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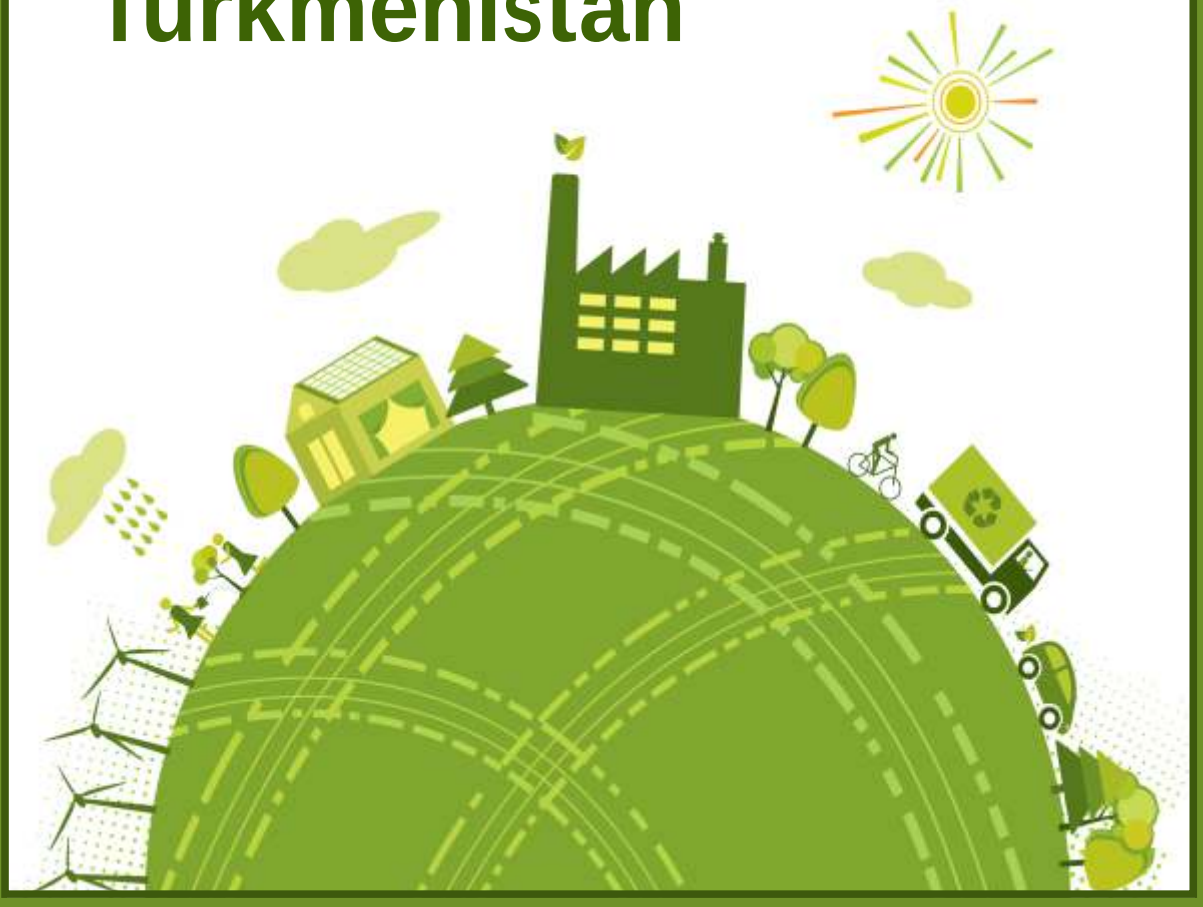
Promoting Green Innovation

Policy assessment and recommendations

Turkmenistan



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Introduction

Climate change policy has two main pillars: mitigation and adaptation. Mitigation aims at stabilizing the emissions of greenhouse gases associated with human activities. Adaptation refers to how human systems adjust "to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities".[1] While the benefits of mitigation are global, the direct benefits of adaptation will be mainly local.

Because of its geographical position and its strong reliance on agriculture for food security, Turkmenistan is highly vulnerable to climate change impacts. The major risks include increased water scarcity, soil degradation, droughts, floods, storms, and health impacts. The country will need to design policies and build institutions to enable it to adapt to climate impacts and minimize the economic, social and environmental costs.

In general, how a country deals with climate change will depend on its capacity to adapt. This includes factors such as human and financial resources, technology, education and the legal and institutional framework. Effective adaptation will depend largely on the development and diffusion of innovative and environmentally sound, i.e. "green" technologies, which points to the importance of a performing national innovation system.

I. Socioeconomic context

Turkmenistan is a central Asian country that has borders with Afghanistan, the Islamic Republic of Iran, Kazakhstan and Uzbekistan. The western part of the country borders the Caspian Sea. About 80 per cent of the country's territory is desert. The population has been growing very rapidly. In 2011, it was estimated at 5.1 million, up from 4.6 million in 2000. Nearly 60 per cent of the population live in rural areas, where poverty appears to be widespread (no official poverty statistics are available).

Turkmenistan is richly endowed with oil and gas resource. Production and exports of natural gas and oil have been the dominant drivers of economic growth during the past decade. In recent years, domestic economic activity has also been fuelled by strong growth in public infrastructure investments, including housing.

Real gross domestic product (GDP) rose at an annual average rate of some 13 per cent between 2000 and 2012. Real GDP per capita (in national currency units) rose by a factor of 3.5 over the same period.

The World Bank classifies Turkmenistan as an upper middle-income country. The structure of the economy is dominated by the hydrocarbon production sector, which, including oil refining and gas processing, is estimated to account for more than half of GDP and more than 90 per cent of total merchandise exports.

Agriculture still plays an important role in the economy both for reasons of food security and as a source of income. It provides employment for nearly half of the domestic labour force. But largely due to the dynamic growth of the hydrocarbon and service sector, the share of agriculture in GDP fell from some 20 per cent in 2000 to around 12 per cent in 2010.

