S&T&I priorities for the Russian natural resources sector

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Abstract

Purpose – *This paper aims to analyse three individual foresight projects referring to the natural resources sector in Russia, their interconnection and influence on policy decision making.*

Design/methodology/approach – *The three foresight studies used different methodologies depending on the project's goal. First the projects' interconnections are explained. Second, each of the studies is characterised from different viewpoints, including their aims, structures, methodologies and results. Finally their influence on policy-making is evaluated.*

Findings – *The paper concludes that implementation of these three interrelated studies allows identification of S&T&I priorities that have a strong connection with policy decision making. Therefore, on the basis of this experience, it is suggested that a widespread national Delphi survey for the identification of science and technology (S&T) priorities should be complemented by the identification of key long-term demand for resources and reshaped management systems.*

Originality/value – *For the first time the paper presents an analysis of Russian foresight projects connected to the natural resources area and an evaluation of their influence on policy decision making.*

Keywords *Priority-setting, Russia, Natural resources, Long term planning, Foresight, Project planning, Innovation, Technology led strategy, Sciences*

Paper type *Research paper*

1. Introduction

In recent years, studies focusing on the identification of science, technology and innovation (S&T&I) priorities have become an integral part of government policy making in almost all developed countries, including the efficient use of natural resources and environmental protection. However, approaches and techniques used to identify priority areas for S&T&I development in various countries strongly depend on local peculiarities, socio-economic policy objectives, the availability of natural resources, the state of the environment, and various other socio-economic factors.

The prospects and problems of the natural resources sector constitute a major section in most national science and technology foresight studies. Many individual foresight exercises are specifically devoted to the rational use of natural resources and environment protection. These aspects are also analysed during the course of various foresight studies undertaken in such sectors as transport, energy, agriculture, etc.

In the last ten to 15 years, Japan (National Institute of Science and Technology Policy, 2010), Finland (University of Joensuu, 2010), the UK (Loveridge *et al.*, 1995), Norway (Nordic Innovation Centre, 2007), Canada (National Research Council Canada, 2005) and other developed countries have accumulated significant experience with such projects. Many international organisations, including the European Commission (2004a, b, 2003), the Organisation for Economic Co-operation and Development (2006), the United Nations Industrial Development Organization (2007), and OPEC (OPEC Secretariat, 2010), have

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been active in the development of long-term strategies for the rational use of natural resources and in the sphere of environmental protection.

Russia possesses significant reserves of minerals. Over a third of the world's natural gas, coal and iron ore reserves are located in the Russian Federation, along with about one tenth of the world's oil, and many other mineral resources. Russian fresh water reserves amount to 20 per cent of the total global stock; Russia also has significant forest resources.

However, the Russian economy still remains resource-oriented. Mining of natural resources generates more than 20 per cent of the total output, while the mineral resources sector's share of total Russian exports is as high as 80 per cent (Russian Federation, 2009). All Russian hydropower plants together generate just 20 per cent of the electricity produced in the country (Russian Energy Strategy: 2030, 2009).

The natural resources sector includes numerous players (federal and regional government agencies, public and private companies and industrial enterprises, R&D centres, environment protection organisations, and the general public). Their relations with each other are often affected by their opposing interests, which – given the weak legal system – engenders many problems. In particular, these include problems with the efficient utilisation of natural resources, environmental protection, and management of the natural resources sector.

Russian companies that are active in the natural resources sector routinely display high emissions figures – several times higher than in other countries. Accordingly, a difficult environmental situation has been developing in Russia over the decades, which negatively affects the quality of life, health and life expectancy. Currently about 40 million Russians live in unfavourable environmental conditions, and one million reside in regions where the level of pollution is dangerous for health.

The only efficient way to deal with these and many other problems, and to respond to these challenges, is by radically increasing innovation activities in the natural resources sector. However, accomplishing this is not an easy task due to a number of reasons, the most important of which include the low level of innovation activities of Russian companies, an underdeveloped innovation infrastructure, inefficient legislation, etc. Therefore, identifying S&T and innovation priorities for the natural resources sector has become an extremely important issue, especially for policy makers.

