Mongolian Master Plan for Science and Technology

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Prepared for UNESCO, Ulaanbaatar, and the Mongolian Ministry of Education, Culture and Science

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Executive Summary

The purpose of this report is to provide an overview of Mongolian S&T and recommendations for action for the forthcoming National Master Plan on Science and Technology, deriving from the working visit of the international expert to the Ministry of Education, Culture and Science (MECS) between July 18 – August 3 2005. The visit was supported by UNESCO and MECS and its main purpose of the visit was to advise MECS's Department of Science and Technology in methodological issues related to obtaining appropriate S&T indicators as well as providing general guidelines on the development of the Master Plan and particular policy suggestions deemed appropriate in the national context.

A series of consultative meetings took place with key actors in S&T that included the MECS's Department of Science and Technology, the Institute of Physics and Technology of the Mongolian Academy of Sciences (MAS), the Institute of Chemistry and Chemical Technology (MAS), the Odon Oron Centre for Geophysics (MAS), Institute of Veterinary Medicine (University of Agriculture), the Hunstech Corporation of Food Research and Production, the Electronics and Machine Research Corporation, and the Mongolian University of Science and Technology.

One of the main outcomes of the visit was the creation of a comprehensive list of S&T indicators where available sources provided reliable, internationally comparable data (see Annexes 1-6) and a list of recommendations to be included in the Master Plan. The recommendations were previously discussed with the Department of Science and Technology to ensure a pragmatic approach to national relevance and include:

1. Creation of a full survey of private sector involvement and expenditure in R&D that represents the most important missing aspect in national S&T statistics
2. Prioritisation of the area of Technology Transfer as a means to capitulate on the existing S&T capabilities that lack product exploitation strategies
3. Re-structuring of the national scholarship programmes to reflect priority needs in sector training and lack of personnel in particular areas
4. Enhancement of Industry-Academia-Government collaboration and promotion of commercialisation of R&D results
5. Creation of a national Science and Society programme with emphasis on issues of public awareness and ethics and responsibility
6. Establishment of an independent Technology Assessment Institute as the main policy advisory body in S&T
7. Promotion of a national Foresight programme in priority areas particularly in agriculture and mining sectors
8. Expansion of the role of the National Science Foundation to include assessment of institutional outputs
9. Re-structuring of the national funding mechanism to include evaluation of research outputs
10. Establishment of a Working Group under the National Council at Departmental level to coordinate actions amongst Ministries and evaluate the progress of the Master Plan

The following report elaborates on these points and provides a first analytical overview of the data generated during the visit.

Introduction

The visit of the international expert, Dr Miltos Ladikas, University of Central Lancashire, UK, took place on July 17 – August 3 at the Department of Science and Technology of the Mongolian Ministry of Education, Culture and Science (MECS) in Ulaanbaator. MECS provided a working space at the Department amongst the team responsible for the creation of the national Master Plan on Science and Technology. The team consisted of Mr. Ganbat Bulgaa, Dr. Khurelbaatar Begzsurengiin, Ms Bayarmaa Dashjamts and Mr Amarbayasgalan Nyamdorj that together with the international expert worked out a series of steps regarding the structure and content of the Master Plan. A series of interviews with key people from national research institutes and universities (as described above) provided additional information that helped the development of particular policy recommendations that will descried in detail below.

There have been two previous visits by teams of international experts in Mongolia related to science policy issues and the Master Plan. The first visit by a team of experts from the United Nations Development Programme (UNDP) took place in 1993 and resulted in a report with policy recommendations ranging from decision making structures to specific research institutes functionalities. Some of the key recommendations were taken up by the Mongolian government, prominent amongst them being the creation of a National Council of Science and Technology at Ministerial level. The second mission by a team of experts from STEPAN Australia was lead by Prof. Tim Turpin and took place in 2003. The final report gives a detailed overview of the Mongolian science sector and develops a series of recommendations targeting science policy structures. This report is focusing mainly on the development of the Master Plan.

Both reports were very important and informative for the work involved in this visit. The current report aims to build on them and offer additional perspectives, particularly in the areas of expertise of the author. The three reports should be read as complimentary pieces of work since they have different focus and aims. The UNDP and Turpin reports provide advice to the government on their policy in S&T, this report provides advice to the unit creating the first draft of the Master Plan. The statistics generated during the working visit will be used as background information for the creation of the Master Plan and furthermore for the creation of any action plan in specific sectors that might derive from it. Here, we will offer a general sketch of S&T in Mongolia based on these statistics while their use in the Master Plan should be more detailed, contextual and relative to other information that will be gathered by the Master Plan team from various Ministries and the private sector as agreed.

The report will is divided into three main parts. The first part provides general contextual information on Mongolia in terms of economics, education and S&T decision making structures. The second part focuses on S&T indicators. The third part provides a series of policy recommendations for potential inclusion in the Master Plan.

PART I – GENERAL INFORMATION

1.1 Introduction

Mongolia is a land-locked country located between Southern Siberia in Russia and the Chinese provinces of Sinkiang and Inner Mongolia. The population of Mongolia is 2.5 million and its total land area is 1.56 million sq km, making it one of the most sparsely populated countries in the world (1.4 persons per sq km). The average elevation is 1600 meters and its climate is semi-arid, continental with very cold winters and short, hot summers. Average life expectancy is 64.5 years.