[1] IPCC 2007.

The agricultural land is mainly desert pasture; and only 4 per cent (1.7 million ha) is cultivable land. Agriculture is highly dependent on irrigation given the minimal precipitation in the country.

Most of the agricultural activity is done by peasant associations (composed of individual leaseholders) that are subject to tight State controls concerning the production of "strategic crops" (cotton, rice, sugar and wheat). Policy instruments applied comprise mandatory production quotas, output price regulation, State supply of inputs at subsidized prices and concessional State lending.[2]

In contrast, household plots and so-called *daikhan farms* are considered to be private farms. The pasture livestock sector is also organized on a private basis. But the boundaries between the collective and the private sector are blurred. Private ownership of land doesn't exist.

Farmers and other citizens have some rights to land, which exclude, however, its sale or mortgaging. Transfer of land rights is only allowed through inheritance. There are no land-use rights for non-agricultural purposes; leasing of land for these purposes requires a special permission by the President.

State budget surpluses are accumulated in the national Stabilization Fund—a sovereign wealth fund that is mainly a mechanism for cushioning the adverse effects of external shocks on the economy.

But its objectives and operations appear not to be aligned to best international practice to ensure longer-term fiscal sustainability. In 2011, the Government established a State Development Fund, which will act as the financial agent for investment projects financed by the Stabilization Fund. The Fund can provide loans at concessional terms to enterprises (State-owned and private) for financing investments for modernizing the productive capital stock and create jobs.

Although the new Government, which has been in place since 2007, has committed to reforms to move towards a more market-based economic system, progress has been slow. The State continues to play the leading role in the economy, owning most of the productive assets. It manages a widespread system of price controls and subsidies, including the provision of free utility services for the population and supply of free irrigation water to farmers, which poses a heavy financial burden on the State budget.

There's no level playing field for private and State-owned businesses. Private-sector businesses face considerable barriers. All the banks operating in the country are State-owned; they are not adapted to commercial operations, which makes it difficult for businesses outside the State system to obtain loans.

The situation of ownership rights and the enforcement of contracts is unclear. Turkmenistan has so far not participated in cross-country evaluations of business climate, such as the World Bank's annual *Doing Business* reports. According to the European Bank for Reconstruction and Development (EBRD), commercial laws and the legal infrastructure do not correspond to internationally accepted standards.[3]

[2] FAO (2012a).
[3] EBRD (2010a).

Privatization has been limited to small-scale economic entities—mainly in the retail trade, services and food-processing sector. Some 75 per cent of the total economy is estimated to be still under State control. Foreign direct investment (FDI) has been restrained by the lack of rule of law and by inconsistent regulatory practices. In a more general way, permission for FDI inflows is driven by political considerations and has been mainly limited to the oil and gas sector.

The Government has also been aiming to attract FDI for the construction and textiles sectors, given their lack of modern technology, knowledge of export markets and experience in international business practices. In 2010, net FDI inflows corresponded to 10.4 per cent of the gross domestic product.

In November 2012, the Government announced a plan for large-scale privatization of State enterprises and other State assets during 2013-2016 within the framework of the State Programme for Privatization of Enterprises and Objects of State Property. The plan is to privatize major enterprises in the manufacturing, construction, transportation and communication sectors.

The Programme also identifies strategic State-owned companies that will not be subject to privatization. Implementation of the plans requires, however, the adoption of correspondingly revised privatization legislation. The goal is to raise the share of the private sector in the non-hydrocarbon sector of the economy to 70 per cent by 2020.

The promotion of private entrepreneurship in the national economy has so far focused on small and medium-sized enterprises (SMEs), and the Government has adopted a Law on State Support to SMEs.

In 2008, a separate public organization—the Union of Industrialists and Entrepreneurs of Turkmenistan—was established to represent and defend the interests of privately owned companies. But it's difficult to gauge how independent it actually is. In 2012, the Government allocated $30 million to it for the support of business start-ups.

SMEs can also benefit from concessional lending from local State-owned banks. Local SMEs have also been benefiting from international financial and technical assistance (e.g. EBRD, Eurasia Foundation, World Bank, USAID). Their projects, although relatively small, can act as catalysts for strengthening the role of SMEs in the whole country.

In a more general way, FDI and foreign-assistance projects have been associated with transfer of technology and know-how in the corresponding economic sectors, with major emphasis on the oil and gas sector. An example from the agricultural sector is the USAID AgTech Program, which through education and transfer of technical skills and knowledge to private smallholder farmers in livestock and horticulture development (such as improvements of greenhouses; feed demonstration programmes) aims to raise yields and farmer income.

The National Programme for Socioeconomic Development 2011-2030, which was adopted in May 2010, emphasizes the goals of diversifying economic activity and strengthening competitiveness within the context of further market and institutional reforms.
It envisages a stronger role for the agricultural sector and domestically processed goods, a greater reliance on renewable energy sources and the development and increased use of

environmentally sound technologies. In a more general way, it aims also at strengthening the national science and education system (see below).

Recently, the Government introduced structural reforms related to accounting and financial reporting standards, removal of administrative barriers for access of SMEs to State loans for private investment projects and engagement in foreign trade transactions; reduction in the number of economic activities that need a licence; and streamlining of procedures for allocation of land to be used as enterprise sites. The Government also announced its intention to privatize State banks as of 2016-2020.

II. Vulnerability to climate change

Turkmenistan's climate is among the most severe among the five central Asian countries, its main characteristic features being the highest air temperature and the lowest precipitation levels. Its inherent vulnerability to climate change is largely due to an already extreme dryness, which is being exacerbated by global warming.