In 2007, the RF Ministry of Education and Science initiated the National S&T Foresight until 2025 to identify S&T priorities (Sokolov, 2008a, 2009). The final objective was a preparation of policy recommendations on the basis of the S&T priorities; however, this objective was not totally achieved. Additional information concerning assessing the required resources (human, financial, technological, etc.) and a description of specific innovation projects was required for policy decision-making. Therefore for this additional investigation the RF Ministry of Education and Science initiated the second cycle of the National S&T Foresight until 2030. Within the implementation of this foresight study it was realised that S&T priorities should be complemented by innovative priorities for corresponding development of the Russian management system in the field of natural resources, otherwise the S&T priorities could not be fully implemented. The third foresight study commissioned by the RF Ministry of Natural Resources and Ecology was devoted to exactly this task: the identification of innovative priorities for the development of the Russian management system.

So, in Russia, three foresight projects related to the topic of natural resources were conducted. They were interconnected and the results of the earlier projects were used in the subsequent studies to accomplish the overall objective, i.e. to prepare recommendations for shaping Russian national S&T and innovation policy in the sphere of natural resources and environmental protection. This policy must promote the advanced development of priority technological areas, which would contribute to increasing the growth rate of the economy, environmental safety and the competitiveness of Russian companies, and help to deal with the most acute social problems.

The analysis of these three Foresight projects is presented below.

2. Methodology

The methodology of the paper includes several steps:

- characterisation of the projects;
- analysis of the interconnection of the projects' structures and their results; and
- an assessment of their impact on policy-making.

For characterisation of the projects, several dimensions are used. First of all an aim of the project is highlighted, then we describe foresight studies that created a base for our analysed projects. The structure of the project, including analysed S&T areas and levels of analysis, is characterised in the next step. Then we present the project's methodology (methods used, stages, number of experts engaged and main criteria for analysis). Finally the main results are described and illustrated.

In the second step of the analysis the interconnection of the structures of the projects is explored. Then we investigate the issue of the interconnection of the results of the projects. For this objective, three characteristics are used:

1. the *research focus*, meaning the main research objective of the study;
2. the *main results*, where we specify the key received results of the project and conclusions made on the basis of this results; and
3. *questions for further investigation* – on the basis of the main results and conclusions of the project we identify directions for further analysis in order to increase the impact of the project's results on policy-making.

So, in the framework of this analysis we show how the results of one project are added to the results of the following project, and why the following project was initiated.

Finally, the impact of the projects on policy-making is assessed. For this assessment the following scale is used:

- *Indirect impact* – This means that the project results (such as lists of priorities, the most important research topics, policy recommendations) were used for informing policy-makers. In this case project materials are used as one information source among others, and do not have direct influence on policy-making.
- *Direct impact (medium)* – This means that the project results were used directly for decision-making at Ministry level (corresponding decisions could concern the forming of a research agenda, budget allocation, etc.).
- *Direct impact (high)* – This means that the project results were used directly for decision-making at government level for the development of national strategic documents.

To identify the impact of the projects considered according to this scale, different documents (like project materials, reports and documents on their basis) were analysed and interviews were conducted with heads of project teams.

3. Russian FS approaches

3.1 National S&T Foresight: 2025 (FS1)

The aim of this foresight study was the identification of the most important and well-developed S&T areas in Russia in the long-term perspective. These areas should be in line with relevant national competitive advantages. Accordingly, the following objectives were set:

- identification of R&D areas that are most important and promising to Russia;
- estimation of possible timeframes for major S&T breakthroughs;
- evaluation of the position of Russian R&D centres in the international S&T landscape; and
- determination of the most relevant steps to be taken to support the development and commercialisation of science and technology.

This study was based on another foresight study devoted to the identification of national S&T priorities and a corresponding list of critical technologies (Sokolov, 2008b). The following criteria were used to make the list of critical technologies:

- contribution to increasing the GDP growth rate;
- improvement of the structure and increasing competitiveness of the Russian economy; and
- contribution to Russia's national security, including environmental security.

The final conclusions made in the course of the study were used to develop and implement the federal goal-oriented programme ''S&T priorities for Development of the Russian S&T Sector in 2007-2012''. This programme was structured in accordance with the identified S&T priorities, and specific projects were selected on the basis of their relevance to the identified critical technologies.

The structure of this study has three levels. There are nine thematic areas at the first level (which correspond to National S&T priorities), 56 technology areas at the second level (which correspond to critical technologies) and more than 900 topics. The thematic areas include:

- Information and Telecommunication Systems;
- Industry of Nanosystems and Materials;
- Living Systems;
- Medicine and Health;
- Rational Use of Natural Resources;
- Transportation, Aviation and Space Systems;
- Power Engineering and Energy Saving;
- Manufacturing Systems; and
- Safety.