During the last two decades, urbanisation has been rapid and uncontrollable. This appears to be the result of loss of traditional markets for farmers, a series of particularly harsh winters that resulted in unprecedented loss of livestock for the rural communities, but also the creation of rapid wealth in particular sectors of the urban economy (construction, ICT, banking, retail, etc.). At present the population of the capital is estimated at over 900,000 (30% of the total population) although the correct figure could be higher due to lack of reliable figures. More than 50% of the Mongolian population is under the age of 15 and the annual population increase is relatively high at about 2.8%. The combination of population expansion and uncontrollable urbanisation has resulted in severe strains to basic infrastructure, health care and social welfare.

The United Nations Human Development Report ranks Mongolia on the Human Development Index in 117th place along with a group of countries including Vietnam, Tajikistan, South Africa and India.

1.2 Economic Transition

Mongolia adopted communist in 1924 and remained closely aligned to the ex-USSR until its collapse in the mid eighties. Mongolia was heavily dependent on the USSR for aid and trade that gave the country preference trade status and subsidies in basic amenities and energy sources. The demise of USSR had catastrophic consequences for the Mongolian economy since its main trading partner disappeared overnight. The economic transition from a centrally controlled market system to a market economy happened in the space of few years. The result was uneven expansion in economic sectors, the creation of a "parallel" economy and increase in tax evasion and corruption. It is estimated that the parallel economy is at least as big as the official economy resulting in significant loss of public revenues.

The GDP of Mongolia is about $1.1 billion of which $260 million is foreign aid resulting in one of the highest ratio of per capita aid in the world (and the highest rate for post-socialist countries). Per capita aid in Mongolia is $99 compared to an average of $13 for low income countries. Budget deficit runs at 4.5% of GDP and official unemployment rate is 4.7% of the total workforce. The agricultural sector's contribution to GDP is one of he highest in similar post-socialist and developing countries but it is constantly decreasing in recent years. Worryingly, the industrial sector's contribution has also decreased recently reaching a below average level for low income countries. Inflation has been under control in recent years, reaching 4.7% in 2003 from highs of 66.3% in 1994.

Foreign Direct Investment has boomed in the last decade increasing from .8% of GDP in 1995 to 11% of GDP in 2003. Compared to similar post-socialist countries such as the Commonwealth of Independent States (CIS) Mongolia receives on average more foreign investment and it even surpasses some countries from Eastern Europe. Most FDI is directed to the mining sector (37% of total) followed by trade (13%) and petroleum (11%).

The main export trading partners of Mongolia nowadays are China (with 45% of total exports) and USA (22% of total exports). Mongolian exports to Russia have collapsed from 30% of total exports in 1994 to 6% in 2003. The main export products of Mongolia are mineral products (mainly copper, flourspar and coal) and textiles (mainly cashmere and wool products); they both account for 80% of total exports. In terms of high-technology exports Mongolia has a low ratio in international comparisons with similar economies. The main import products are minerals (mainly oil), textiles and transportation vehicles. Mongolia runs an annual trade deficit of approximately $200 million. Both exports and imports represent a disproportionate percentage of GDP (67% and 80% respectively) compared to similar post socialist and low income countries which average 21% and 23% respectively.

1.3 Education

The educational level of the Mongolian population is high, particularly compared to other developing countries of same income level. The average Mongolian has 8.4 years of formal schooling and primary school attendance reaches 90% of the population in recent years, a considerable achievement considering the geography and climate of the country that pose great strains to rural education. Nevertheless school dropout thereafter increases constantly, particularly amongst boys in rural areas thus, creating an unequal gender ratio in education: at high-school level school attendance for females is 14% higher than that of males.

In higher education, changes have been dramatic in the last 15 years. The economic transition to market economy and the fall of public revenues put a stop to free higher education and necessitated the introduction of tuition fees in public higher educational institutions. At the same time numerous private institutions appeared as true competitors in higher education. In 2004, out of 184 higher educational institutions operating in Mongolia 129 (70%) were private of which 109 were located in the capital. 32% of higher education students are attending private institutions. The uncontrollable expansion of higher education has created a profiteering attitude and problems of standards that has resulted in the enforced closure of 25 private higher education institutions in the last ten years. The newly established accreditation system of the Mongolian government is slowly reaching maturity and has already accredited 73 institutions.

The number of students enrolled in Bachelor degrees has almost doubled in the last five years: from 64251 in 2000 to 109268 in 2005. The greatest expansion is seen in the areas of language, business management, law, tourism and engineering. The areas of production technologies, agriculture and home security have witnessed an opposing trend with no or even negative growth. The number of post-graduate students (Masters and PhD level) has also grown but in much more modest terms.

