.2 in 1970) (Judt, 2005). However, economic development was slower than in the West, with a widening gulf in standards of living that became evident in the 1980s. Infrastructure did not expand at a similar rate as in Western Europe; even now, there is no all-weather road west to east Russia (Davies, 1996).

In the West, economic growth gave way to recession and inflation in the 1960s and 70s. In response, the US Congress cut more than $45 billion from welfare programs, while Government spending cuts and denationalization was also the response of the UK to recession, while other countries in Western Europe retained high government spending and social protection (notably France and Scandinavia), albeit at the cost of slower subsequent economic growth.

In the 1980s and 90s, agricultural and regional policies of the EU brought rapid increases in standards of living in what had been the poor countries of southern Europe, and so it was hardly surprising that

countries in Eastern Europe queued up to join after the fall of communism. The basic choice facing post-Communist governments was either to attempt a quick transformation from subsidized socialist economies into market-driven capitalism or to proceed cautiously, disposing of problematic sectors of the economy while preserving for as long as possible cheap rents, guaranteed jobs and free social service. Poland, Hungary and the Czech Republic already enjoyed relatively high standards of living and familiarity with western lifestyles, and these countries adopted the first approach. Slovakia, Romania and Ukraine delayed the introduction of change as long as possible and were reluctant to liberalize domestic markets or reduce the state's share in the economy (Judt, 2005). Further east, attempts to reform the inefficient and militarized economies of the former USSR caused sharp impoverishment of wider population, unemployment and destitution.

In the late 1990s the average monthly wage in Poland and the Czech Republic approached US$400, but were lower in non-accession countries, at around US$80 in Belarus, Ukraine and Romania, under US$70 in Bulgaria and just under US$30 in Moldova. However, the real economic boundaries in Eastern Europe are not between countries but between prosperous urban centers and an impoverished rural hinterland. Thus, in 2000, half of Moldavians earned just US$19 per month, a country where 48 % still work in agriculture (Judt, 2005). Not surprisingly, many people in rural areas are seeking employment elsewhere (especially in western Europe), resulting in depopulation and land abandonment. It is estimated that 2M Polish citizens (out of a total population of 39M) have left the country since accession to the EU, while an estimated 7 M people have left the Ukraine to find work since the fall of the Soviet Union, out of a total population of 46 M (Meier, 2006). Around 14 M economic migrants have moved into the US since 1990, especially from Mexico and Asia (US Census Bureau, 2007). Many of these people are employed in the food and agricultural sectors.

These are only the latest waves of migration in NAE. In the mid Century, immigrants to Europe came from former colonies, while Northern and Central Europe saw an influx of southern Europeans, mostly from poor rural areas, responding to labor shortages (Küster, 2000). The US took migrants from Europe, Asia and central America. Migrations in Eastern Europe post WWII were driven by forced expulsions and the steady export of Russian soldiers, administrators and workers, particular into urban areas. In 1945 most residents in the Estonia, Latvia and Lithuania belonged to the respective dominant national group and spoke the local language. By the 1980s only 54% of residents in Latvia were native Latvians and only about 64% of residents in Estonia were ethnically Estonian and Estonian-speaking. While the countryside was still populated by Baltic peoples, the cities were increasingly Russian, and Russian-speaking. In contrast, the population of the Ukraine became more homogenous following Second World War due to the expulsion of Poles in exchange for ethnic Ukrainians forced out of Poland. The only minority present in significant numbers in the Ukraine in 1990 were Russians (11% of the population), who were concentrated in the industrial east of the country and the capital Kiev (Judt, 2005).

The political and economic situation of indigenous peoples in North America has changed greatly in recent decades. In Canada, the Canadian Constitution was amended to existing Aboriginal rights and the Northwest Territories was partitioned to form Nunavat, a self-governing homeland of 2 million square kilometers for the Inuit. Canadian aboriginal peoples account for around 1M of the total population of 32 M, and are a young and increasingly urbanized population (Statistics Canada, 2006). The proportion of reported American Indian and Alaskan Natives in the US is smaller, at around 1%, and also with a lower than average median age (US Census Bureau, 2007). The purchase of the Hard Rock Café chain by the Seminole tribe indicates the increasing wealth and power of at least some of the tribes. There are far fewer native peoples in Eurasia, with around 30,000 native speakers of the Samoyedic and other languages dispersed across northern Scandinavia and Siberia and into the Aleutian Islands.

Literacy rates are high across the region, and funding for education is at least 3 % of GDP in every country. The number of women studying for a university degree has dramatically increased since the war. In both east and western Europe the proportion of women students ranges between 45% and 62%, with almost twice as many taking humanities and arts than science, mathematics or computing. Women now account for over 40% of non-agricultural jobs across most of the region, but in all EU countries women earn less on average than men. The gender pay gap ranges from less than 10 % in Portugal, Belgium and Italy to 22-25% in the UK, US and Germany; in the US (white) women eared 76% of the wage of a (white man). In most EU countries women spend about twice as much time on domestic work as men, although the ratio is considerably smaller in Sweden and Finland and much larger in Italy and Spain. However, women on average still earn less then men in these countries. The gender pay gap (2004) is smallest in Slovenia (9%) and largest in Estonia and Slovakia (24%). Women also still spend twice as much time per day on domestic work than men (Eurostat, 2007).

During the period 1913-1998, populations in W Europe increased 1.5 fold, mostly before 1950, and those in E Europe and USSR increased 1.7 fold, while the US population increased 2.8 fold, much nearer the global average of around 3.3 fold (Maddison 2001). NAE populations have become older: the median age in the US is now 36 years, as opposed to 28 as recently as 1970 while in Europe 1.6% of the population was aged 80 or over in 1970 while today the figure is 3.5% (UN Population Division, 2005b). This is 80 years for Canada, 77 for the US, 79 years in western Europe, but only 65 in Russia and 66 in the Ukraine (UN Population Division, 2005b) where there are twice as many deaths as there are births in the Ukraine at the moment; health problems include alcohol, smoking, tuberculosis and AIDS/HIV, which has increased dramatically since the early 1990s (Meier, 2006). Populations in Russia and Eastern Europe may decline by over 20 % by 2050, those in western Europe and North America are more likely to increase slightly (UN Population Division, 2005a). This disparity is reflected in the great variation in wealth across the region (the gross nation incomes (GNI) per capita of Luxembourg, Norway and Switzerland

exceed £50,000, while several countries in Eastern Europe have GNI values of less than $5,000 (World Bank, 2006))

People in NAE have become more urbanized, to an extent that varies greatly across the region. It is highest in the densely population countries of north-west Europe (over 90 % in Belgium). 60% of the US population now live in metropolitan areas of at least 1M people, and citizens move on average 10 times during their lives. Demographic change and suburbanization have been similar in Canada, where there has also been a migration westward, especially to the oil-rich state of Alberta. Urbanisation is least in Eastern Europe (less than 50 % of the populations of Albania and Moldova), though here the differences in well-being between urban and rural people may be the greatest.