The thematic area ''Rational Use of Natural Resources'' covers the following five technology areas:

1. environmental monitoring and forecasting (atmosphere and hydrosphere);
2. estimating resources and forecasting (lithosphere and biosphere);
3. processing and utilising anthropogenic substances and wastes;
4. environmentally safe mining and extraction of natural resources; and
5. risk and damage containment after natural and technogenous disasters.

Eighty-two topics were formulated for these five thematic areas, in the form of briefly described S&T results, promising technologies or innovation products (e.g. ''Techniques for assessing anthropogenic systems hazardous to environment'').

The methodology of this study included various expert and analytical techniques being engaged to prepare this S&T foresight (analytical research, bilbliometric and patent analysis, interviews with and polling of experts, expert panels, benchmarking, etc.). The Delphi method was the key instrument. The principal stages included:

- preliminary desk research;
- socio-economic objectives analysis;
- selection of experts;
- identification of thematic areas;
- Delphi topics;
- survey methodologies;

- expert panels;
- data analysis; and
- discussion and dissemination of results.

More than 2,000 experts from 40 Russian regions took part in the Delphi survey, representing all leading R&D and industrial centres. More than 150 experts were recruited to assess development prospects for the Rational Use of Natural Resources area.

In the framework of the Delphi survey each topic was evaluated by the following criteria:

- importance to Russia;
- expected timeframe for developing technological solutions;
- current level of Russian R&D;
- world leader country;
- support measures for Russian R&D;
- expected timeframes for commercialisation and implementation;
- support measures for commercialisation; and
- possible results.

As the result of this foresight exercise a large database of promising S&T areas was created, with integrated scores for all selected criteria. The characteristics of five major topics for the thematic area ''Rational Use of Natural Resources'' are given in Table I.

As shown in Table II, Russian experts considered the most important topics in this area to be ''Technologies for accelerated and efficient recovery of damaged lands, landscapes and biodiversity'', ''Technologies for environmentally safe processing and recycling of consumer and industrial waste'' and ''Geoinformation database of forest fires in Russia, allowing monitoring of fire situations in real time''. For these topics, the most urgent support measures were derived (see Figure 1). So, according to the experts, the most important required support measures are improvement in the research infrastructure, increasing budget R&D funding and training (percentages imply the percentage of experts who marked the measures as being most important; experts could choose more than one answer). These issues were deeply analysed in the FS2 framework.

3.2 National S&T Foresight: 2030 (FS2)

The aim of this study was an evaluation of required resources and possible innovation projects for the most important S&T fields.

The National S&T Foresight: 2030 was based on the FS1 results and also on a renewed version of the National S&T Priorities and Critical Technologies.

The study covers three thematic levels, the first of which corresponds to the revised list of National S&T Priorities:

- Information and Telecommunication Systems;
- Living Systems;
- Industry of Nanosystems;
- Transportation and Aerospace Systems;
- Rational Use of Nature Resources; and
- Energy Efficiency and Energy Saving.

''Rational Use of Nature Resources'' was therefore considered one of the key priorities. It included three critical technologies (at the second thematic level):

- prevention and liquidation of environmental pollution, monitoring and forecasting environmental conditions;

Table I Major topics of the ''Rational Use of Natural Resources'' thematic area

No.	*Topic*	*Importance index*[a]	*Expected time of developing S&T solution*	*Possible results (percentage of experts; two top scores)*	*Technology area*
1	Technologies for accelerated and efficient recovery of damaged lands, landscapes and biodiversity	97.6	2019	Contributing to dealing with social problems (76.3 percent) Improving positions on international markets (31.6 percent)	Technologies for environmentally safe mining
2	Technologies for environmentally safe processing and recycling of consumer and industrial waste	96.7	2016	Contributing to dealing with social problems (79.5 percent) Improving positions on international markets (40.9 percent)	Technologies for processing and utilising anthropogenic substances and wastes
3	Geoinformation database of forest fires in Russia, allowing monitoring of fire situations in real time (number of fires and affected area)	96.1	2014	Contributing to dealing with social problems (73.8 percent) Improving positions on international markets (47.5 percent)	Technologies for forecasting the state of the lithosphere and biosphere
4	Geophysical techniques for oil and gas prospecting in complex environments; assessment of productivity of oil fields; techniques to monitor oil and gas fields, identifying possible ore-bearing, oil- and gas-saturated zones	95.7	2018	Improving positions on international markets (78.1 percent) Contributing to dealing with social problems (25 percent)	Technologies for environmentally safe mining
5	Technologies for efficient decontamination of polluted territories using plants and biomaterials	94.0	2018	Contributing to dealing with social problems (82.6 percent) Improving positions on international markets (50 percent)	Technologies for processing and utilising anthropogenic substances and wastes

