STUDIES OF STRATEGIES AND MANAGEMENT

METHODOLOGY OF TECHNOLOGY MAPPING IN VIETNAM

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Abstract

This paper introduce methodology of technology mapping in Vietnam, in which includes technology map for industries, products and technology fields. Technology mapping will provide some specific information of technological status, gap among technologies in the world. Authors also analyses the status and trend of technology development, regional and world market. It provides the important information for management agencies, research institutes, training organizations, associations and other enterprises in industry. The technology maps primarily distinguished in structure of technology maps as defining the objectives, scope, technology tree, market analysis or technology application.

Keyword: *Technology mapping; Methodology.*

Code: *16081802*

1. Introduction

Experience in some countries showed that before developing technology mapping, it is necessary to survey and assess technology current status and capacity in industry and R&D capacity in institutes/universities. Database of technology status and capacity as well as technology gap can be developed ahead or parallel with carrying out building technology roadmap, depending on the development level of this country. Normally, developed countries have multiple different databases are dispersed in industry and management organizations, they only conduct to synthetic current status serving to develop roadmap.

Because of appearing in the most advanced science and technology country (USA) where technology roadmapping based on current technologies is significantly concerned, USA and other developed countries frequently use the phrase "technology roadmapping" rather than "technology map". In

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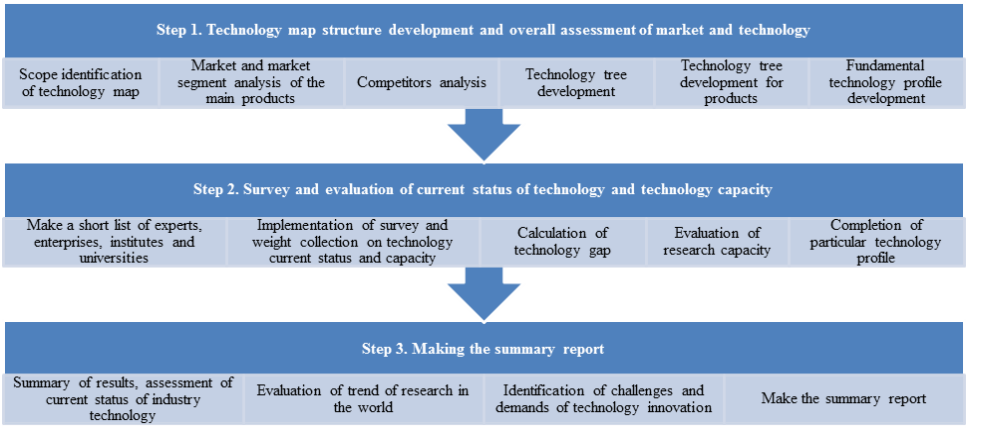
other developing countries including China, the S&T statistic database is too insufficient, the investment resources for innovating and developing technologies is too weak so instead of using the phrase "technology roadmapping", they use 03 phrases: technology map, technology roadmapping and technology innovation roadmapping. This way will indicate clearly the suitable steps for Vietnam condition in the process of industrialization and modernization.

In the report, the authors introduced a feasible approach of technology mapping in Vietnam in the point of view of the application for "following countries" with the purpose to assess technology status and competitors, making development and technology innovation plans in optimal ways to saves investment costs, improve quality, productivity and competitiveness of enterprises.

During the working, the professional experts from Fraunhofer ISI, Strategic Business Insight and Korea Institute of Science & Technology Evaluation and Planning provide very helpful support to establish the necessary methodologies for technology mapping, roadmapping in Vietnam

2. Technology mapping process

Technology mapping process will be implemented in three steps as follows:



Source: State Agency for Technology Innovation (SATI)

Figure 1. Process of developing technology roadmap

2.1. Step 1. Technology map structure development and overall assessment of market and technology

2.1.1. Step 1.1. Identification of objectives and scope of technology map

The identification of objectives and scope of technology map is based on selected objects for technology mapping, including a technology industry (engineering, biology, electronics, new materials, etc.) or a manufacturing industry (shipbuilding, pharmaceuticals, chemicals, etc.) or a sub-sector (agricultural machinery mechanics, mechatronics, etc.) and an even smaller product group (mold, vaccines and similar rice, etc.). The selection of objects will determine the scale and scope of technology map including the identification of related technologies and products.

The application objective of technology map is to define which organizations will mainly use this technology map. For state management agencies, technology map will be developed with a low level of detail, and high level of generality. For large enterprises focusing on new product development, technology map will have a higher level of detail. In this case, technology tree will be analyzed to the extent of patents.

2.1.2. Step 1.2. Market and market segment analysis

Before market analysis is implemented, the main products which are being considered in the industry need to be classified according to the technical characteristics from low to high of the products.