1.2.1.3 Human health in relation to food

Undernutrition is unusual across the region, but by no means absent. Levels are estimated at below 2.5 % of the population across the region (nb these are the minimum figures provided by the FAO) but are as high as 10 % for Serbia and Montenegro, 9 % for Bosnia and Herzegovenia and Bulgaria (provisional figures for 2001-03 (FOASTAT, 2006)). The share of total consumption devoted to food varies much more than the availability of adequate nutrition, from as low as 14 % in the US to well over 50 % in the Balkans and Ukraine (FOASTAT, 2006).

At the end of WWII, the major concern about nutrition in Europe was of food insecurity. Now, by contrast, food supplies are taken for granted across most of the region. Average energy intake is very high in western Europe, Canada and the US by global standards (FOASTAT, 2006), with most countries exceeding 3,500 kcal /day, leading to health concerns associated with overnutrition, centred around obesity, with associated increased risks of hypertension, diabetes, heart disease and strokes. The increase is obesity has been particularly dramatic in the US. In 1991, four states had obesity prevalence rates of 15–19 percent and no states had rates at or above 20 percent. In 1995, obesity prevalence in each of the 50 states was less than 20 percent. In 2000, 28 states had obesity prevalence rates less than 20 percent. Ten years later, only 4 states had obesity prevalence rates less than 20 percent, while 17 states had prevalence rates equal to or greater than 25 percent, with 3 of those having prevalence equal to or greater than 30 percent (Louisiana, Mississippi, and West Virginia) (Centers for Disease Control and Prevention, 2006). Obesity is lower in Europe, but the gaps is starting to narrow, with levels above 25 % in Greece. Britain, Spain, Portugal, Italy and Greece have child obesity rates exceeding 20%. Interestingly France has a very low obesity prevalence of 10 %, despite a diet very high in saturated fats (North East Public Health Observatory, 2006).

Food safety is an important issue across the region. While outbreaks of salmonella, foot and mouth disease (FMD) and bovine spongiform encephalitis (BSE) and its human form variant Creutzfeldt-

Jakob Disease (CJD) have raised fears about disease transfer from food, the risks appear low compared with many other health risk factors. FMD does not transfer to humans, and so far there have been 158 deaths attributable to vCJD in the UK up to December 2006, or about 15 % of all CJD cases (Unit, 2007). There is always the possibility of new diseases appearing that are associated with agriculture and the food chain: avian flu is one such, but as yet (March 2007) no human cases have been reported in the region (World Health Organization, 2007).

There are also food safety concerns about the potential presence of pesticides, mycotoxins, hormones, antibiotics and genetically-modified organisms (GMOs) in food. Concerns over pesticide safety were highlighted by Rachel Carson's classic text "Silent Spring" (Carson, 1962), and since then the regulation of food quality has increased greatly. However, breakdowns do occur; for example there was an outbreak of ill-health associated with aldicarb use in watermelons in California in 1985, with over 1,000 cases of illness reported, including 47 cases involving pregnant women, two of whom miscarried (Goldman et al., 1990). Concerns about possible risks to human health from GMOs, antibiotics, growth hormones and intensive agriculture in general have helped promote the increase in organic agriculture.

There are also health issues arising from agriculture that are not associated with diet or nutrition. Five deaths were reported of workers exposed to 24-D in production plants between 1980-92 in the US and Europe (Anon, 2000), while an average of 475 cases of pesticide poisoning incidents were reported in California every year between 1997-2000 (Reeves and Schafer, 2003).

There is also concern of health risks through reductions in water quality caused by run-off of fertilizers, slurries and manures. Large levels of nitrates in water are converted to nitrite in the guts of small children, reacting with their heamoglobin, and resulting in the "Blue Baby syndrome". With nitrate levels increasingly controlled, the health risks of faecal coloniforms associated with livestock are now being considered (Mølbak, 2004).

1.2.2 Natural resources and their management

The NAE is circumpolar, bounded in the south by mountains, deserts and the Gulf of Mexico, Mediterranean and Black Seas. The climates are determined largely by latitude, altitudes and proximity to prevailing winds from the oceans. North-south gradients range from polar to desert: Russia is the coldest populated country in the world, with a mid-annual temperature of –5.5 degrees C, and more than half of the country currently occupied by permafrost; by contrast Death Valley in California experiences the hottest temperatures recorded on the planet. Precipitation is governed more by east-west gradients. In Eurasia, the climate is milder in the north-west, which is warmed by the Gulf Stream that also carries rain from the Atlantic. Further east, the climate becomes drier and more continental, with greater variation between winter and summer. The equivalent gradients in North America are east to west, with

precipitation decreasing until deserts are reached in the south-west. Wet, warm winters and hot, dry summers characterize the climates of the Mediterranean and California.

Eurasia and North America were separate for most of the last 50 M years, but were repeatedly linked during the last 1 M years via a land bridge across the Bering Straits as sea levels fell during ice ages, giving rise to ecological assemblages with many, but not all, species in common. Northern Europe, Canada and Siberia were all covered with ice sheets during the Wisconsin glaciation that ended around 10,000 years ago. As the ice retreated, so the biomes of the region shifted northwards, and were subject to modification from human populations that were already present in Eurasia, and dispersed into North America via the land bridge.

1.2.2.1 Polar regions and tundra

The areas north of the tree line constitute the arctic and tundra. Hunter-gatherers have long exploited the biome, and were at least partly responsible for the extinction of the megafaunas of the region. Indigenous peoples still continue traditional practices, but population densities are very low, and impacts on natural populations tightly regulated. Thus while Nunavat relies heavily on hunting for its economy, it has a total population of less than 30,000 (Statistics Canada, 2006). The Sami people of northern Scandinavia herded reindeer as well as hunter-gathering, but this nomadic lifestyle has only been practiced by small numbers in recent centuries, and has virtually ceased. It is still practiced by some of the Nemets peoples further east. The natural resources of the area (fossil fuels, minerals and marine fisheries) are more exploited by external peoples. Climate change is already influencing this biome: the polar icecaps are shrinking, glaciers retreating, and permafrost is starting to thaw, releasing methane to the atmosphere, changing hydrology and transforming the region from a sink of greenhouse gases to a source (ACIA, 2005).