The government provides higher education scholarships for families under a certain income level and also offers a number of prestigious scholarships for studying in foreign countries. Although lacking official data it has been clear during the interviews that the scholarship scheme has not been working well. While many low income families still cannot afford to send their children to university, at the same time the vast majority of overseas scholarship receivers stay abroad to pursue a career after completion of their studies (despite an official obligation to return to Mongolia). The failure to secure the return of foreign trained researchers is already felt in many public research institutes that lack personnel in specialised areas. The future of higher education in Mongolia and its ability to provide the S&T sector with high quality researchers is therefore uncertain.

1.4 Science and Technology Structure in Mongolia

Mongolian S&T has a simple and straightforward structure (see diagram below). The highest decision making body is the National Council of Science and Technology. Its membership includes two Ministers (of Science and Finance), nine Deputy-Ministers, and thirteen representatives of research institutes and universities (mostly from the Mongolian Academy of Sciences). The Chair of the Council is held by the Prime Minister. The creation and constitution of the Council was a recommendation of the UNDP report and follows the Japanese model of S&T. The Council meets every six month and takes decisions on a wide range of issues including legislation, budgeting, fund distribution and priorities setting in S&T. It lacks a permanent Secretariat and therefore its ability to monitor government programmes is restricted to reporting from group members.

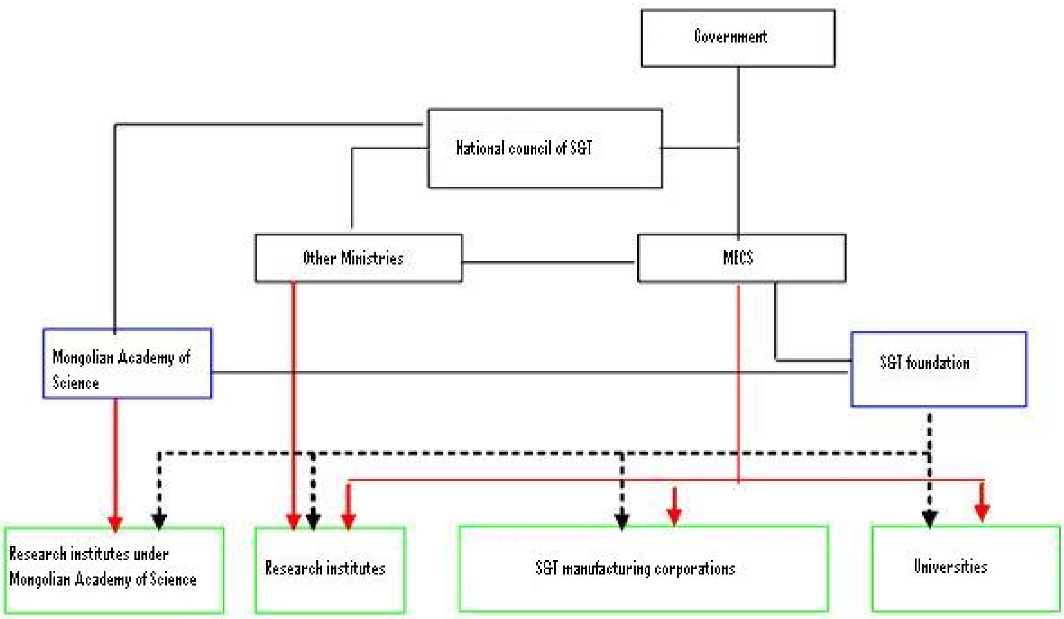
Under the National Council of S&T and responsible for the implementation of S&T programmes is the Ministry of Education, Culture and Science (MECS) as well as other Ministries with relevant programmes (e.g. Trade and Industry, Agriculture, Justice etc.). MECS main role is the implementation of Council decisions. Its Department of Science and Technology though consists of only six full-time staff, making it the smallest by far Department in the Ministry. Amongst the responsibilities of this Department is the drafting of the national S&T Master Plan which a team of four full-time staff has been dedicated for.

The Science and Technology Foundation is the main funding agency with responsibilities to run programme competitions and distribute funds according to decisions by the National Council. The Foundation's remit appears to be wider, including policymaking functions, but its day to day work is limited to fund distribution, budgeting and accounting.

One of the main key players in Mongolian S&T is the Mongolian Academy of Sciences (MAS). Based on the well-established Soviet model the mission of MAS is to oversee scientific research and advance research policy at national level. MAS has six scientific divisions (Biological and Agricultural Science, Engineering Science, Geology and Geography, Medical Sciences, Physics, Mathematics and Chemistry, Social Science) and fifteen Research Institutes (Physics and Technology, Astronomy and Geophysics, Informatics, Biology, Botany, Geoecology, Geography, Mineral Resources, Pleontology, Chemistry, Literature, History, Philosophy, International Studies, and National Development). The influence of MAS in S&T policy cannot be overestimated since it is traditionally the most prestigious and politicised organisation at national level. For instance the majority of the National Council membership comes from MAS.

Deriving from MAS structures but currently having independent status, is a number of research corporations. The corporations' remit is to enhance applied research and form partnerships with industries and private companies in fostering product development. Most of corporations' income derives from private sources nowadays and the extend of their partnership with the private sector is turning them in de facto private research laboratories. There are eight such corporations: the Building, Architecture, Research, Experiment, Enterprise and Business Corporation; the Light Industry Science, Technology and Manufacturing Corporation; the Electronics and Machine Research Corporation; the Renewable Energy Corporation; the Centre of Scientific and Technological Information; the Science, Technology, Manufacturing Corporation; the Mongolian Agricultural Engineering Corporation; the Food Research and Production Corporation; and the Traditional Medical Science-Technology and Production Corporation.