Note : [a]Calculated as (No. of "High"*100 + no. of "Moderate"*50 + no. of "Low"*25 + no. of ''None'')/(no. of responses of important). This index shows the relative importance of each topic according to aggregated expert opinion

- prevention and liquidation of emergencies related to natural and technogene emergencies; and
- technologies for processing and utilising anthropogenic substances and wastes.

The third level of ''Rational Use of Nature Resources'' covers 40 technology groups, which were identified on the basis of the most important and well-developed FS1 topics combined into extended technology FS2 groups.

Since the main objectives of the study changed against the first cycle, the methodology was also properly adjusted. An important new methodological aspect was the development of roadmaps, the identification of potential large-scale innovation projects, and most promising research areas offering significant innovative potential.

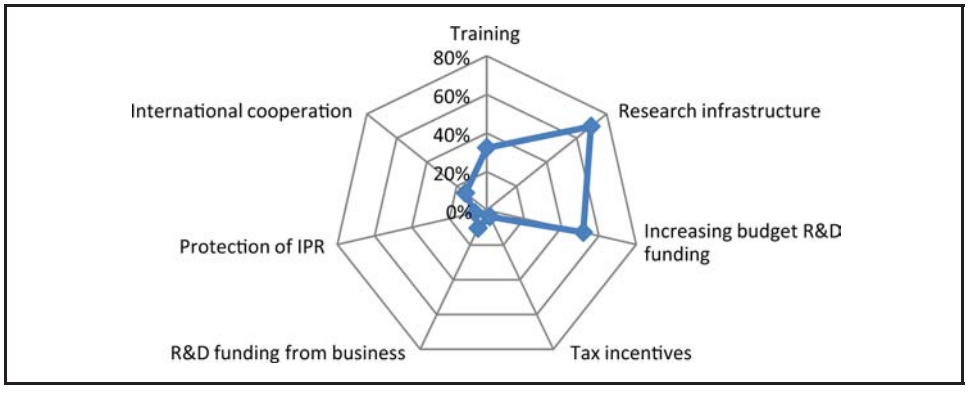
This foresight methodology consisted of various expert techniques (surveys, interviews, workshops), and analytical research. All in all, 50 in-depth interviews, two expert surveys and over 20 workshops were held to prepare this national foresight. More than 300 experts from the S&T and business communities, as well as government officials, took part in the exercise.

Table II Characteristics of most developed technology groups in the ''Rational Use of Natural Resources'' thematic area

Technology group	*Index of R&D level*[a]	*Cumulative effect*[b]
Monitoring and control systems, various equipment for rescue operations and emergency situations management	66.7	1.71
Remote monitoring techniques based on space satellite systems	62.5	1.86
Forecasting natural and anthropogenic disasters and their consequences based on monitoring data and advanced understanding of their origins and development	57.1	1.71
Techniques for prospecting natural resources, including those based on advanced physics achievements	56.3	1.50
Selective disintegration processes	56.3	1.75

Notes: Calculated as (No. of ''At the level of leading countries"*100 + no. of ''Somewhat behind"*50 + no. of ''Behind''*25)/(no. of all responses); this index shows an average estimation of R&D level according to aggregated expert opinion. [b]Calculated as sum of the number of answers for the two top scores (among the following possible answers: ''increasing share at global market'', ''contribution to social development'', ''competitiveness at domestic markets'', ''integration to global value chain''). This index shows the cumulative effect of each group evaluating technology according to aggregated expert opinion

Figure 1 Support measures for ''Rational Use of Natural Resources''



New objectives of the study also demanded adjusting *evaluation criteria* for the technology groups (accordingly to the FS1 results). Special criteria were suggested to assess resource requirements and evaluation criteria for emerging markets for products based on technologies developed within these technology groups. A number of criteria were used to assess these groups, including R&D level, contribution to innovative relevant projects, availability of human resources (researchers, engineers and technicians), required level of funding and fixed assets. Experts also estimated the potential for implementing large-scale innovative projects based on the results achieved and the market prospects for relevant innovation products.