The region's mountain chains also have climates too extreme for cultivation, and fishing - hunter-gathering is typically by tourists. Herders have traditionally exploited the uplands during summers, bringing cattle, sheep and horses down to lower elevations during the winter. This practice of transhumance influenced culture and biodiversity, creating, then maintaining, cultural landscapes of meadows interspersing forests. These landscapes are very ecologically diverse because of their fine spatial grain, low inputs of nutrients and their continuity of long periods of time. The conservation of transhumance in Europe is now a matter of choice than economic necessity. The EC seeks to retain such landscapes through regional development and agri-environment policies, but the reality is that in many areas the meadows are giving way to forest as rural areas become depopulated and land is abandoned. In Switzerland they are being supported through the marketing of cheese. The rivers running from the region's mountains determine the water supplies to the lowlands and the potential for hydro-power; the reliability of these resources is at risk because of warming conditions.

1.2.2.2 Coniferous forests

South of the tree line is a belt of coniferous forest, extending across Canada, Scandinavia and Siberia. Like the polar and tundra regions, conditions are too extreme for agriculture. These boreal and taiga forests are very extensive, accounting for much of the estimated 1.6 $x10^9$ ha found in NAE, 40 % of the world total (FAO, 2006). Russia has the largest area of forest of any country, at 809 x 10^6 ha, nearly twice as much as Brazil, with the vast proportion found in Siberia, while Canada and the US hold the third and fourth largest areas of forest (310 and 303 x 10^6 ha respectively. Populations of large mammals are still to be found, including moose, caribou or reindeer, brown bear, wolf and the extremely rare Siberian tiger. The forests continue to support indigenous cultures, including 80% of indigenous Canadians and 26 distinct peoples in Siberia (Taiga Rescue Network, 2007).

Timber extraction was important to the economies of medieval Europe, and sustainable forest management practices were developed in Germany in the 15th Century. Commercial logging was introduced to Canada by the French in the 17th Century, and was intensified in succeeding centuries, transforming the forests. Recognizing that natural landscapes required protection if they were to survive, the US and Canada established national parks, beginning with Yellowstone in 1871. European-style forest management was introduced at the start of the 20th Century, when the forests of both Alaska and Siberia were opened up for exploitation for timber, minerals, fossil fuels and hydro-electric power. Conflicts between commercial and environmental and indigenous interests have sharpened in recent decades. Areas of forest are now stable in North America, and increasing slightly in Europe. Rates of wood removal have been more or less constant during 1990-2005, and carbon stocks have increased slightly (FAO, 2006).

1.2.2.3 Broadleaved forests and natural grasslands

Further south of the coniferous forests, the climate is milder, suitable for a natural vegetation of broadleaved woodland where rainfall is high enough; scrub, grassland and even desert elsewhere. In the absence of people, much of Europe west of the Black Sea, and much of the US east of the Rockies, would have been forested. There remains very little European forest in its primaeval state (the Bialowieski Forest, mixed coniferous and deciduous woodland straddling Poland and Belarus, is the only surviving large area with a reasonably intact fauna), the rest having been cleared or transformed by management. Originally, these landscapes were shifting mosaics of woodland and clearings, supporting large herbivores, including European bison, wild horses and the aurochs, ancestor of domestic cattle. Land clearance began as agriculture spread into Europe, around 9,000 years ago. Large areas of forests remained until around 1100 AD, but these were impacted by population growth, the use of charcoal as fuel and timber for shipbuilding. By 1500 AD, the forests were depleted to the point that they could no longer sustain the demands for fuel and food, to be met by the use of coal and a reduced meat diet.

Deforestation was much later in the US; most of the Mississippi basin and areas eastward were covered by virgin forest in 1650, with large tracts remaining 200 years later, but only fragments survive.

The steppe areas of Eastern Europe have been home to nomadic tribes for millennia, until some of the land was collectivized and used for agriculture during the 20th century. The Great Plains of the US were also home to nomadic tribes until the late 19th century, when bison herds were replaced by cattle ranching. Early attempts to crop the land were hit by drought, but the widespread introduction of irrigation in the 1950s has transformed much of the land into cereal cropping.

Areas of secondary forest are increasing in Europe, partly through policy and partly as a result of abandonment of agricultural land. Managed forests are increasingly required to serve multiple functions, including tourism, fuel, timber and provision of forest foods, but comparable data are hard to obtain across the region of areas involved (FAO, 2006).

1.2.2.4 The spread of agriculture

Eurasian agriculture began in south-west Asia around 9,000 with the deliberate cultivation of first emmer and einkorn wheat, then hulled barley, peas, lentils, bitter vetch, chick peas and flax. These are annual plants with edible seeds that germinated in the gappy vegetation created during the hot summers. The acts of cultivation and harvest changed the ecosystems near population centres, disturbing the soil to renew the gappy conditions required by the crops, and promoting new ecological assemblages of animals, plants and diseases. As arable agriculture spread north and west across Europe, new biological elements were added, including tree and root crops and animals. Forests and scrub were cleared by felling or fire to make way for complex landscapes that contained woodland, crops, grasslands, heaths, combining species from across the region to provide food, fibre, fuel and other products, landscapes now highly valued for their biodiversity, cultural heritage and beauty. Terracing, irrigation, drainage and food plain management were used to manage water availability, while woodland edges were retained as hedgerows and lines of trees to provide barriers to livestock and additional food resources. Relatively slow rates of gene flow between areas enabled the development of local breeds and varieties. Crop rotation systems were developed to manage crop nutrition and diseases. By 1300, the population of Europe is believed to have reached a peak of 70 to 100 million (compared with over 450 M for EU-25 in 2006), only to plummet with the Great Famine in 1315, then the Hundred Years' War and the Black Death of 1348-1350. Further east, nomadic societies developed that herded domesticated animals for meat, milk, hides and transport, later to develop trading routes between Europe and east Asia. Agriculture had developed independently in the Americas, with cropping of maize, squash and beans spreading north from Central America, supplementing hunter-gathering for a population of around 10 M in what is now the US in the late 15th century.