Finally, there are sixteen national universities that are funded directly by the S&T Foundation. The vast majority of funds though (about 90% of total) is absorbed by just three universities: University of Agriculture, Mongolian National University, and Mongolian University of Science and Technology.



PART II – GENERAL S&T INDICATORS

2.1 Introduction

One of the purposes of this mission was to discuss and generate appropriate statistical data in S&T that can be used in the creation of the Master Plan. The choice was lead by pragmatism (i.e. availability) and the need to offer meaningful international comparisons (particularly with similar developing and post-socialist societies). The team decided on a number of indicators that are described shortly below. The biggest hurdle has been the total lack of private sector data in R&D in Mongolia. The interviews we conducted make clear that the Mongolian private sector is very active in R&D (albeit in specialised areas such as mining and food processing). In some instances, more than 90% of total R&D conducted by particular institutes is funded by the private sector. Nevertheless, there is no official data that the team could use. This is an important issue that the Master Plan itself has to address. One of the main recommendations offered in this report takes up that issue. The data generated during the visit and discussed below, therefore, relate to public R&D only.

2.2 R&D Expenditure

R&D expenditure in Mongolia is financed solely by the national Science and Technology Foundation. There has been a steady increase in R&D funds in recent years from 1.09 billion Tugriks in 1996 to 3.39 billion in 2004. This increase was necessary to cover for heightened, and at times uncontrollable, inflation rate that reached a peak of 66% in 1994. In real terms though, national funding has remained relatively stable the last eight years representing a slight increase from .17% in 1996 to .19% of GDP in 2004 when the most recent statistics can be obtained.

According to sector breakdown natural science receive one-third (34%) of total funding (increasing from 30% in 1996), engineering 16% (down from 20% in 1996), agriculture 18%, medical science 10% (down from 15%), humanities 7% and social sciences 12%. The distribution of funds reflects the priorities set by the National Council and MAS that has a strong voice in it. But the implementation of fund allocation has seen major changes in recent years when MAS administered projects were allocated to the Ministry of Science (MECS) thus turning MECS into the biggest research project administrator in the government (administering more that 50% of total funds), a place that MAS held in the past. The Ministries of Health, Agriculture, Industry and Infrastructure administer almost all remaining R&D funds.

University R&D expenditure represents 22% of total expenditure. But almost all funds (90% of total) is granted to only three universities: the University of Agriculture, the Mongolian National University, and the Mongolian University of Science and Technology. The other thirteen national universities receive the remaining 10% of public funds. It is true that these three universities are the biggest and enjoy high reputation for quality and effectiveness. Nevertheless, the unequal distribution of R&D funds to universities disadvantages peripheral institutions and probably adds hurdles to efforts for decentralisation in Mongolian society.

Although we lack official data, it has been clear during the fact-finding interviews that the majority of public funds is used for administration and salary payments. This situation is particularly evident in MAS institutes that absorb most public funds and lack private sector investment. Funds for purchase of new laboratory equipment are virtually non-existent thus, severely restricting the ability of the institutes to develop their work and produce more applied research. The recommendations in part III address funding issues but it is also clear that the government would also have to increase direct R&D funding to help recover lost ground in public institutes. Although beyond the remit of this report, it appears feasible to increase R&D funding beyond the 1% of GDP threshold in the next decade.

2.3 Human Resources

Mongolian human resources in R&D are a fine asset to national S&T. The country has a total of 3219 researchers in public R&D. The number has decreased slightly in the last decade (1995 estimates: 3599) presumably due to the expansion of the private sector that offers better income and career opportunities. The majority of R&D personnel (82%) are full-time permanent employees. Non-permanent employees (contract researchers) are employed on project basis mainly at university institutes (MAS institutes have very few contract researchers). There is relative gender balance in R&D personnel with 46% of the total being female.

More than half of full-time R&D researcher have a post-graduate degree, in the majority of cases a Doctorate in Science or Education. According to the Soviet educational system, the highest title in academic life is that of "Academician", denoting international reputation; 13% of full-time researchers in Mongolia have achieved the title of Academician.

In the international comparative stage Mongolia is performing well considering its size and macro-economic indicators. It has more researchers per million population than countries like India, Malaysia, Vietnam or Philippines. Nevertheless, break down by age distribution shows a decline over the years in number of researchers at ages 31-40, possibly as a result of reluctance in recent years of foreign trained researchers to return in Mongolia.

Overall, human resources in Mongolia appear adequate to feed the existing S&T sector. The increasing lack of new, highly specialised personnel could be a severe problem in the medium-term. Once the Soviet-era researchers have outgrown the latest scientific developments and the new generation continues seeking elsewhere career opportunities, public research will suffer greatly. Some of the recommendation in part III attempt to address this issue as well.