Over the past decade, the average annual increase in air temperature amounted to some 0.2°C. Climate change scenarios reported in Turkmenistan's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCC) in 2010 suggest the following main climate change impacts:

- Further increase in average annual temperatures, including higher number of extremely hot days
- Reduction in annual average rainfall
- Increase in average regional water evaporation rates
- Increase in frequency and intensity of droughts and floods
- Reduction in flow rates of the Amu Darya—an international river that is the major source of water in Turkmenistan—as well as of other smaller local rivers.

Turkmenistan's main vulnerabilities are water resources and agriculture, and food security. The country faces an increased scarcity of water, which will be accentuated by the projected growth in population and overall economic development. Its water resources are already limited due to its climate and geographical position. This increased scarcity, in turn, will have serious adverse consequences for the agricultural sector, which is wholly dependent on irrigation as there's so little rain. And rising temperatures and longer spells of drought also raise the issue of the drought-resistance of the domestic crop varieties.

Water resources are therefore among the most critical factors limiting the future economic and social development of the country.[4] Other climate change risks pertain to the impact on human health, on the coastal area along the Caspian Sea and the potential disasters from more frequent extreme weather events.

The climate-related risks to these sectors are amplified by human-made factors. Farmers tend to employ traditional surface irrigation technologies that use water inefficiently and that greatly exceed international agro-technical standards for irrigation. Given the excessive volumes of water used, more than 60 per cent of agricultural land is now salinized. There

[4] UNECE (2012), *Environmental Performance Review – Turkmenistan*, chapter 7.

also appears to be a widespread lack of sustainable farming practices such as crop rotation and good management of pastures used for livestock.

The irrigation infrastructure and other parts of the water-sector infrastructure are in poor condition, reflecting a lack of adequate maintenance and renewal measures. This, in turn, has meant considerable losses of water channelled through the irrigation network to agricultural land.

III. The challenge of adapting to a changing climate

A. Building adaptive capacities

Adaptive capacity refers to the capabilities, resources and institutions of human systems to implement measures that effectively reduce the vulnerability to climate change impacts. The vulnerability of a country (or a region and economic sector within a country) to climate change depends on the country's sensitivity to climate change as well as on its adaptive capacity.

Adaptive capacity is largely determined by the available human capital stock, technology, financial resources, and social institutions.[5] The boundaries between adaptation and sustainable development are blurred. In a general way, adaptation to climate change can be regarded to be a subset of sustainable development.

Future vulnerability to climate change also depends on the development path that a country choses, and there's broad agreement that it's strongly correlated with incomes per capita and technological developments. More generally, the promotion of growth and diversification of economic activity, investment in health, education and R&D, strengthening resilience to extreme weather events (natural disasters) and improvements of social safety nets will help to promote adaptation. In fact, this is probably the best strategy.

Conversely, among the major barriers to widespread adaptation are constraints on information and knowledge flows, lack of technical and managerial skills and know-how, ineffective policy framework (e.g. regulations and other policy instruments), as well as of course financial constraints.

It's important to include adaptation in the national economic development strategies or specific development strategies for sectors that are particularly vulnerable to climate change. Similar mainstreaming is also required for local development strategies.

Developing a coherent and robust adaptation strategy first requires an assessment of the current and projected vulnerabilities and the policies and institutions impinging on the sectors most affected. This provides a baseline for assessing the technologies needed for effective adaptation, and for evaluating and prioritizing the available options, taking into account the need for promoting sustainable development.[6] This has to be followed by a strategy of necessary changes in policies and the legal and institutional framework.

In fact, adaptive capacity can also be enhanced by legal and policy constraints such as command and control measures (regulations on pollution norms) or economic instruments (water tariffs) that provide incentives for more rational water use.

[5] IPCC (2007), chapter 17.
[6] UNDP (2010a).

Economic instruments, if adequately set up and properly administered, give resource users a continuous incentive to use natural resources in the cheapest way. They provide incentives not only to reduce emissions over time but to look for efficient ways of using natural resources through developing new technologies.

In the short run, the scope of adaptation measures is constrained by a fixed capital stock (e.g. physical infrastructure such as irrigation systems), entailing that the main options are limited to variable inputs to production (e.g. switching of crop variety or changing planting dates). Investments in fixed capital stock require in general a longer planning horizon and an assessment of the associated costs and benefits.[7]
In general, countries have used their National Communications to UNFCCC as a platform for developing such a baseline. The Framework Convention has also encouraged countries to establish national adaptation programmes of action. These programmes could provide a synthesis of information on climate vulnerability and natural-disaster risk, as well as identify and prioritize key adaptation measures.

Because of the insufficient knowledge about adaptation, no solid information frameworks for adaptation decisions can be established. This also reflects the large uncertainties concerning subnational climate change impacts due to the insufficient geographical resolution of climate change models. It's therefore important to draw up strategies that combine national and sectoral development objectives and adaption measures—so-called "no-regret options".

B. The role of national innovation systems

Technological innovations have become increasingly central to the competitiveness of firms and are a major driving force of countries' economic development. Against the background of rising environmental pressures, the development of more environmentally friendly goods, services and means of production ("green technologies") has become a dynamic growth market in the world economy. This also includes technologies to mitigate climate change and improve the adaptation of economies and societies to climate change impacts. Examples are solar and wind power, green buildings and innovative irrigation technologies.

From an economic perspective, the term "technology" refers to the total available knowledge concerning the means and methods of producing goods and services. The development of technology is increasingly science-based, and besides physical techniques also comprises acquired skills, practices and methods of organization.

The key for innovative processes are the interactions, i.e. the flows of information and technology, among people and institutions in developing, diffusing and applying innovations. They could be enterprises, universities and government research institutes.[8] These formal and informal networks constitute what has become known as a "national innovation system". Major outputs of the system are knowledge, increased capabilities and innovative technologies. A national innovation system provides an enabling framework for adopting already existing technologies and developing new ones by facilitating knowledge spillovers.