For each technology group, scores for all of the criteria mentioned above were obtained in the course of the study. The characteristics of the five most developed topics in the ''Rational Use of Natural Resources'' thematic area are given in Table II.

Among the most promising innovation projects selected by experts were:

- combined solid minerals extraction and deep processing systems (2010-2015);

- integrated information systems for evaluating the current state and forecasting the future state of the environment, based on Russian meteorological and natural resources satellites (2015-2020); and
- an atmospheric pollution monitoring system, capable of the early detection of conditions potentially leading to natural or anthropogenic environmental emergencies (2015-2020).

Thus, the major development areas relating to the ''Rational Use of Natural Resources'' field for the period until 2030 were described in the course of the exercise and technology groups with the best prospects and conditions for further development were identified, together with the most promising markets (and their specific segments) and appropriate innovative product groups with the potential to significantly increase the competitiveness of Russian natural resources companies.

In the FS2 framework, the sector's needs for and availability of human, financial and infrastructure resources were analysed, technological roadmaps for several high-technology market segments where Russia has the possibility to improve its positions were developed, and trajectories for implementing innovative projects and major promising research topics were identified.

At the same time, the FS2 results showed that the Russian management system in the natural resources area could be more effective and S&T development is almost impossible within the inertial development model for a number of reasons, including insufficient funding, obsolete and worn-out capital assets, lack of skilled personnel, exhausted reserves of easy-to-mine raw materials, increasingly more stringent environmental safety rules, etc. Probably the only way to bridge this gap is to identify new innovation priorities for the Russian management system; the identification of such priorities was the objective of FS3.

3.3 Innovation priorities for the Russian natural resources sector (FS3)

Innovation priorities for the Russian natural resources sector for the period until 2025 were identified in the course of a special study commissioned by the RF Ministry of Natural Resources and Ecology. ''Innovation priorities'' in the above study were considered to be major activities in the Russian natural resources sector's management system that would contribute to achieving the RF S&T priorities and solving the main problems in the area.

The following structural components of the natural resources sector were analysed in the framework of the project:

- mineral resources;
- water resources; and
- environment (i.e. air, biodiversity and specially protected nature areas, dangerous natural phenomena, industrial waste and cumulative ecological damage, and land and soils).

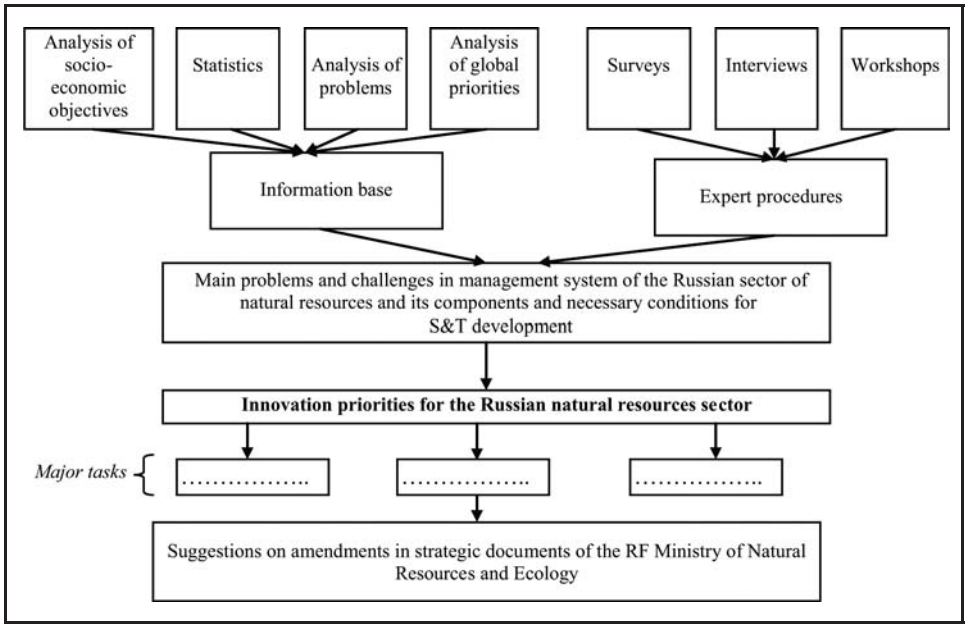
The overall structure of the project provided opportunities for broad involvement of all stakeholders into priority setting, developing a shared expert opinion concerning preferred medium- and long-term development alternatives, and used the project results to shape national policy. The project covered a wide range of information, analytical and expert studies (see Figure 2).