2.4 Performance Indicators

Performance indicators refer to the “output” part of the S&T equation. It is notoriously difficult to draw any conclusions for the relation between input and output in S&T. What constitutes acceptable levels of performance vary greatly between S&T structures and it is particularly sensitive in public R&D that is not primarily pre-occupied with wealth generation. We decided to follow two broad performance indicators in Mongolia: publications and patents. These are widely used world-wide and offer good comparative data. Publications reflect the science base of the country while patents are signs of innovation. Sectoral analysis is offered when data allow for such breakdown.

Mongolian researchers produced a total of 5828 publications in 2004, 2844 of them being scientific articles (the accepted international unit of comparison). The majority of the article publications (85%) were published in Mongolia with a further 15% of the total published abroad. Sectoral breakdown shows that the majority of published articles were in natural science (30%) followed by engineering and technical science (24%), social sciences and humanities (18%), agricultural sciences (23%) and medical sciences (5%). The strength of theoretical science in this performance indicator reflects the structure of the educational system, based on the Soviet model, that puts emphasis on basic research. International comparisons show that Mongolia’s sectoral contribution to the total publication record is rather different from the norm. Compared to thirty two countries with significant publication records (admittedly most of them from the West since records are more readily available there) Mongolia shows the greatest share by far of social sciences and humanities, but also of engineering, technology and mathematics. As a result, life and physical sciences publications in Mongolia are below the average for other countries. Finally, with an average of 1.4 articles per total researchers Mongolia is well above average in international leagues.

Overall, the production of publications is satisfactory and shows a very good ratio of input-output in R&D. Naturally, since most publications are written in Mongolian for local consumption, there is little point in trying to measure their “impact factor” which is another crucial aspect of this performance indicator. Mongolian scientific publication cannot therefore be objectively measured with common international standards; instead it has to be assessed on its own merits.

Patents are also a performance indicator that carries along its own caveats and warnings. Although patents are considered to be signs of innovation, they do not reflect innovation per e. Many patents do not give rise to any innovation while others represent great leaps in innovation. Strictly speaking, patents only reflect knowledge with potential for innovation.

Patent applications have shown a steady increase in Mongolia during the economic transition period. Resident patent applications have increased from 78 in 1989 to 121 in 2002 (the most recent year that patent statistic can be obtained). Non-resident applications have also seen exponential growth from 92 in 1989 to 89,985 in 2002. International comparisons show Mongolia in a good light with .38 patents for 10,000 population; a higher number than many other post-socialist countries such as Poland, Romania, Lithuania, Estonia or Bulgaria. Most patents cover the area of “human necessities” (42% of total) followed by chemistry and metallurgy (25%), “performing operations / transporting” (9%) and mechanical engineering (8%).

During the interview sessions it became clear that the regime of intellectual property is not properly enforced in Mongolia and as a result royalties are rarely collected for use of registered patents. Many organisations are therefore opting for a “one-off” payment for patent use that clearly deprives them for potential income in case of particularly successful patent applications. Moreover, some institutes cannot afford to apply for patents and resort to co-applications with companies that eventually receive most benefits deriving from the patent. Some of the recommendations in part III attempt to tackle this problem.

2.5 Technology Diffusion

Technology diffusion is a general measure of S&T penetration in society at large. It is not a performance indicator per se but it nevertheless presents a clear indication of potential; where technology use is widespread in society, development of the S&T sector is easier and smoother. The relevant statistics that are available for Mongolia are telephone (both fixed line and mobile) users, internet users and users of personal computers.

The number of telephone subscribers has increased considerably the last decade. This is mainly due to liberalisation of the telecommunications market and the introduction of mobile telephony in the last years. At present there are 155,560 fixed line telephone subscribers in Mongolia compared to 69,300 a decade ago. Mobile phone subscribers are a staggering 536,330 (ca 20% of the total population) a number achieved in only five years of mobile telephony in the country. This trend is also witnessed throughout the developing world and as a result Mongolia does not present a special case in this sector. International comparisons show that Mongolia has more phone subscribers than countries with similar income level (low income) while it lags behind other post-socialist (but richer) countries.

Internet users and users of personal computers shows a more impressive picture. Mongolia has 58 internet users per 1,000 population which places it in favourable position in the international stage. Mongolia has more internet users than most Central Asian republics or many other developing countries including China, India and Philippines. In that respect it compares favourably even with lower middle income countries. Similarly, there are 77 users of personal computers per 1,000 in Mongolia, a ration that reaches that of even upper middle income countries.

Overall technology diffusion shows what many visitors in Mongolia cannot fail to witness: a society that willingly adopts modern technology and eagerly uses the latest communication means. This can be considered a sign of fertile ground for further development of science and technology in the country.

PART III – POLICY RECOMENDATIONS

3.1 Introduction

The above short description of the statistics generated during the visit provides a first interpretation of the available S&T data. Some issues that require particular attention are evident from it already. More unofficial information deriving from the series of interviews that we held with leaders of research institutes and universities helped us in having a more comprehensive picture of the issues surrounding S&T in Mongolia. It is clear that many of them will have to be tackled in the national Master Plan. A preliminary outline of the Master Plan has already been discussed during the visit. The exact content should await further sectoral analysis that can only be achieved with the good-will collaboration of other related Ministries. Following is a series of policy recommendations that the expert deemed appropriate for inclusion in the Master Plan. They have been discussed with the team to ensure a measure of "realism" in the Mongolian context.