The colonization of North America from Europe involved the import of farming systems, their crops and animals, and the introduction of some American plant species into Europe. This "Columbian exchange" resulted in the introduction of whole ecosystems in America, including pests, weeds, and diseases, transforming indigenous habitats (Crosby, 1986). Approximately 90-95% of the indigenous population of North, Central and South America died after exposure to new diseases from the Old World for which they lacked immunity, and through extermination by invading Europeans (Diamond, 1997). Indigenous cultures were pushed to the margins of productive land or forcibly assimilated.

By the early 19th Century, small-scale, mixed farming had developed in ways that were largely consistent across the region. These systems were multifunctional, providing farming families and local communities with food, fibre, animal feed and fuel. Technological developments had included three-year rotations of rye and fallow, the three field system, the use of legumes and manure for nitrogen. Perhaps the major exceptions were the plantations in the US South that were completely dependent upon slavery to cultivate cash crops sugar, cotton and tobacco.

1.2.2.5 Agricultural intensification

The trade and exchange of agricultural produce has taken place for millennia, whether for luxury goods (such as the medieval spice trade) or for commodities (eg the import of grain from North Africa by the Roman Empire). But the scale increased dramatically in the 19th century, thanks to developments in transport and refrigeration, and the domination of Great Britain over trading routes. Goods, capital and labour flowed freely between western Europe, North America and many other parts of the world, as benefits of competition were thought to outweigh those of protecting markets. Profitability was sought through increases in production and labor efficiency, developed through the increasing application of science and technology to breeding, fertilization and mechanization. Western America was opened up to settlers, transforming native prairie to cattle ranching and arable production.

The rate of change was far slower in Eastern Europe, where land remained in the hands of peasants and former serfs. In the early years of the Soviet Union, all aspects of agricultural production and science development were influenced by the centralized administrative-command system. Collectivization began in mid-1918, and by 1940 as much as 97% of peasant holdings had been merged into kolkhozes. Western agriculture fell into depression during the 1930s, and in the mid-West USA, cropped lands recently converted from prairies were struck with drought, creating the "dust bowl", creating poverty that displaced hundreds of thousands of rural families from Oklahoma.

Post-WWII Europe faced massive food shortages. Food rationing was an effective crisis-management tool, but the longer-term policy in Western Europe and the US was to stimulate production by economic instruments (tariffs, quotas and subsidies), the provision of new varieties, artificial fertilizers,

agrochemicals and machinery, as well as advice over their use. Production increased, and the successful farms grew larger and increased financial efficiency by reducing labour, increasing inputs of energy and agrochemicals, increasing field size and specialization into fewer crops. Labour- intensive patterns of land management, such as transhumance, declined as they were both economically inefficient and increasingly unattractive to young people who increasingly migrated to urban areas. Food production also increased in the Soviet Union, but more slowly than in the West. Grain was imported in most years from the 1960s on. Food prices were kept artificially low, with rationing and inflation masked by periodic food shortages and long lines in shops (Patterson, 2000).

In the EU, food insecurity gave rise to embarrassing surpluses during the 1980s, despite increasing evidence of environmental harm, damage to rural cultures and negative impacts of food dumping on external markets. In response, the CAP moved away from simply increasing production to transfer wealth from urban to rural areas, transformed several million peasants into relatively prosperous farmers (Davies, 1996), and to conserve natural, cultural and economic resources in rural areas through agri-environment and regional development schemes. This policy shift, now extended to the new member states of the EU, coincides with increasing demand for food that is produced outside the intensive agricultural system, including organic, fair trade, animal welfare-friendly, GMO-free and local food. More recently, though, the issues of energy security (National Economic Council, 2006) and climate change (Stern, 2007) have become more important: policies and practices are being developed to reduce the environmental foodprint of agri-food systems (Miliband, 2006), to use agricultural land to mitigate climate change by carbon sequestration (Lal, 2004) and to replace some fossil fuel use by the production of biorenewables (Brown, 2003).

1.2.2.6 Agricultural biodiversity

The domestic plants in the region come largely from three sources. Crops developed in southwest Asia are typically small-seeded (e.g. wheat, lentils), grown with the use of ploughs. North American tribes domesticated sunflowers, cranberries, pumpkin and Jerusalem artichoke roots, while maize, beans, squash, potatoes were domesticated in central and south America, and were carried north by trade. These crops were sown with the help of a hoe and digging stick; ploughs were unknown until the arrival of the Spaniards. Most farm animals were domesticated in central and southwest Asia, except for the horse in the Caucasus, and the pig in China (Solbrig and Solbrig, 1994). Non-cropped plants and animals remained important in the diet until populations became urbanized.

The genetic diversity of these species was maintained by adaptation to local conditions and selection by farmers, giving rise to many traditional breeds and varieties. Intensive agriculture resulted in the increasing homogenization of agricultural environments, and was driven in part by changes in plant breeding to favour high-yielding varieties. Breeding is now largely carried out within the private sector, with the economies of scale dictating that fewer varieties are being developed, expected to be grown over

larger areas. This is especially so for genetically modified crops, that require rigorous testing for food and environmental safety. The net result is a decline in agricultural biodiversity, with xx% of food being obtained from only XXX species, with XXX major varieties dominating the market.

Interest in the conservation of genetic diversity is increasing across the region. The requirements for agriculture are changing; interest in organic produce, local varieties, bioenergy and control of nutrient balance is reflected by the increased use of varieties with traits that had fallen out of favour. Moreover, the wish to develop new breeds with novel characteristics, including production of pharmaceuticals, is intensify the search for novel genes within existing gene banks and in wild species. *State of gene banks in the region – includes Kew, etc etc*

Agriculture depends on ecosystem goods and services from non-cropped taxa, especially for pollination, pest control and in the soil. Populations of pollinators have declined across parts of the region; declines have been attributed to diseases, acaride mites, pesticides and, in the US, the spread of Africanized bees. In the UK, bee declines have been attributed to reductions in wild nectar sources in agricultural landscapes that are themselves consistent with effects of nutrient inputs into the landscape from agriculture and transport. The importance of biological pest control was highlighted when the widespread use of pesticides was followed by outbreaks of resistant and secondary pests. Now integrated pest management systems are being adopted across the region that emphasise creating the environmental conditions that disfavour weeds, pests and diseases (e.g. by the use of rotations) and favour natural enemies (eg by creating beetle banks) (Gurr et al., 2004).