In general, a national innovation system comprises specialized innovation systems for major sectors such as energy, transport, construction and agriculture. Against the backdrop of

[7] Stern, N. (2007).
[8] OECD (1997).

climate change and the implications for food security, attention has been drawn to the need to develop "sustainable agricultural innovation systems" notably in developing countries.[9]

The major stages of the innovation process are research and development (R&D), market development and diffusion of technologies. Because of the public-goods nature of knowledge, in addition to the risks and uncertainties involved (notably of green technologies), government support for private-sector R&D is often essential.

Knowledge spillovers can, for instance, be promoted by cooperation among universities, public research institutes and enterprises; by establishing local science parks (an agglomeration of enterprises, universities, research institutes, laboratories etc.); and cooperating with foreign research institutions. An effective domestic educational system is essential for building the skills necessary for the various stages of the innovation process.

In general, lower-income countries (including countries in Central Asian) will have to rely heavily on imported technologies. The main traditional channels for this technology transfer are international trade (imports), FDI and licensing. Stringent intellectual property rights legislation is a central condition for technology transfer. These foreign technologies will have to be adapted to local circumstances, hence the importance of having domestic R&D capacities for acquiring knowledge developed elsewhere. This is especially relevant for climate change adaptation technologies, where local contexts matter greatly, such as in the agricultural sector.

Given the local nature of adaptation, it is important to ensure local empowerment and participation. Most innovations are not technological breakthroughs but rather incremental improvements in already existing knowledge and products.

For small countries such as Turkmenistan, inward FDI and knowledge flows, extensive international collaboration and engagement in research networks can overcome constraints due to lack of a critical mass of resources for innovating. But this doesn't substitute for strong investments in the national R&D and educational system and the search for successful niche strategies.[10]

C. Categories of adaptation technologies

Adaptation technologies comprise all technical equipment, techniques, practical knowledge and skills that reduce the vulnerability, or increase the resilience, of a natural or human system to the impacts of climate change. Based on this generic definition three main categories of adaptation technologies can be distinguished: hard, soft, and organizational.[11]

Hard technology: technical artefacts such as machinery and equipment (e.g. a sprinkler irrigation system; earth observation systems) and physical infrastructure (e.g. dykes, seawalls).

Soft technology: (social) information (know-how for production and use of hard technology), experiences and practices, capacity-building, policy and strategy development.

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[9] See, for example, United Nations (2011), *World Economic and Social Survey 2011 – The Great Technological Transformation*; UNCTAD *Technology and Innovation Report 2010*; FAO, *Developing a climate-smart agriculture strategy at the country-level: Lessons from recent experience*. 2012.

[10] Roolaht, T. (2012).

[11] Clements, R. et al.

Organizational technology: legal and institutional arrangements that support and complement the use of hard and soft technologies at the national or local level (e.g. building codes for infrastructure; local water user associations that ensure sustainable water use on their farms; legislation for the application of water tariffs).

Table 1 shows some further examples for these three technology categories for different sectors.

Table 1.
Examples of adaptation technologies, by main sector

Sector	Technology type		
	Hard	Soft	Organizational
Agriculture	Crop switching	Farming practices; research on new crop varieties	Local institutions (farmers' associations)
Water resources	Ponds, wells, reservoirs, irrigation systems	Improved water use efficiency; water recycling	Water user associations; economic instruments (water tariffs)
Coastal zones	Dykes; seawalls; tidal barriers	Development planning in exposed areas	Building codes; early warning systems; insurance
Health	Vector control, vaccination, improved water treatment and sanitation	Urban planning, health and hygiene education	Health legislation
Infrastructure	Climate proofing of buildings, roads and bridges	Knowledge and know-how	Building codes and standards

Source: Christiansen, L. et al. (eds.) Technologies for adaptation. Perspectives and practical experiences. November 2011. UNEP Risø Centre.

IV. Adapting to climate change

A. Policy framework

Turkmenistan signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995. It also ratified the Kyoto Protocol as a non-Annex I country in 1999. The first national communication to the UNFCCC was submitted only in 2006; the second in 2010.[12]

National communications are intended to provide information on national circumstances concerning climate change related issues, including an assessment of vulnerability and possible measures (adopted, suggested or planned) for contributing to climate change mitigation and for adapting to climate change impacts.

In June 2012, the Government adopted a National Climate Change Strategy that covers mitigation and adaption issues. The Strategy is to be implemented on the basis of a National

[12] Turkmenistan as a non-Annex I country has no fixed dates for submitting national communications to the UNFCCC.

Action Plan, which is still to be developed. It's envisaged to mainstream mitigation and adaptation measures in development strategies for economic sectors, notably the water and agricultural sectors.

The Strategy also mentions the need to promote scientific research and technology development work as well as assessments of climate risks. An inter-sectoral, interdisciplinary coordination mechanism for implementing the *Strategy* will be established, which will comprise representatives of ministries and State agencies.

The adaptation measures are identical to those proposed in Turkmenistan's Second National Communication to the UNFCCC. These are composed of the three technology types already mentioned. The Strategy is divided into a short-term plan (until 2020) and a long-term plan (until 2030) but is not specific on how the identified measures will be spread over time.

It will be financed from a National Clean Climate Fund, which is planned to be supported from State budget resources and foreign donors. It's been estimated that adaptation costs in the water sector (with a focus on irrigation water supply for agriculture) could amount to some $5 billion compared to a baseline investment (traditional infrastructure rehabilitation and modernization) assumed to amount to some $10.5 billion over the period from 2009 to 2030.[13] Given the uncertainties and the fact that the estimates are not related to specific planned measures, these figures should, however, be taken with a pinch of salt (table 2).

Table 2.
Adaptation costs for the water-resources sector in Turkmenistan
(Billions of United States dollars)

Activity	Baseline scenario	Adaptation scenario
Improving efficiency of existing irrigation methods	6.5	8.2
Introducing advanced irrigation techniques	1.8	4.4
Increasing water resources	0.8	1.4
Rehabilitating and extending water reservoirs	0.8	1.3
Improving water management and agricultural production patterns	0.6	..
Total above	**10.5**	**15.4**
Total water savings (billion m^3)	4.2 – 5.5	7.3 – 8.5

Source: Atamuradova, I. (2010).