3.2 Recommendation 1 - Creation of a full survey of private sector involvement and expenditure in R&D that represents the single most important missing feature in national S&T statistics

Despite the fact that there are some well established private companies in Mongolia active in R&D intensive sectors (e.g. pharmaceutical, ICT, engineering), also in collaboration with public institutes, there is no reliable data indicating their involvement and/or expenditure in R&D. This is not surprising considering that private corporations are a recent phenomenon in Mongolia and that the market economy approach is still under development. Issues of control and auditing of the private sector are a new undertaking for the Mongolian government.

Nevertheless, there are signs that private sector R&D expenditure surpasses public expenditure in many areas. For example the University of Science and Technology receives annually ca. 1.4 billion Tugrits in R&D related private sector contracts with its laboratories. This represents 94% of its annual research funds (the remaining 6% derives from National Science Foundation funds). Other universities also receive the majority of their R&D funds through private sector contracts. However, this income is not monitored and the amount of private funds or the extend of private sector R&D expenditure is still unaccounted for in official statistics.

The first recommendation is therefore to create a full survey of private sector R&D to be included in official statistics. This can be done with the collaboration of relevant Ministerial departments overlooking higher education and medium-high technology industries. Additionally, a comprehensive questionnaire could be distributed to major universities, research laboratories and private companies that is designed to uncover information on R&D expenditure. Due to the depth and intensity of this type of work, it is suggested that the Department of Science and Technology of MECS should create a working group specifically for that purpose and allow ample time (i.e. at least one year) for the completion of this survey.

3.3 Recommendation 2 - Expansion of the area of Technology Transfer as a means to capitulate on the existing S&T capabilities that lack product exploitation strategies

Mongolia has a law on Technology Transfer that entered into force in May 1998. The law stipulates the processes and conditions of technology transfer along with penalties for misuse and misappropriation. This development shows that the government has been aware of the potential of scientific research in promoting the economy and creating wealth. Nonetheless in reality there is still plenty of scope to promote R&D achievements taking place in the public sector. The government has created a number of "corporations", mainly previous public research laboratories, with a new remit to activate collaborations with the private sector in search of new product development. These corporations have shown a varied level of success and they are increasingly depending on private funds for their operations. Recently there has even been discussions on the possibility of severing completely the corporations' ties with the public sector, which is an awkward suggestion given that some of the corporations are responsible for controlling the quality of public goods (e.g. foodstuff, drinks, machinery, etc.).

At the same time many publicly funded laboratories lack the know-how and the funds to transfer their research results into products. This is a common issue in R&D that has been the focus of debate in many industrialised countries as well. However, the issue in Mongolia is not to find a healthy balance between basic and applied research, but rather to ensure that the most promising research applications enjoy minimum support and protection by the government. For instance, we were informed that many patents deriving from research in the Institute of Chemistry of the Mongolian Academy of Sciences were registered under private companies or individuals for lack of public funding to support patent applications. Given that some of these patents can be applied to popular market products, a potentially great source of revenue is inaccessible to public laboratories.

It is not clear how one can resolve this issue in a pragmatic manner that fits the current situation in Mongolia but it is clear that the Master Plan ought to try. Promotion of joint ventures between public (particularly the Academy of Sciences) laboratories and private companies is a possibility. The recent but extensive experience that "corporations" have in the area could be invaluable in creating these ventures. Public laboratories lack the mentality of measuring success in product development and financial profit (and perhaps they should not) but basic training in intellectual property protection and product development processes should be undertaken to raise staff appreciation for the economic potential of their work.

3.4 Recommendation 3 - Re-structuring of the national scholarship programmes to reflect priority needs in sector training and lack of personnel in particular areas

Data in higher education student enrolment show some imbalance: 51% of students enrolled in higher education institutions in Mongolia study humanities and social sciences with only 4% studying natural sciences, 2.7% computer science and 16% studying technology related subjects. The most recent trend proves the depth of the problem: humanities and social sciences enrolment has shown an annual increase of 8% while natural sciences and technology enrolments have decreased (by .7% and 3.6% respectively).

It is inevitable that this imbalance will have an effect on the workforce in the medium term. Due to lack of reliable data it is not yet clear how far professional sectors have been affected by decreasing graduate numbers in science and technology subjects. Our understanding from informal conversations is that there is indeed a recruitment problem and lack of well qualified young researchers and engineers. At the same time the government as the main provider of student scholarships in higher education, should investigate the situation and amend its scholarship policy accordingly. Scholarship quotas should reflect the needs of the job market and some sectors be prioritised over others. Good candidates for further investigation and prioritisation are the sectors of mechanical engineering, ICT related subjects and chemistry.