1.2.2.7 Fisheries

The region borders some of the most important marine fisheries in the world, notably the largest, the northwest Pacific (21.6 M tons in 2004) and the fourth largest, the northeast Atlantic (10.0 M tons). Catches have declined recently in the northern Pacific, but not as precipitously as in the northwest Atlantic, where catches are now around 2 M tons /yr, around half the levels in the early 1970s. Five species of marine fish caught here are now considered to be critically endangered (Devine et al., 2006); indeed, most of the marine fisheries are fully or over-exploited. To prevent further erosion of the resource base and ensure sustainable development, Fisheries and Oceans Canada is working with a range of stakeholders to develop and implement integrated ocean management plans as part of the 1997 Oceans Act (Quigley and Harper, 2006; Rutherford et al., 2005). Reporting of inland catch fisheries is much less precise, but it seems that Europe and North America account for only around 6 % of global catch, with dramatic declines in Europe. Aquaculture is increasing, but at very low levels compared with Asia (FAO, 2007b).

1.2.2.8 Freshwater and irrigation use/potential

The water resources of the region are distributed unevenly across the region, both in terms of geography and per capita. In 1995, the region consumed around 300 km^3 of water, out of a global total of 1,800 km^3; nearly two thirds of this was used for irrigation (Rosegrant et al., 2002). There is increasing competition for water in the arid western sections of the USA, not only to meet agricultural and hydropower needs, but also for drinking water in growing urban areas, Native American water rights, industry, recreation and natural ecosystems: as a result, many aquifers are losing water at rates far higher than recharge rates. In Canada, water consumption per capita is high by international standards (1420 m^3 of water per capita in 1996, but consumes only 2 % of the available renewable supplies. The electricity sector consumed 64%, the manufacturing sector 14% and the primary-resource sector (mostly agriculture) 11% (Gunton et al., 2005).

Water supplies in Western Europe are most under pressure in Germany, France and the Mediterranean because of the low rainfall, high irrigation demand and high populations. Many states in Eastern Europe also have water use rates of over 20 %. The Russian utilization rate is low, 2 %, but hides great inequalities. This is why it has been proposed to divert the Volga, Ob and Irtysh rivers to provide more water to Central Asia, with very uncertain environmental consequences. On a per-unit area, irrigation is most widespread in the Netherlands and the Mediterranean countries, Italy, Greece, Spain and Portugal (FAO, 2007a).

1.2.2.9 Energy

The major requirements for energy were fuel for fires and wind and, in medieval Europe, hydro-power to drive mills for flour production. Wood and charcoal were the major fuels until they became scarce, when coal mining increased. Hydro-power, coal and oil provided the energy for the Industrial Revolution. As agriculture intensified, it became increasingly reliant on fossil fuels in the production of fertilizers, the transport of materials and the processing and transport of the final product. A recent study in Sweden showed that a meal of beef, rice, tomatoes and wine required inputs of 19.0MJ, compared with the dietary energy of a mere 2.5 MJ (Carlsson-Kanyama et al., 2003). Concerns about global climate change and energy security are changing perceptions about the use of fossil fuels in the food chain, as can be seen in the increasing awareness of the issue of food miles (Pretty et al., 2005).

Moreover, agriculture and forestry are increasingly seen as sources for renewable energy, in the forms of biomass, biodiesel, and biogas. Biomass can be produced using crops such as willow, poplar and *Miscanthus* that can be grown on land that is marginal for intensive agriculture, and so can be considered as production that is at least partly additional to food production, but could compete for land used for other purposes. Biogas can be produced from a greater variety of sources, including manures, sewage and vegetable wastes, and so may be able to complement existing agri-food systems. Biodiesel and bioethanol are rather different, in that within NAE they are produced currently from varieties of crops used

also for food, namely maize, soybean and oilseed rape. Very large increases in production are anticipated, driven by changing policies across the region: in the United States, for example, biodiesel production capacity is expected to increase to 2.5 billion gallons per year by the end of 2008, from 2 million gallons in 2000 (National Biodiesel Board, 2007). The diversion of large areas from food to biofuel production will have uncertain, but very large consequences for agri-food systems, especially if land and water availability are simultaneously reduced through climate change, sea level rise and increased urbanization.

1.2.2.10 Use of natural resources by agriculture and the food chain

Increasingly, ecosystem processes are being diverted to meet human needs. It is estimated that, globally, 30% of terrestrial net primary production is appropriated as food, fuel and fibre, with levels of around 70 % for western Europe (Imhoff et al., 2004). This has been achieved by the transformation of the coniferous forests into managed forests, of broadleaved woodland into agriculture, of prairie into crops. Few virgin habitats remain in the region beyond the poles and high mountains, and these are subject to changing climates. There is little potential land that is not currently used for agriculture (Fischer et al., 2001), and the pressure on existing land, both from competition and from changing climates, will increase.

The changing agricultural context will, inevitably, change the agricultural landscapes and their ecological functions. Many of the agricultural landscapes in Europe have a long heritage, often developed over centuries of continuous management practices that have resulted in unique assemblages of species and communities that are now highly valued for their biodiversity, cultural importance and beauty. However, they are already being transformed by the twin pressures to intensify and abandon production, both with the result of landscape homogenization and reduction in biodiversity (Petit et al., 2001). The new pressures to increase production will again lead to new landscape patterns, with changes to species composition and abundance (Firbank, 2005). The increase in intensive agriculture has also been associated with the decline of other ecosystem functions across the region, including resource protection, water supply and pollination (Millennium Ecosystem Assessment, 2005). While farming systems that seek to combine production with ecosystem service delivery are increasing in both area (especially organic farming) and sophistication (including eco-efficient farming (McNeely and Scherr, 2003)), the trend towards homogenization of landscapes, agrobiodiversity and farming systems remains very strong.

1.3 Significance of NAE in the generation, use and control of AKST

1.3.1 Importance within the region

1.3.1.1 Impacts on development goals

AKST is less relevant than policy choices within most countries of NAE on meeting development goals of reducing hunger and poverty, improving nutrition and human health, enhancing livelihoods and equity,

promoting environmental sustainability, and sustaining economic development. That is, AKST is not the main limiting factor in achieving these goals, with the important exceptions of building resilience and adaptive capacity to deal with consequences of global climate change and learning how to restore degraded ecosystem services.