B. *Identified adaptation technologies and measures implemented*

The Strategy identifies a range of hard, soft and organizational technologies planned for various sectors (table 3). Given the geographic position and natural climatic conditions of Turkmenistan and the overall importance of agriculture, a major focus is on measures to address the scarcity of water resources and the exposure of agriculture to drought, heat and soil erosion.

[13] Atamuradova, I. (2010).

In the water sector, the proposed measures include:

1. Introduction of innovative irrigation technologies (such as sprinklers and drip irrigation)
2. Rehabilitation and extension of existing irrigation network, including water reservoirs, pumping stations, and desalinization facilities
3. Continuation of the construction of the artificial Turkmen lake
4. Development of tools that create incentives for rational water use.

In the agricultural sector, they include:

1. Switching to heat-, drought and salt-resistant crops
2. Switching to less water-intensive crops
3. Changing the farming practices (crop rotation; nutrient management).

Little information exists on the national adaptation measures taken so far. A range of measures have been taken during recent years that focused largely on raising agricultural productivity and increasing the efficiency of water use mainly by reducing water losses in the irrigation network. But these measures were not embedded in an explicit adaptation strategy.

Table 3.
Suggested adaptation technologies for Turkmenistan

Sector	Measures
Water resources	- Improving water management - Introducing advanced irrigation methods - Constructing water-storage reservoirs and modernization of hydraulic engineering structures - Continuation of construction of Turkmen Lake - Incentive tools for rational water consumption - Strengthening international cooperation on conservation and use of transboundary waters.
Agriculture	- Optimizing spacing/allocation/distribution of agricultural production facilities - Specialization of agricultural production (crop varieties) - Conducting selection work to breed drought-resistant and salt-resistant crops - Conducting phytomelioration work - Introducing strict rotational pasture use; promoting the formation of pasture protection belts consisting of fodder dendro-shrubby plants -Developing pasture farming -Introducing methods and practices so that crops can be harvested several times a year
Land-use efficiency	- Adopt a new law on pastures to prevent degradation of pastures - Prepare a detailed soil and land inventory -Combat soil salinization, pasture degradation and desertification - Control engineering projects that risk to deplete productive soil layers -Introduce measures designed to improve the status of usable lands -Improve crop farming culture.
Public health	-Prepare scientific assessment of the health effects of high air temperatures in different regions of Turkmenistan -Develop preventive programs to reduce adverse health impacts -Develop specific recommendations for behaviour of population under conditions of heat waves -Develop a national report to assess the impacts of climate change on public health.

Sector	Measures
Forestry	Develop a national forestry programme, including an improved forest inventory system -Expand the forest coverage area and the protected area systems -Improve mechanism for economic incentives designed to ensure rational use of foreistry
Monitoring of extreme weather conditions	-Improve monitoring systems and forecasting systems for hazardous weather phenomena; early warning systems; adaption of construction standards to ensure resilience of infrastructure to hazardous weather events. -Develop insurance systems for climatic risk insurance.

Source: National climate change strategy of Turkmenistan (approved on 15 June 2012).

Thus, the amount of land for growing cotton, a very water-intensive crop, was greatly reduced—by more than 100,000 ha—in recent years. But rehabilitation of degraded lands has led to increased productivity. Crop rotation has been used in some parts of the country to improve soil quality. And measures have been adopted to develop water-saving technologies (e.g. production of plastic pipes for drip irrigation, as well as pilot projects on drip irrigation).[14]

The Government has also recently allocated large budget resources to rehabilitating the water-sector infrastructure that is supporting the large-scale collective farming of cotton, wheat, rice and sugar beet. There is no information available on the amount of financial resources, type of technologies, or the cost-effectiveness of these measures. But they appear to be largely insufficient for closing the projected water supply deficit.

A major role in the Government's strategy to increase irrigation water supply is played by the use of saline drainage water from the agricultural sector, which, in the past, was discharged into the Amu Darya. The Government has built collectors to divert the saline drainage water into an artificial Lake Altyn Asyr (also called Turkmen lake) located in the middle of the Karakum Desert. The water accumulated in the lake (with a surface of 3,500 km^2 and a planned capacity is 130 km^3) will be recycled for irrigation after desalination treatment. This lake could make 4,000 km^2 of surrounding land viable for agriculture.

But the inflow of water is slower than expected and there are concerns about adverse environmental impacts due to the massive irrigation with even low-salinity water.[15] The main potential beneficiaries from this system are State farms that produce cotton and wheat. The construction of the Turkmen lake, which is now part and parcel of Turkmenistan's climate change strategy is continuing and is expected to be completed by 2020.

A major problem that has not yet been addressed is the absence of incentives for farmers to use water more efficiently, as the country has no volumetric tariff for use of irrigation water. Only a small fee has to be paid to the State agency that manages the irrigation network for repair and maintenance work. Private households and enterprises pay no water charges. Despite its increasing scarcity, water continues to be viewed as a "free commodity".

Turkmenistan has no effective legal framework for integrated water resources management (IWRM). IWRM goes beyond the maintenance of water resources and related infrastructure and aims to integrate economic, social and environmental concerns in water resources management.

[14] Sapamuradov, K.; and UNDP (2012),
[15] FAO (2012a); UNECE (2012).

And the potential role of water users associations in achieving more sustainable use of water has still to be addressed. These associations are based on contractual arrangements between farmers who exploit the same hydrological subsystem concerning the maintenance of the irrigation and drainage system, which is supported collectively by means of various inputs (capital, labour, knowledge).