3.5 Recommendation 4 - Enhancement of Industry-Academia-Government collaboration and promotion of commercialisation of R&D results

From the fact finding interviews and unofficial discussions that we held during the period of the visit, it has also been clear that there is a need for increased collaboration between industry, academia and government in S&T. So far, collaboration between industry and academia has taken place only in specific sectors (e.g. mining) and with a handful of universities (e.g. the national University of Science and Technology). Most of public research laboratories' funds derive from public sources (particularly those under the Academy of Sciences) and can barely cover salaries and administration costs.

A common complain we heard during the interviews is that the government does not promote or adequately protect intellectual property rights. Research institutes resort to their "own deals" with the private sector to derive income from their intellectual property rights, usually in the form of an "one-off" payment by the end user. This area will need better regulations in the future.

In order to successfully face the problems surrounding the application of S&T in the market and society at large, closer collaboration should be promoted between the main actors. There are many different ways that one could pursue such collaboration, from creation of working groups with the participation of the private sector to specialised round table discussions and seminars on market applications. The Department of S&T at MECS is ideally situated to coordinate this action and instigate such collaboration.

3.6 Recommendation 5 - Creation of a national Science and Society programme with emphasis on issues of public awareness and ethics and responsibility

Science and Society is a relatively new area of research that covers the whole spectrum of the relationship between society and scientific research and practice. From communication and perception aspects to ethics and risk assessment, this line of research has been established in many industrialised countries with significant levels of success. The European Commission's programme on science and society enters its third circle of review (after eight years) while national research councils in Europe (e.g. the Economic and Social Research Council in UK, the National Research Council in The Netherlands, etc.) have started their own programmes. The Japan Science and Technology Corporation have also had their own related programme since 2001.

The European programmes on science and society typically cover the areas of: Scientific advice, governance & reference systems; Ethics in science; Uncertainty, risk, and the precautionary principle; S&T culture, young people, science education and careers; Women & science. The purpose of the programme is to investigate and enhance the role of science in society, whether that refers to the relationship between civil society and science policy, gender representation and equality in science, ethics in scientific research, risk management, communication with the lay public, etc. Such programmes promote interdisciplinary research with input from the natural sciences, communication sciences, and humanities.

In the current situation in Mongolia an extensive science and society programme would not be viable. On the one hand, there are certain budgetary limits that would make a full programme unattainable and on the other hand, there is no established culture of civil society activity in science to guarantee such a complicated undertaking. Nevertheless, some aspects of this programme should be very helpful and even desirable for the continuing viability of S&T in the country. Public awareness/understanding of science, and ethics and responsibility are good candidates for an initial science and society programme.

Public awareness/understanding refers to communication issues in S&T. How is science communicating to the public and how the public perceives science? What are the main issues and worries that the public has on scientific research and new technologies? Are young people, the future scientists, aware of the potential for a scientific career and what that entails? Is there a need for specific educational initiatives to promote scientific sectors in the public domain? These are some questions that such a programme should attempt to answer. At the same time, and provided funds will be available, a series of public events should be part of this programme such as, open days for science laboratories, S&T exhibitions, public lectures and debates, young scientist prizes, local science shops, etc.

Ethics and responsibility refers to the aspects of scientific research that are socially sensitive and have important repercussions to life and society. Biomedical sciences and biotechnologies are nowadays mostly talked about in relation to these topics but nanotechnologies, brain research, etc. are also coming increasingly in the focus of attention. Mongolian S&T developments in these fields merit their own discussion regardless of their stage of advancement in the world scene. Ethical dilemmas in biomedical research appear more often in the Mongolian news and that increases the need for a proper government report. The National Commission of UNESCO in Mongolia has the expertise to initiate a national programme on bioethics and research ethics training that could form the backbone of this initiative.

3.7 Recommendation 6 - Establishment of an independent Technology Assessment Institute as the main policy advisory body in S&T

Technology Assessment has been defined as the production of information about the possible consequences of S&T developments aiming to improve public policies. It is a type of information about highly scientific or technological issues that tends to come in written form, in documents or reports, and that is developed to improve the information for policy-making. More recently in many European countries, Technology Assessment also seeks to foster debate, public understanding or acceptance of the impacts of science and technology from a neutral, non partisan position, always using scientific information of the best possible quality.

The reason why Technology Assessment Institutes have been accepted by policy makers is to be found in their neutrality and objectivity and also in their proximity to decision making. Decision makers are faced with a volume of information from different sources, many times linked to specific groups and interests, that lack legitimacy and independent information. Advice produced in TA institutes related to parliaments is of course only one of the "types of information products" related to decision-making that is available, but this information is produced institutionally in the parliament, at the request of parliamentary bodies, and that parliamentarians may have influenced when and how it was produced, giving it an "owner" identity. This constellation produces policy advice of the highest quality and direct value in policymaking.

The institutional setting of TA can take various forms ranging from being part of the parliamentary (legislative) civil service structure to have an independent remit outside the government or parliament with a special policy advisory status. In any case, a cross-party board representing the current parliamentary constellation is usually responsible for the overall work plan of the institute and use of the information deriving from it. In Mongolia such institute would be vital in informing the policy debate on S&T issues while remaining outside party politics and interest group influence. Whether that can best be achieved through the establishment of a parliamentary office or an independent office funded by the government is an issue that needs to be debated in the specific context. However, the need for an independent and clear policy advice in S&T is evident and should be pursued if funds allow for this.