More than 100 experts from leading research centres and companies took part in the study, representing all sectors related to natural resources.

The innovation priorities until 2025 for the development of the Russian natural resources sector was developed on the basis of identification of the most important problems and challenges regarding the natural resources sector's management system and necessary conditions for S&T development. So, two main criteria were used for the identification of innovation priorities for the Russian natural resources sector, i.e.:

1. solving key problems; and
2. conditions for S&T priority realisation.

Figure 2 The overall structure of the study



As a result of this study, the innovation priorities and corresponding tasks were formulated for each structural component of the natural resources sector. Also, suggestions on amendments to strategic documents of RF Ministries were proposed. As an example, below are presented priorities for innovation-based development of the ''industrial waste and cumulative ecological damage'' sphere:

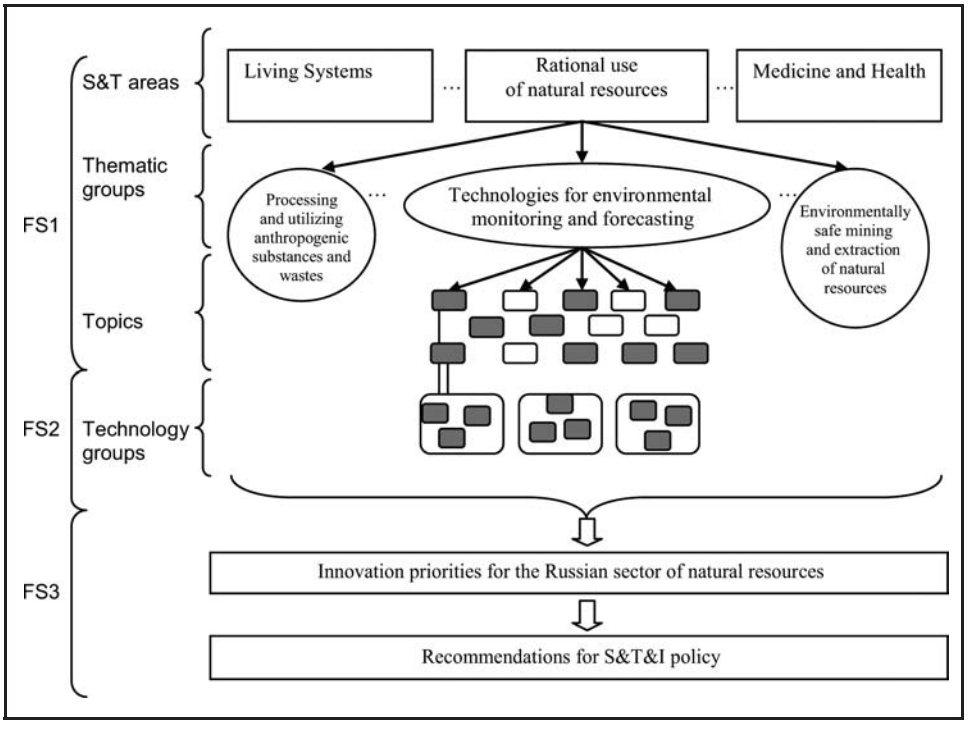
- creation of mechanisms for the elimination of cumulative ecological damage;
- improvements in the law enforcement system and law enforcement practice;
- designing effective economic mechanisms for stimulating enterprises to decrease waste formation; and
- increasing the efficiency of intersectoral interaction.

One of the tasks for the innovation priority ''Creation of Mechanisms for Elimination of Cumulative Ecological Damage'' was ''Development of a legal mechanism of responsibility for cumulative ecological damage, order of its assessment and compensation procedures''. For this task implementation it was suggested to that amendments were made to the Ecological Doctrine of the Russian Federation (i.e. to key factors of environmental degradation in Russia, the main principles of state ecological policy, the list of strategic approaches of natural environment restoration, and other sections), as well as corresponding amendments to the Civil Code of the Russian Federation, the Land Code of the Russian Federation and the federal law ''About Environmental Protection''.