1.3.1.2 Economic

The past few decades of application of AKST resulting in the consolidation of global value chains that control the supply of most agricultural products, have had tremendous effects on the distribution of wealth in society and prospects for making a living through agricultural production. Only operators of very large-scale production agriculture are able to support a household by full-time commodity farming; all other commodity producers are reliant on off-farm income because of low and unstable commodity prices. This problem is aggravated in the United States by lack of universal access to health care. On the other hand, immense wealth is sequestered among the small number of shareholders with expansive holdings, owners, and executives of transnational agribusinesses. The application of AKST has enabled the growth of these companies, sometimes through research partially subsidized in public universities and laboratories and other forms of public support (development of irrigation and water delivery systems, roads, railroads, etc.). [NOTE: Sections 1.3.1.2 through 1.3.1.4 need to be balanced with the Introduction to avoid redundancy, yet introduce the important points adequately. The emphasis here should be on what an assessment of AKST generation, use and control within NAE contributes to a global assessment, not simply listing economic, social and environmental consequences of the application of AKST.]

1.3.1.3 Social

The application of AKST within NAE has been associated with profound social changes, including large-scale immigration in search of jobs in agricultural industries (with resultant shifts in the demographic profile of regions), changing diets and health, and the disconnection of most people from food production. While AKST has improved the availability and access of many foods in NAE and eased hunger, diet-related health problems caused by excessive consumption of processed foods low in nutrient value and lack of physical activity are on the rise.

1.3.1.4 Environmental

The application of AKST has led to habitat transformation (draining of wetlands and changes in patterns of forestation as land is cultivated or abandoned), loss of biodiversity, declining quantities of freshwater and increasing competition for what remains, degradation of the quality of groundwater and surfacewater, and impacts on soil quality. Transportation of agricultural products contributes to greenhouse gas emission and poor air quality due to particulates. Appropriate AKST that improves environmental quality, such as no-till planting methods and crop rotations, is used in most parts of NAE but not exclusively.

1.3.2 Importance to the rest of the world

1.3.2.1Impacts on development goals

Individual countries and the private sector in NAE control resources that are crucial for achieving the development goals under consideration by IAASTD: reduced hunger and poverty, improved nutrition and human health, enhanced livelihoods and equity, environmental sustainability, and sustainable economic development. These essential resources include arable land, gene banks, money, scientific infrastructure, and human capital. Therefore, a substantial proportion of investment and material assistance will need to come from NAE. Enterprises based in NAE and governmental agencies in its countries control technology now that could make a real difference in poor regions, were it affordable to the people who most need it. But the assistance needed most desperately may be in building capacity to educate poor regions' farmers, food system employees, teachers and researchers so that they can generate their own site-specific agricultural knowledge and technology. While poor countries and regions are developing the ability to fully care for their citizens' needs, NAE must provide funds and material support for food production, processing, food distribution and nutrition education to increase food security and health; and provide resources needed to improve the production and distribution of other bio-based resources important to sustainable livelihoods.

Global climate change is predicted to cause less severe environmental disruption in NAE than in developing regions. Particularly because NAE countries bear the most responsibility for the accumulation of greenhouse gases, they have a moral obligation to assist countries suffering the consequences of global climate change. This is likely to include emergency food assistance following severe storms, heat waves, floods and droughts that will result from global climate change.

In addition to actions aimed at sustainable development, NAE has responsibilities to desist from current policies and patterns of trading with developing countries that diminish their ability to feed their own people. This means a halt to dumping food at below the cost of production, thereby undercutting prices of farmers in developing countries. It also means stopping food aid that cuts out local and regional farmers. In addition, NAE needs to shrink its ecological footprint, and take steps to ensure that it is not taking advantage of impoverished or politically weak countries and removing their necessities of life to provide excess food and other goods to citizens of wealthy countries. These are legitimate expectations, but they raise thorny issues of fairness and where the lines will be drawn between "enough" and "too much".

1.3.2.2 Export of AKST

NAE countries produce much of the knowledge and technology used outside the region, as well as within. International development agencies, financial institutions, and transnational corporations have exported many elements of the agricultural systems developed in NAE into developing countries through extension services, other types of training, demands to adopt certain kinds of agriculture as part of structural

adjustments on which loans are conditioned, market incentives, and deals set up between corporations and the governments of developing countries. This is a push/pull flow of knowledge and technology, to some extent, because developing countries often are eager for access to the factors that have helped NAE become a dominant force in global production and marketing of agricultural goods and services. While the application of agricultural knowledge and technology has contributed to North America and Europe's development and relatively high levels of wealth, it also has contributed to the persistence of poverty and poor prospects for livelihoods based on agriculture. Inequity in many countries of NAE is rising, and the numbers of people trapped in pockets of underdevelopment characterized by poverty and non-viable rural livelihoods are also increasing. Therefore, parts of NAE are also in need of development.

1.3.2.3 Export of concepts of development

Along with tangible exports and discrete clusters of AKST, NAE has the influence to ensure that concepts and ideas about economic development held by powerful entities in the region are adopted in other regions. These concepts been especially important when they infuse mandatory structural adjustment plans or poverty reduction plans, or when granting a loan or other aid is contingent on adopting them. [Note: Needs more work.]

1.3.2.4 NAE's footprint

Agricultural knowledge and technology in NAE have very large ecological footprints and social impacts in other regions of the world. The globalized agricultural system, in which importers source raw products from the cheapest source and seek to sell processing products where they garner the highest price possible, touches every country in the world. Developing countries frequently supply the genetic resources; unprocessed food, feed and fiber; and labor to process commodities into goods that can be sold at higher prices. Demand for cash crops has trumped land use for subsistence farming from Brazil to Indonesia, and demand for cheap labor for farm work or food processing sets up a flow from rural areas, where poor people have increasing difficulties making a living from agriculture. Sometimes this is because land conversion for cash crops and livestock—which may result from trade agreements—has marginalized poor farmers onto unproductive and vulnerable land. In other cases, population growth, conflict, and global climate change have increased the ratio of people to productive land. And sometimes unintended consequences of the application of agricultural science and technology have made formerly productive land non-arable.