C. International cooperation and support

Turkmenistan has participated in regional and global projects funded by international donors (such as ADB, FAO, GEF, UNDP, Finland, Germany, Norway, Switzerland, United States). These projects have focused on capacity-building in various areas related to climate change, including adaptation. At the recent Rio+20 meeting, Turkmenistan proposed establishing, in cooperation with the United Nations, a special Regional Climate Change Centre, which could be located in Ashgabat. The Government has offered to provide the entire necessary infrastructure for its operations. The Centre, which doesn't yet have a mandate, could provide the platform for the exchange and transfer of knowledge among enterprises, academia and government from both inside and outside the region.

Turkmenistan is a member of the Asia Pacific Adaptation Network (APAN), a regional programme for managing and sharing knowledge and best practices on climate change adaptation. It's also a member of the Central Asian Countries Initiative for Land Management (CACILM), which tries to combat land degradation due to desertification and promote sustainable land management.

In principle, such regional networks offer many opportunities for knowledge exchange given the broadly similar climate change impacts in the various countries. But Turkmenistan's involvement in regional cooperation appears to be very limited.[16] It may be indicative that Turkmenistan is the only country that's not covered by a recent review of climate adaptation practices in central Asia prepared by the Regional Environmental Centre for Central Asia (CAREC).[17]

The Government has so far not addressed the water needs in the non-State agricultural sector, which is dominated by small-holder farmers. A project recently launched by the United Nations Development Programme (UNDP)[18] focuses on developing community-level water-management approaches in selected regions with significant potential for diversified non-State agriculture, horticulture and livestock management.

While the main emphasis is on measures at the local level, the project also aims at reforms of national legislation (water code and secondary legislation), in order to allow scaling up the measures taken at the community level. This pertains notably to reform of water tariffs in order to create adequate incentives for water savings across all user types. The project has a budget of $2.93 million.

UNDP (with the financial support of the Global Environment Facility) has recently launched a project on "Improving energy efficiency in the residential building sector of Turkmenistan". It is being implemented together with the state enterprise "Turkmengas" and covers building

[16] Bizikova, L. et al. (2011).
[17] CAREC, Review of the climate adaptation practices in Central Asia (January 2012).
[18] "Addressing climate change risks to farming systems in Turkmenistan at national and community level". A US$ 2.93 million project.

codes, legislation to support energy-efficient construction as well as the development of know-how for energy-efficient construction.

V. National innovation system

A major determinant of the adaptive capacity of countries is the capability to adopt innovative (mainly hard) technologies that will reduce environmental pressures (including abatement of GHG emissions) and help to cope with climate change impacts. A central challenge is adapting these generally global technologies to the specific national and local contexts. The national innovation system, however, is rather opaque and there's little publicly available information on its activities and outputs.

A. R&D and education

The R&D and educational systems were greatly set back by the regressive policies pursued by the former President Niyazov during the 1990s and the first half of the 2000s. Financial and human resources were cut back drastically. In 1997, the Academy of Science, the backbone of research at that time, was abolished and replaced by the Supreme Council for Science and Technology, a political body under the President.

Most research institutions, as well as research and educational programmes such as PhDs, were closed down. These measures eroded the national R&D base, which was reflected in an increasing shortage of qualified teachers at national universities and qualified local professionals in sectors such as agriculture, energy, communication and large-scale infrastructure projects.

The mandatory duration of education was reduced from 10 to 9 years. Textbooks were out-dated, and subjects such as arts and foreign languages were abolished. The number of teachers was cut back, leading to overcrowded classes. The minimum period of instruction at higher education institutions was reduced from five years to two. Higher education was made subject to payment without any concern about how low-income families might be able to afford it. Degrees earned by Turkmen students at foreign universities were no longer recognized. The school infrastructure remained in poor condition.[19]

The new Government, which took office in late 2006, recognized the overriding importance of a performing R&D and educational system for Turkmenistan's economic development. The Academy of Science was re-established in 2009, research institutions have been rebuilt and PhD programmes reintroduced.

In 2009, the new President defined a range of priority areas for research, including (from an environmental and climate change perspective) alternative energy sources, seismology, town planning, environmentally sound production technologies, rational use of land and water resources, and efficient use of natural resources. The priorities also include the fostering of regional and international cooperation by means of integrating into regional and international research networks; and the creation of an environment conducive to transferring technology from developed countries (based, for example, on FDI).

The R&D sector in Turkmenistan is dominated by State institutions. Recent reforms have also provided a legal base for the involvement of SMEs in research activities, but the modalities

[19] Turkmenistan's education system in downward spiral. 4 May 2004. www.eurasianet.org

have not been specified. No information is publicly available on private-sector involvement, if any, in R&D.

The Academy of Science is fully funded from the State budget and comprises 11 scientific research institutes (table 4). The government sets the broad research directions of all these institutions. The main goals of the Academy of Science are to support the government policies in R&D and education. This includes coordinating the research activities of higher education institutions. In 2012, the President established a special foundation for supporting young scientists in engineering research.

There are, moreover, a number of sectoral research institutes which are subordinated to the corresponding branch ministries or other State bodies, which determine the corresponding research priorities (table 4). A new National Space Agency was established in 2009, which should promote, among other things, the development and application of information and communication technologies.

Table4.
Scientific research institutes under the Academy of Science

- Institute of Seismology
- State Seismological Service
- Botanical Institute
- Sun ("Gyun") institute
- Institute of Physics and Mathematics
- National institute of Herbs of Turkmenistan
- Institute of Archaeology and Ethnography
- Institute of Manuscripts of Turkmenistan
- Institute of Language and Literature
- Institute of History

Source: www.increast.eu/en/189.php

Table 5.
Scientific research institutes under government ministries or State agencies

Ministry/Agency	Research institute
Ministry of Health	Scientific Centre of Oncology
Ministry of Education	Institute of Education
Ministry of Agriculture	Cotton-growing Research Institute Farming Research Institute at the Agricultural University
Bakeries Association of Turkmenistan	Research Institute on Grain Crops
Ministry of Oil, Gas and Mineral Resources	Geological Prospecting Institute
Ministry of Water Management	Turkmen State Institute for Water Economy
Ministry of Nature Protection	National Institute of Deserts, Flora and Fauna
State concern "Turkmengas"	Oil and Gas Institute
State concern "Turkmenoil"	Institute of Turkmennebitylymtaslama
Ministry of Construction and Construction Materials	Institute of Antiseismic Construction

Source: IncrEAST – Turkmenistan Country Report (last updated 19 March 2012). [www.increast.eu].