So, as can be seen, all three studies were interrelated. The general scheme of the structure of the projects' interrelation is shown in Figure 3. The FS1 structure had three levels and the FS2 structure also had three levels. The main difference was at the third level. In the FS1 framework S&T topics were assessed by different criteria, and in the FS2 framework technology groups were assessed (identified on the basis of the most important and well-developed FS1 topics).

The FS2 criteria for the evaluation of technology groups were mostly identified on the basis of the results of FS1 (see Table I). National S&T Foresight: 2025 underlined the importance of improving the infrastructure and increasing the budget for R&D funding and training; these issues were the focus of FS2. So FS1 and FS2 were connected not only by what we should evaluate, but also by which criteria should we use.

Figure 3 The general scheme of the structure of projects interrelation



The results of both projects have become an important information source for the follow-up FS3 project devoted to innovation priorities for the Russian natural resources sector. FS3 was not interrelated with FS1 and FS2 structurally, but the results of FS2 showed (on the basis of the expert survey) that the Russian management system in the natural resources area needed to be much more effective and that this was preventing S&T development. FS3 was initiated on the basis of these results and commissioned by the RF Ministry of Natural Resources and Ecology (because the focus of FS3 is in the the sphere of responsibility of this Ministry). Also, the results of FS1 and FS2 that showed the crucial support measures for the government (FS1) and key limitations for S&T development (FS2) created the framework and demands for the identification in FS3 of innovation priorities (see Table III).

So all three projects were interrelated with each other in terms of their structure, criteria and results. Each of the follow-up projects was initiated for further investigation of and to supplement the results received from the previous project.

4. The influence of the foresight studies on policy decision-making

As can be seen above, in the FS1 framework a large database of promising S&T areas was created; this allowed policy makers to derive a wide range of an information, for example:

- key areas to strengthen positions of Russian producers in global markets on the basis of technological advantages;
- estimates of the level of Russian R&D *vis-à-vis* the world leaders for major S&T areas;
- possible time periods for obtaining R&D results, their commercial use and expected outcomes; and
- measures to support R&D and their commercialisation for all major S&T areas.

These FS1 results were used as an information source for many political purposes:

- revision of National S&T Priorities and Critical Technologies;

Table III The interrelation of the projects

	Research focus	*Main results*	*Questions for further investigation*
FS1	The evaluation of topics by the following criteria: importance, current level of Russian R&D, support measures and others	A large database of promising S&T areas, estimated by nine criteria by 2,000 experts. In particular the results showed that the most important support measures are improvement in the research infrastructure, and increasing the budget for R&D funding and training	The evaluation of required resources (human, financial and infrastructure) for the most important and well-developed topics and their market prospects
FS2	The evaluation of technology groups (as combinations of the most important and well-developed topic on the basis of the results of FS1) by the following criteria: contribution to innovative relevant projects, availability of human resources (researchers, engineers and technicians), required level of funding, fixed assets and others	Estimation of resources and risks List of markets and segments where Russia can improve its position Detailed description of chosen groups The most important innovation projects The most important research projects In particular, the results showed that the Russian management system in the natural resources area is not now really effective and this is preventing S&T development	Innovation priorities for the Russian management system in the natural resources area, which should create conditions for S&T development and promote solving the key problems identified in the FS2 framework
FS3	An identification of innovation priorities for the Russian management system in natural resources until 2030	The innovation priorities and corresponding tasks were formulated for each structural components of the natural resources sector. Also, suggestions for amendments to strategic documents of RF Ministries were proposed	Update of the list of innovation priorities

- design of large-scale innovation projects;
- identification of research projects to be funded within federal and sectoral goal-oriented S&T programmes;
- designing sectoral strategies for industries;
- regional priorities for innovation development; and
- priorities for international S&T co-operation.

However, the real contribution of the Delphi study results to the development of policy documents was mostly indirect because they were used only as one information source among others and we could not assess the real contribution of these materials. So according to our scale (see section 2) the influence of FS1 on policy-making was indirect.

In order to prepare direct recommendations for shaping S&T and innovation policy it is necessary to have more detailed and precise information about resource requirements, the evaluation of emerging markets, promising innovation projects and other information required for policy decision-making. These tasks were solved in the FS2 framework.

This study provided a more profound knowledge of national competitive advantages, the resources required for development of the most important S&T areas, and perspective innovation projects for investment.

The project-based recommendations for Russian S&T policy were used to adjust decision-making to future trends, whereas the technology roadmaps for perspective product groups created a background for particular measures aimed at development S&T. The RF Ministry of Education and Science used the lists of the most important innovation and research projects as a basis for the selection of projects to be funded. So in terms of our scale, the results of FS2 had a medium direct impact on policy-making because the results were used for decision-making at the level of the Ministry.