Nations do not simply use the natural resources within their own borders. For example, while the UK appears to be self sufficient in water, in that water is not imported directly, large quantities of "virtual" water are imported in terms of the amounts of water used to grow, manufacture and transport agricultural and industrial produce. Taking these factors into account shows that the UK imports 70 % of the water that it actually uses. The dependency on imported water within NAE is particularly great in northwest

Europe (Chapagain and Hoekstra, 2004). Equally, by importing food, these countries import solar energy also, denying it from local ecosystems. Most countries in NAE have footprints beyond the capacity of their own territories to support, except for the arctic countries of Canada, Russia and Sweden, and Romania and Belarus (Global Footprint Network, 2006; Figure 1.10).

[Insert Figure 1.10 Ecological creditors and debtors]

NAE has a "consumption footprint" as well as a footprint connected with production. The "Western" diet, high in fats, salt, sugar, and processed foods, has spread rapidly into developing countries around the world, promoted by agribusinesses in NAE. Their brand-names can be seen in the smallest and remotest villages. The created demand for dietary changes, particularly increased proportions of beef and other large animals in the diet has a dramatic effect on land use worldwide and the amount of land required to feed a population.

1.3.2.5 Wealth and political power

North America and Europe have unique characteristics stemming from their histories and assets that make them critical parts of the IAASTD. NAE countries and corporations have disproportionate power in agricultural knowledge, science and technology (and in science and technology more generally), compared with other world regions. NAE contain the wealthiest nations in the world, and many of the countries with the steadiest and most sustained growth in per capita income since 1945. Much of this wealth has accrued through extracting resources and labor from other regions, which is one of the ways in which greater power has been exercised and in which it perpetuates itself.

Agricultural knowledge and technology are controlled in unusual ways in NAE, compared to other regions of the world: the private sector plays a dominant role, especially in North America. The ratio of public to private investment in agricultural research has dropped steadily since 1980. As late as 1940, agricultural research represented 40 percent of all federal research funding, but national security concerns became pre-eminent with World War II (Fuglie et al., 1996). Investment in private agricultural research has grown more rapidly than public investment in research and has exceeded funds for public research since 1980 (Meeks, 2006). NAE countries are the point of origin of most transnational corporations (TNCs) that now dominate globalized food systems. Six of the top ten pesticide companies by total sales, eight of the top ten seed companies, all of the top ten global food retailers, and all of the top ten beverage and food processing corporations are based in the United States or Western Europe (ETCGroup 2005). Not surprisingly, NAE countries are also the source of development of most genetically modified organisms, and companies based in NAE hold more than half of the Intellectual Property Rights (IPR) relevant to agriculture.

1.4 Typology of Global Agricultural Systems

[Insert Figure 1.11 Pressures acting on alternative agricultural value chains]

1.4.1 Agri-food systems and value chains

Traditional agri-food systems were localized; food, fuel and fiber were consumed close to the point of production, driven by the local needs, in economic systems relatively independent from the rest of the world, driven by the needs. But, as we have seen, these gave way to globally integrated value chains based on the international trade of commodities. Concern about the environmental and social costs of such systems, new systems are evolving that are more responsive to non-economic signals, some globalized, while others involve the re-invention of localized, fragmented food supply chains. It is helpful to characterize food systems according to globally integrated v fragmented, and responsive to multifunctional signals as opposed to simply economic signals, not least as this typology reflects the axes used to develop scenarios in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2003).

Agricultural systems have evolved greatly in the region in the last century. After long periods where the food supply has been constrained by economics, technology or politics, it is increasingly driven by the consumer. There is now a far greater range of food available to more people than ever before in history. There is an abundant variety of affordable native and exotic foods available in all but the poorest countries in the region. Because of prosperity and extensive culinary choices (including convenience and fast food) on the one hand, and increasing pressures of time from the changing nature of work on the other, cooking at home has become less frequent (Küster, 2000) These changes all drive increased globalization, encouraging systems to respond primarily to economic signals. They also promote the integration of food production, distribution, preparation, and supply, adding value each step, into value chains.

However, ethical and health concerns are increasingly promoting systems that respond to a wider range of concerns, either through market forces or regulation. Many of these concerns are reactions to perceived failures of globally integrated supply chains that are most responsive to economic values, and can be traced back to the environmental protest movements of the 1960s and 70s. They include the vegetarian movement, a reaction to factory farming of animals. In Britain, for example, there were 100,000 vegetarians in 1945 and by the 1990s there were 3 million, the number having doubled during the 1980s. Purchasing fair trade produce is another, a reaction to concern that global trading systems and TNCs disadvantage those that are already poor. Health concerns focus on both the presence of undesirable “contaminants” of food and the overall diet. Public concern about contaminants including pesticide residues, growth hormones, antibiotics and foreign genes has increased the market for organic goods. Organic and locally-produced goods are also considered to be ways of avoiding the perceived

blandness and stereotypical nature of much modern food that constitute unhealthy diets that tend to be high in refined carbohydrates, sugars and salt and low in fiber and essential vitamins and minerals (Spencer, 2000).

Inevitably, public policy addresses all of these issues. The appropriate balance between open trade and the use of barriers, tariffs and subsidies remains highly contentious, as can be seen in the Doha round of the world trade talks. Such issues have increased the roles of international trading blocks such as the EU and NAFTA. In Europe, the circle between the political requirements to stop subsiding food production and to continue to support farming communities has been squared by changing the emphasis of the CAP to support rural development and environmental goals. Regulations are used to lay down minimum environmental standards of farming and food quality. Sustainable development is a major policy goal, encompassing agriculture, forestry and fisheries, monitored using a wide range of social, economic and environmental indicators. The policy trend in Europe is to promote more proactive agricultural systems, both global and fragmented, with a much greater emphasis on the provision of ecosystem services (such as pollution management, carbon storage and the provision of habitats) and the management of natural resources (such as soil, water and air quality) (Miliband, 2006). These objectives may clash with the more recent concerns over energy and climate change, that are likely to incentivize the use of land for biofuel, with the possibility of dramatic changes to rural landscapes and economies. These trends all point to increasing demands from the land, delivering the full range of ecosystem services in rapidly changing economic and climatic conditions.

1.4.2 Fragmented value chains, responsive to economic signals

Hunter-gathering and peasant agriculture both involve meeting the needs of the immediate community from the resources available. Dependence on hunter-gathering is now restricted to very small numbers of people, almost entirely in polar and forest regions, while peasant agriculture is declining through both formal policies and rural depopulation (though, interestingly, there is renewed interest in nomadic pastoralism in central Asia). Hunting, fishing and gathering natural products from forests is of high economic value throughout the region.