There's no publicly available information on the human resources in the R&D sector and government spending on major R&D activities. There are also no publicly available activity reports of all these research institutions. Research on climate change and its impact has been conducted at academic institutions such as the Turkmen State University, the Turkmen University of Agriculture, the National Institute of Deserts, Flora and Fauna, the Scientific Research Institute of the Ministry of Water Economy and the Service of Land Resources of the Ministry of Agriculture. But this research work has generally been of a limited scope.[20]

Statistics from the World Intellectual Property Organization (WIPO) show that 137 patent applications and patent grants were recorded for during 1997-1999, of which about half by non-residents. There were no patent applications and grants between 2000 and 2006, and less than a handful between 2007 and 2011 (table 6).

Table 6.
Patent applications and patent grants in Turkmenistan

Year	Patent applications		Patent grants	
	Residents	**Non-residents/abroad**	**Residents**	**Non-residents/abroad**
1997	52	50/0	154	52/0
1998	41	16/0	45	89/0
1999	44	5/0	32	63/0
2000-2006	0	0	0	0
2007	1	0	1	0/8
2008	0	0	0	0
2009	1	0	1	0/8
2010	0	0	0	0/1
2011	0	0	1	0/8

Source: WIPO. Statistical country profiles – Turkmenistan.
www.wipo.int/ipstats/en/statistics/country_profile/countries/tm.html
Note: Resident filings refer to domestic filings by national residents; non-residential filings refer to domestic filings by foreigner. Filings abroad refer to filings by the country's citizen at a foreign patent office.

The "Gyun" (Sun) Institute, which was established by the Academy of Science, has since 2009 been cooperating with European experts to develop the requisite engineering skills and technology for the use of solar power in Turkmenistan. European experts have been providing distance learning, skill transfer and solar cell performance monitoring using the CAREN and pan-European GÉANT research networks. The aim is to make the Institute a centre of excellence for the emerging renewable energy sector in central Asia. The Institute has already trained more than 700 people.[21]

In 2012, an industrial techno-park was being constructed near Ashgabat. It is designed to conduct work in alternative energy sources (solar, wind), nano-technologies, information technologies and the application of new technologies in production processes. The

[20] UNECE (2012) p.169
[21] CAREN helps harness Turkmenistan's sunshine. http://caren.dante.net.

Government has also established an Academy of Civil Service in 2009 to upgrade the skills of government employees to better support the national development strategies.

Planned legislative reforms to promote the development of public-private partnerships appear not to have advanced very much.

Compulsory education was re-established at 10 years as from school year 2007/2008. A new Law on Education that entered into force in August 2009 formed the basis for a fundamental reform of the educational system. It also allows for the establishment of private educational institutions and provides for the possibility of distance-learning (by correspondence and online). In March 2013, the Government decided to increase the compulsory education period from 10 to 12 years. Observing an increasing admission rate of Turkmen students within and outside the CIS, a Presidential decree of July 2010 was issued, that has an effect to restrict Turkmen students' international mobility.

Overall, the improvements in the educational system have so far been only partial and slow. This is also reflected in the Presidential decree of early 2012 designed to develop standards for the "comprehensive reform of the national education system and improving teaching methods".[22]

The Government has also begun to upgrade the infrastructure of the educational system, including the equipment with computers and technical equipment. The Ministry of Education, in cooperation with the United Nations Children's Fund (UNICEF) has developed curriculum guides for mathematics, geography and vocational education with new approaches in content development, teaching and testing.

The quality of education in Turkmenistan does not compare favourably with that of other countries in the region, reflecting for instance the use of traditional teaching methodologies. There's a shortage of qualified teachers, and teacher retention is also a big problem, notably in rural areas.

Turkmenistan is also reforming its higher and vocational education through introducing new technologies. UNICEF (2010) notes that young people have to cope with limited employment opportunities and a lack of access to technology. Internet availability within the country is very low. Computer literacy among young people is limited.

Entrepreneurial education is also limited due to the fact that many teachers at State educational institutions don't have the requisite knowledge and experience. But there is a nascent market for private business educators and trainers coming from the pool of qualified personnel employed in the private sector.

The higher education institutions are State-owned and governed by the Cabinet of Ministers. The minimum length of university programmes was restored to five years (six for medicine). The number of places is limited, making admission highly competitive. The share of university graduates in total employment is correspondingly negligible; but there are no publicly available statistics.

[22] Turkmenistan: Is this the education reform we can believe in? www.eurasianet.org/node64918.

B. Intellectual property rights

Innovation, economic growth and intellectual property rights (IPR) are closely interrelated. Intellectual property rights can be important both for domestic technological developments and for access to foreign technologies (technology transfer). In 1995, Turkmenistan signed the World Intellectual Property Organization (WIPO) documents on industrial property rights and patent cooperation. It is also a member of the Eurasian Patent Organization, which was established as part of WIPO for the Commonwealth of Independent States. But it has not signed the WIPO Copyright Treaty or other WIPO treaties such as the Internet Treaty.