In this step, the group of technology mapping will analyze the current situation and market trends (market size, market segment) for each group of products or technology application classified above. This information can be collected through the synthesis and analysis of reports on domestic and foreign industry market as well as directly through the investigation at enterprises, research units and economics and management experts. In case of necessity, the group of technology mapping need to estimate the required volume of information and the cost to buy the market reports (if necessary), especially the foreign reports.

2.1.3. Step 1.3. Competitor analysis

Competitors analysis is for the purpose of identification of comparable objects in technology map. Identification of comparable objects is a prerequisite to assess the technology gap. Technological gap can be determined when a technology is compared to the most currently advanced technology in the world (in the growth phase) or compared to the identified comparable object.

For examples, comparable objective for enterprises is the competitors on the domestic or foreign market. For sectors, industries of the country, comparable objective is competitive nations in international markets. For example, for Vietnam's rice industry, Thailand’s and China’s is the main

competitors. The technology in Vietnam will be compared to the technology being used in China and Thailand.

Assessment of competitors as a whole shall be made by SWOT analysis. Besides that, information on support policies of the government and the market share will be aggregated from the reports available in the world.

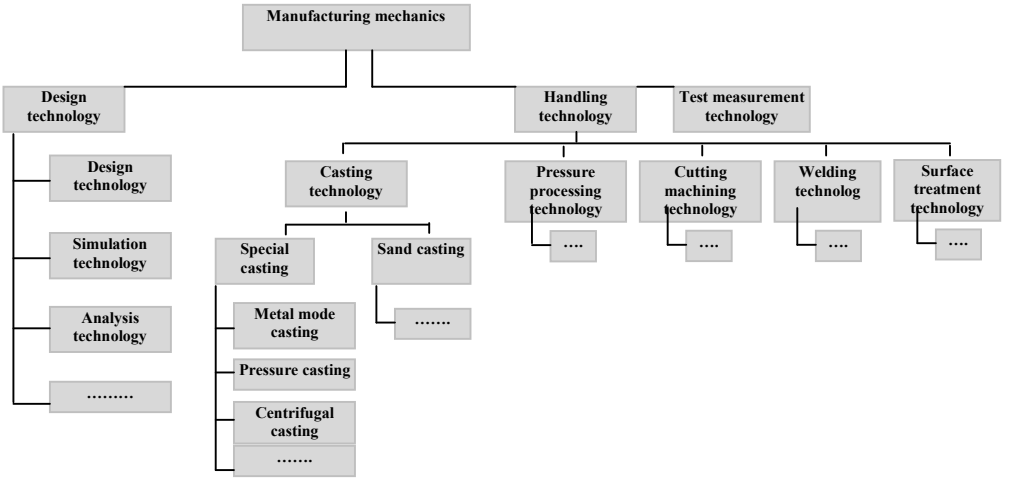
2.1.4. Step 1.4. Technology tree development

In this step, the more detailed technologies will be continued to develop in turns by each layer to the final specific technology identified in the scope of the technology map. A technology portfolio by each layer will be determined with the amount of technology in every layer and the names of each specific technology.

After the detailed list of technologies has been identified, it is necessary to identify how many technologies in this list each product or specific application needs. (eg. blow mold in the mold group will involve 59 technologies among 89 major technologies in layer 4) as well as how many products a technology can have an impact on. This makes sense in defining the roles of each technology in product manufacturing.

Developing technology according to production processing can be made with disciplines, sub-disciplines and enterprises.

For example, in manufacturing mechanics, technologies in this discipline can divide as following:



Source: State Agency for Technology Innovation, 2015

Figure 2. Technology branches of technology tree

2.1.5. Step 1.5. Fundamental technology profile development

Fundamental technology profile development includes the main content is described in the following table: technology describe, technology application and technology cycle, technology current status, technology capacity, technology gap, research and development trends,…

<table>
<tr><td>Name of technology</td><td colspan="6"></td></tr>
<tr><td>Technology layer</td><td>n</td><td>n + 1</td><td>n + 2</td><td>…</td><td>…</td><td>k</td></tr>
<tr><td colspan="7">Scope of application</td></tr>
<tr><td colspan="7">Technology description</td></tr>
<tr><td colspan="7">Actual state of technology: Assessing the characteristics, specifications, year of production of technologies (device/software)</td></tr>
<tr><td rowspan="2">Technology capacity</td><td colspan="4">Production capacity: selecting, using technology, operating, maintaining technical specifications effectively</td><td colspan="2">Ownership organizations</td></tr>
<tr><td colspan="4">Research capacity: improving and developing new technologies, main challenges and the technological readiness</td><td colspan="2">Implementing organizations</td></tr>
<tr><td colspan="7">Technology cycle/technology generation: year, specifications, new products etc.</td></tr>
<tr><td rowspan="2">Comparing with other countries</td><td colspan="2">Production capacity</td><td colspan="4">Comparing the specifications with definite objects (world or region leader…)</td></tr>
<tr><td colspan="2">Research capacity</td><td colspan="4">Research and development orientations of the world, comparing with Vietnam</td></tr>
<tr><td colspan="3">Assessment the gap with other countries in the world (%)</td><td colspan="4"></td></tr>
</table>