The traditional form of agriculture across much of the region comprised small, family farms supplying produce largely to the local market either directly or through independent retailers. In general, these localized food chains are either giving way to globalized ones through acquisitions and competition, or else are being transformed into local markets with high perceived added value. The remaining small farms outside these added value chains have either persisted for many generations, or have been created from decollectivization in the east. In the Caucasus and southern Balkans, the plots are often used to grow cereal and oil crops for subsistence and fruit, vegetable and animals products to supplement often very low incomes (Dixon et al., 2001).

1.4.3 Fragmented value chains, responsive to multifunctional signals

In the EU, the risk of loss of small farms to rural communities was a major driver of the early versions of the CAP, which protected them from international competition using subsidies, and this remains an issue across Europe, especially in the countries that have recently joined the EU. A small number of farms are starting to charge premium prices through farmer's markets, specialist retailers and across the Web. They have achieved this by adding value to the food more widely available in the supermarkets, by providing food that is organic, has local distinctiveness, has high standards of animal welfare or has been value added through its processing and packaging. Markets for food with local provenance, traditional varieties and (especially) breeds are increasing in both Europe and North America. Europe has seen a rapid growth in organic agriculture since the early 1990s, but this is now slowing down. Latest figures suggest around 3.4 % of EU agricultural land area is now organic, compared with around 0.3 % in North America (Willer and Yussefi, 2006).

While the traditional family farm represented food systems that are fragmented and responsive to economic signals, these new local food systems are increasingly responsive to environmental and social concerns about intensive agriculture and globalization (as argued by Harvey, 1997; Pretty, 1998; Tudge, 2003 among others). They also provide a new balance between globalization and fragmentation, in that the food chains themselves are ideally localized, minimizing food miles and maximizing engagement at all levels of the food chain, but using Fair Trade to import goods that cannot be produced within the region. These food systems are also starting to form part of new systems that use knowledge, ideas and values alongside monetary currencies.

1.4.4 Globalized, integrated value chains, responsive to economic signals

The increase in food trade during the 19th and 20th Centuries ensured that the successful farmers were often those that responded to market signals and produced commodity foods at competitive prices, increasing efficiency by increasing in scale and productivity. This happened throughout the supply chain, with a strong trend to fewer, larger corporations providing seed, fertilizers, agrochemicals and machinery to farmers, and consolidation of the supply chain from the farm. The experience of buying food has been transformed: at the turn of the 20th century, the goods in shops were on shelves behind a counter, and were packaged and passed to the customer by a shop assistant. Supermarkets reduced costs by enabling the customer the select the produce themselves. They first appeared in the US in the 1930s, and after WWII became part of suburban culture, combining car parking, low prices and an increasingly wide choice. A process of consolidation has taken place, with Wal-Mart now dominating the American market, Carrefour in France and Tesco in the UK. Increasingly, these transnational companies (TNCs) sell not just food, but clothes and electrical goods. They have been accused of driving prices down to the farmers, and driving out small businesses through competition – practices that are globalizing and

reactive. Consumption of pre-prepared food has become increasingly important, in both shops and fast food outlets.

Because of the emphasis on profit, social and ecosystem goods and services were externalized and under-valued. Consumers became disconnected from the value chain, and in some cases suspicious of new technologies with little or no apparent benefit to them (in particular, GMOs in Europe [Heller, 2003]).

1.4.5 Globalized, integrated value chains, responsive to multifunctional signals

The agrifood industry can only survive by adhering to regulations and meeting customer needs. All levels of the industry are increasingly seeking to demonstrate their commitment to responsible production and retailing through accreditation, auditing and traceability. Potential markets in production and management of energy, water, nutrients, pharmaceuticals and pollutants are expanding the very concept of agriculture. The emerging markets in organic and local produce can also be tapped by TNCs, as more flexible supply chain systems can transport organic produce around the world, or tie into local producers. Moreover, it is now possible to tailor the food chain to the precise dietary needs and wishes of individual customers, by connecting personal data, household appliances and distributors over the Web – a globalized, integrated, yet personalized vision of agricultural chains.

The increasing market signals for added value food, of known provenance and produced to high social and environmental standards, are changing the way value chains operate. Certification is becoming more important, to demonstrate compliance with standards for sustainable production, food safety and animal welfare. To help assure these new standards, companies such as Sainsbury are establishing direct contracts with farmers around the world, bypassing systems of wholesalers. Such vertical integration of the agricultural system not only allows a more proactive approach to retailing, it allows control and auditing. The Environmental and Social Report of Unilever (Unilever, 2005), the environmental plans for Wal-Mart and the commitments to Fair Trade by Sainsbury's (Sainsbury's, 2006) are but a few of a rapidly increasing number of examples. Equally, some supermarkets are encouraging local production, exploiting the new markets in local food systems. In the UK, some ASDA stores (a Wal-Mart company) devote shelf space to local producers, while Waitrose and Booth's stress to customers their use of named local suppliers. In this way, TNCs are seeking to integrate local sensitivity within global strategies. This process is most fully realized in companies such as Whole Foods Markets, which sell organic and "natural" produce only, through a rapidly expanding network of outlets, each with considerable local autonomy: instead of globalized corporations seeking to become more proactive and locally sensitive, Whole Foods Market, is an example of a fragmented, proactive institution becoming globalized.

1.5 Relationships between AKST and Sustainability Goals

[Insert Figure 1.2: AKST dynamics]

1.5.1 AKST dynamics

[NOTE: This section will be no more than half a page, explaining the AKST Dynamics and giving examples of entities in the following categories, whose interrelationships are shown in the figure.]

1.5.2 Actors and networks (e.g., public and private agricultural research organizations, universities, public extension services, independent agricultural consultants and other businesses, CGIAR, supply chains, civil-society organizations)

1.5.3 Processes (e.g., knowledge and technology generation, dissemination and extension, adoption, and evaluation for all sectors in supply chains; trade; public-private investment; advertising; provision of credit and financial resources)

1.5.4 Rules and norms (e.g., international agreements such as ITPGRFA, CBD, TRIPS, WTO settlements, IPR, ISO14000, Codex Alimentarius; subsidies; national regulations; tax structures; local customs)

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