The legal framework for intellectual property rights in Turkmenistan has been reformed in recent years with the Law on Inventions and Industrial Design and the Law on Trademarks, Service Marks and Places of Origin, both of which entered into force in 2008. (These two laws replaced the Patent Law of 1993). A new Law on Legal Protection of new varieties of plants was adopted in 2011. In 2012, Turkmenistan adopted a Law on Copyrights and Related Rights. It went along with an amendment of a separate section of the Civil Code, which was entitled "Author's Rights" but is now entitled "Legislation on intellectual property". It provides an outline for the legislative base of the entire intellectual property area, including copyright and related rights, database rights, patents, industrial designs, trademarks and commercial names.[23]

In March 2012, the Government established a new State Agency for Intellectual Property, which will operate under the Ministry of Economy and Development.[24] It will take over patent registration and related matters from a special patent department at the Ministry of Economy and Development. (A Patent Agency established in 1993 was abolished in 2008.) The Agency is expected to become operational in 2013. It has been designed to align the national IPR system with international standards and guarantee the effective protection of IPR.

The IPR regime has been suffering from significant deficiencies; and adherence to the legal provisions has been weak. (Selling of counterfeit goods is a pervasive phenomenon in Turkmenistan). In principle, the Law on Foreign Investment of 2008 guarantees the protection of the IPR of foreign investors, including artistic and scientific works, software, patents and other copyrighted items. But no effective administrative or civil procedures or criminal penalties exist for IPR violations.

C. International cooperation in R&D and education

A major avenue for upgrading the science and technology sector is international cooperation. Turkmenistan has signed over 30 bilateral agreements on cooperation in education, science and technology, mostly with CIS countries. There has been extensive bilateral cooperation with higher education institutions in the Russian Federation. International donors, such as UNICEF, UNDP, EU, Asian Development Bank, Islamic Development Bank, GIZ (the German Society for International Cooperation), Japan International Cooperation Agency (JICA) , Norway, Fulbright Foundation, USAID have provided support for capacity-building, with a focus on reforming and modernizing the educational and R&D system.

[23] Petosevic (2013),"Turkmenistan amends IP legislation". February 23, 2012. www.petosevic.com/resources/news/2012/02/000871.
[24] Idem.

EU Tempus programme. Projects under this programme[25] have been promoting innovative education for sustainable agro-industrial and rural development, covering areas such as sanitary control of water, air and soil. Tempus has also promoted international cooperation between Turkmen universities and similar institutions in neighbouring countries, as well as in the EU.

One of the Tempus projects provided academic support for developing solar cell technology in Turkmenistan, which is among the high priorities of sustainable-development policies. This was associated with the creation of an educational platform through a master's-level curriculum and the development of ICT-supported teaching programmes.

CAREN. Turkmenistan has been participating in the EU-funded Central Asia Research and Education Network (CAREN) since July 2010. The Network has notably established a Turkmen Education Research Network with high-speed access to the Internet. CAREN promotes the strengthening of educational and scientific-research connections between researchers from Central Asia and Europe by means of a high-capacity regional Research & Education network based on broadband Internet. It also provides access to the pan-European research and education network (GÉANT), which interconnects Europe's national research and education networks. CAREN replaced the former satellite connections established by the Virtual Silk Highway project and funded by NATO.

Under the Virtual Silk Highway project, a Turkmen research educational national (TURENA) network had been created in 2003. It comprises educational universities, scientific research institutions, colleges and secondary schools and public R&D institutions. The network, which interconnects to CAREN, is managed by the Academy of Sciences. The aim of the project has been to significantly increase the exchange of information with and between academic and educational institutions in the Caucasus and Central Asia.

VI. Conclusions and recommendations

So far, the attention paid by the Government to climate change issues has been modest, and Turkmenistan is only just beginning to address such issues. An institutional framework (policy design, coordination and monitoring) for managing them in an integrated and comprehensive manner has still to be built.

Climate change hasn't yet been effectively integrated into national and sectoral development strategies. The country still needs a national adaptation action plan that defines priorities for concrete measures to be put in place and which should be based on a robust assessment of technology needs.

The adaptive capacity to address climate impacts is low. Major barriers to adaptation include the lack of skilled human capital and expertise, limited R&D capacity, lack of financial resources, and systemic constraints. Thus, current assessments of climate change vulnerabilities in Turkmenistan lack sufficient data. Very limited resources for climate modelling and analysis are allocated to the National Committee for Hydrometeorology, the main State institution for climatic observation.

[25] Tempus is an EU programme that supports the modernization of higher education in the Partner Countries of Eastern Europe, Central Asia, the Western Balkans and the Mediterranean region, mainly based on cooperation projects.

An important potential role could be played by the national innovation system for developing and deploying innovative environmentally sustainable technologies that would promote general economic development, including effective climate change adaptation and mitigation. But the information base for assessing the performance of the national innovation system is still inadequate.

Little if any information is publicly available on climate-related research on agriculture and water use, although these sectors are especially affected by the changing climate. And little is known about the deployment of relevant technologies and the problems encountered and the experience gained with adapting technologies to local circumstances.

However, the Government has taken measures to upgrade both the science and technology sector and the education sector. Enhancing and upgrading the adaptive capacities will require adequate investment in the national innovation system to strengthen the capabilities for the smooth adoption and deployment of new technologies. It will also require promoting technical collaboration with countries facing similar problems.

Participation in regional-cooperation projects should therefore be strengthened, as these projects offer a platform for exchanging knowledge. The capacity of human resources in government services will need to be upgraded to integrate climate adaptation into the planning of government activities across major economic sectors, including for accumulating expertise and building skills for climate projections and impact assessments.

Legal and institutional reform will be needed. An effective legal framework for intellectual property rights (and their implementation) helps to create a favourable environment for FDI, entrepreneurship and innovation. Promotion of foreign private-sector participation in infrastructure and utility services (and the associated transfer of knowledge) —within the framework of public-private-partnerships—will require a solid legal basis for concession arrangements.

Policies must encourage the sustainable use of natural resources. Irrigation water is currently seen as a free resource for farmers. This provides no incentive for water savings, even when innovative irrigation technologies have been installed. And production targets imposed on collective farms lead to over-irrigation of crops and lack of flexibility in changing crop varieties.

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