3.8 Recommendation 7 - Promotion of a national Foresight programme in priority areas particularly in agriculture and mining

Foresight is a particular tool developed to provide challenging scientific visions of the future and to ensure effective strategies. It does this by providing a core of skills in science-based futures projects and access to leaders in government, business and science. Foresight projects aim to either identify potential opportunities for the economy or society from new science and technologies or consider how future science and technology could address key future challenges for society. The starting point for a project area is the identification of a key issue where science holds the promise of solutions or an area of cutting edge science where the potential applications and technologies have yet to be considered and articulated. Each project has a sponsor in the form of a leading policy figure and lasts between 9-18 months.

The value of foresight exercises is in bringing together key stakeholders from government, industry, academia and civil society to create a common vision in a particular area of scientific and technological research. The outcome can be of immense help in setting up strategic goals in policy and direct funds and legislation that will unleash the potential of science. National foresight programmes have been instigated in most industrialised countries and are a prime example of coordinated work at the highest levels of decision making in government and industry.

A Mongolian foresight programme would therefore be of great value in identifying priorities and strategies in those sectors of the economy that show the greatest potential. Agriculture and mining are the two most prominent candidates for a national foresight programme as they are two of the fastest expanding export oriented sectors of the economy. Other sectors might also be considered once the process of foresight has been activated in the Mongolian context. It has to be mentioned that foresight exercise are strenuous and expensive undertakings but they offer a unique opportunity to activate and coordinate the work of industry and academia while keeping a clear objective in the welfare of the nation. Their value therefore goes beyond the specific sector under consideration as it helps to create a common vision and closer cooperation in the future.

3.9 Recommendation 8 - Expansion of the role of the National Science Foundation in the evaluation of institutional outputs

According to the structure of Mongolian S&T governance all available S&T funds go through the National Science Foundation for distribution to research institutes (whether within universities or the Mongolian Academy of Science) and public corporations. This is a valid manner to distribute funds and from interviews and discussions during the visit we did not register any dissatisfaction about the funding stream. Nevertheless, the National Science Foundation’s function in the Mongolian S&T system is undervalued as it focuses mainly on accounting and budgeting issues. It is clear that its position and expertise in the area could be put in better use.

The suggestion here is to expand the remit of the National Science Foundation into evaluation of research results and institutional functions. The Foundation’s position and independent status makes it an ideal candidate for this function: on the one hand it is the only distributor of funds and receiver of progress reports and on the other hand it employees highly skilled personnel with specialised experience in S&T policy. The manner of evaluation is an important issue that needs to be discussed at different levels of decision making and there is plenty of relevant experience in other countries to aid this process. Changes in the institutional functions and work plans of the National Science Foundation is a necessary obvious first step.

3.10 Recommendation 9 - Re-structuring of the national funding mechanism to include evaluation of research outputs

This recommendation is related to the previous one and follows as the natural next step. It is also a understandable wish for many leaders of research organisations. So far, there has been no comprehensive evaluation of the work of research institutes and no debate on input-output relationships. This is an important issue that has been pursued intensively in many industrialised countries although in many aspects it still remains inconclusive. Despite a series of research output evaluation methods there are many critics of each system adopted as it inevitably favours one type of research over another. For instance, basic research is notoriously difficult to evaluate in terms of outputs since it is a long term process that is not easy to break down into cause-and-effect series.

In any case most countries do have a system, however imperfect, of evaluating research outputs and distributing future funds according to the outcome. Mongolia should also introduce such system tailored in its own needs and purposes. Otherwise there is the risk that funds are distributed according to political clout and occasional favouritism, something that disturbs and distorts the whole S&T system in the country. The exact methodology employed in this process need to be decided beforehand and the process itself should enter the mechanism of national funding.

3.11 Recommendation 10 - Establishment of a Working Group on S&T under the National Council of S&T at Departmental level to coordinate actions amongst Ministries and evaluate progress of the Master Plan

The National Council of S&T is a cabinet level decision making body chaired by the Prime Minister. It was established on recommendation of the UNDP report and it is similar in constitution and function to the Japanese Council of S&T. Despite its important role in deciding national S&T programmes and budget issues, the National Council is not in the best place to enhance effective coordination amongst relevant government Ministries or evaluate the progress of the forthcoming Master Plan. Its high level of membership and lack of permanent Secretariat pose barriers for more effective day-to-day functions. At the same time there is a clear need to promote closer cooperation between the different Ministries involved in S&T policy. At present, official communication between Ministerial departments is based on bureaucratic processes that can delay information exchange for months at a time.

The recommendation here is to create a working group with the remit to coordinate the work of relevant departments from Ministries involved in S&T policy. This group will be under the National Council and would consist of directors/deputies in Ministerial departments to allow for maximum flexibility and effectiveness in communication. This group would also be in an ideal position to oversee the progress of the Master Plan in S&T and report to the Council with recommendations for actions. The Department of Science and Technology at MECS could organise and chair such group.

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