At the same time, the FS2 project showed that for full use of the priorities identified for the natural resources sector, Russia also needs to implement relevant institutional changes, and

create an adequate management system for the sector. It was for this purpose that the FS3 project was realised.

In the framework of this study proposals to amend the relevant RF Ministry of Natural Resources strategic documents (for example, Ecological Doctrine of the Russian Federation, Civil Code of the Russian Federation, Land Code of the Russian Federation, federal law ''About Environmental Protection'' and others) were prepared in accordance with the selected priorities and major tasks for each component of the natural resources sector. Also the RF Geologic Strategy and Water Strategy were developed on the basis of the innovation priorities for the Russian natural resources sector. Therefore, we can conclude that the results of FS3 had a high direct impact on policy-making.

The summary of the projects' influence on policy-making is shown in Table IV, in which the relative evaluation of this influence is given.

5. Conclusion

The problems and major challenges that the natural resources sector is facing, its significant scale, and the large number of players, imply the need to use integrated approaches for identifying S&T and innovation priorities for this sector.

The innovation and S&T priorities for the Russian natural resources sector were identified in the framework of three connected foresight projects.

Table IV The influence of the foresight studies on policy decision-making

Influence on policy-making		*Evaluation of influence on policy-making*
FS1	The foresight data were used as an information source for many political purposes: – revision of National S&T Priorities and Critical Technologies: – design of large-scale innovation projects – identification of research projects to be funded within federal and sectoral goal-oriented S&T programmes – designing sectoral strategies for industries – regional priorities for innovation development – priorities for international S&T cooperation However, the real contribution of the Delphi study results to policy documents was mostly indirect because we could not assess to what extent the project materials were in the development of these documents	Indirect
FS2	The project-based recommendations for Russian S&T policy were used to adjust decision-making to future trends, whereas the technology roadmaps for perspective product groups created a background for particular measures aimed at the development of S&T. The RF Ministry of Education and Science used the lists of the most important innovation and research projects as a basis for the selection of projects to be funded	Direct (medium)
FS3	In the framework of this study, proposals to amend relevant strategic documents of the RF Ministry of Natural Resources (e.g. Ecological Doctrine of the Russian Federation, Civil Code of the Russian Federation, Land Code of the Russian Federation, federal law ''About Environmental Protection'', and others) were prepared in accordance with the selected priorities and major tasks for each component of the natural resources sector. Also the RF Geologic Strategy and Water Strategy were developed on the basis of the innovation priorities for the Russian natural resources sector	Direct (high)

The first of these projects identified major S&T results in the ''Rational Use of Natural Resources'' area, assessed the current level of Russia's S&T development, and the country's international S&T co-operation potential through the development of a national innovation system. The study significantly extended the information basis for policy-making, which however could not be used directly in decision-making. A clear need was highlighted for more detailed analysis of future demand for human, financial and other types of resources for S&T development.

The results of the FS2 project included the evaluation of technology groups and the identification of those that had the best prospects and conditions for further advancement; the most promising markets (and their segments) for Russian natural resources companies. Assessment of personnel, financial and technological requirements, and the potential for further S&T development identified the need to increase appropriate investments significantly. Also, major innovation projects were identified with the promise of high economic and social return. On the basis of this project recommendations for Russian S&T policy which include the most important research and innovation projects were prepared. The RF Ministry of Education and Science used the lists compiled as a basis for selection of the projects to be funded. However, according to summarised expert opinion, the FS2 policy recommendations are impossible to realise without solving problems in the management system.

The FS3 course identified the innovation priorities and corresponding tasks for improving the management system the Russian natural resources sector, which would contribute to its innovation-based development and help to solve major environmental problems. The results of this project were strongly related to policy decision-making, and some strategic documents (Geologic Strategy, Water Strategy) were prepared on the basis of the output of the study.

So, the analysis showed the synergy of all three projects help to achieve results that had a strong influence on policy decision-making. Therefore for better connection to policy decision-making one might conclude that a common, widespread national Delphi survey for the identification S&T priorities (which was our FS1) should be complemented by the identification of key long-term demand for resources (which was our FS2) and a reshaped management system (which was our FS3). This could be the step from just informing policy to designing policy.

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Further reading

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