Source: State Agency for Technology Innovation, 2015

Figure 3. Information of development in technology profile

2.2. Step 2. Survey and assessment of current status of technology and technology capacity

2.2.1. Step 2.1. Make a list of experts, enterprises, institutes and universities

Survey to assess the current status is the most important activity to be taken for the purpose of capture the entire current status of the existing technologies in Vietnam. On this basis, the state agencies have the overview assessment of the level of technology of Vietnam, identify the existence and orient R&D activities to enhance common technology platforms as well as promote the absorption and mastery of technology in the enterprises. In the ideal case, all the businesses and the institutes related

to the technology mapped sector will be investigated and assessed. However, in cases of finance and time is not permitted, before the investigation, the technology mapping group should identify objects that will be investigated and taken consultation, including: industry experts, enterprises in the sector (at the recommendation of the experts, preliminary assessment of technology capacity of the enterprises by associations), develop the list of enterprises, institutes, universities, conduct a preliminary assessment to classify into different technology levels: advanced, moderate, weak. The purpose of classification is to make a short list of enterprises, institutions, universities for survey and assessment of current status of technology and technology capacity.

2.2.2. Step 2.2. Implementation of survey and assessment of current status of technology and technology capacity

Designing the Questionnaires on investigating enterprises and research units

With the results of the technology profiles developed above, technology mapping group conducts to develop survey framework to supplement and clarify the information in the technology profiles (specific technology profile and general technology profile) including equipment capacity (generation, specifications, etc), operating capacity (management and innovation, production, human resources), investment and research capacity (challenges to be solved, research orientation, technological readiness level of the study) in enterprises, institutes and universities.

Technology mapping group needs to design the Questionnaire on the current status and technology capacity for the enterprises and another for the research units.

Survey implementation

Selection and identification of leading enterprises, research units for each technology or technology branch and making a list of the units to conduct a survey.

Working with enterprises, research units to assess the current status and technology capacity of each unit, identification of key technologies, core technologies of each investigated unit.

Making a summary report of survey results for each investigated unit.

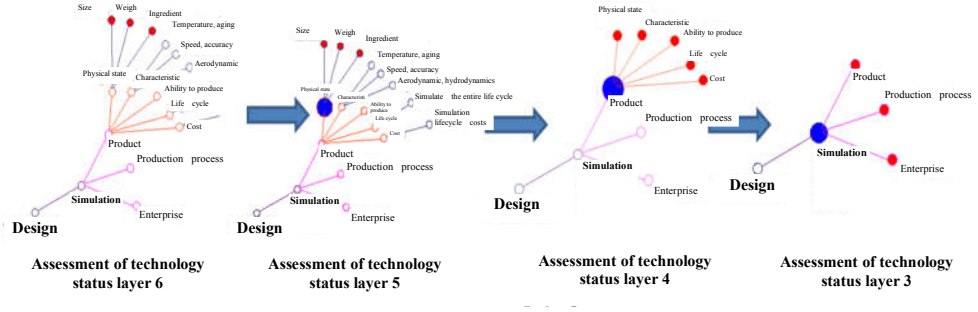
Analysis of results and integration into technology profile

Analysis and assessment of technology capacity and current status of each investigated object. The survey results will be integrated into the

technology profiles and assessment the technology gap of Vietnam compared to the world based on the best owned technology of enterprises and research units. Important technologies, core technologies will be identified in each technology branch in the technology map of the investigated object.

2.2.3. Step 2.3. Calculation of technology gap

There are two approaches used to calculate the technology gap. For specific technology, technical characteristics of the technology are used to directly compare technologies such as precision, the probability of damage, surface gloss, handled types of material, etc. For the production technology including different technologies or for the core technologies held exclusively and confidentially by enterprises, technical characteristics of the products are used to compare technologies for manufacturing such products.



Source: State Agency for Technology Innovation, 2015

Figure 4. Method to assess technology gap from detail layer to general layer

2.2.4. Step 2.4. Evaluation of research capacity

Evaluation of research capacity is based on experts' opinions on the research results (if any) of enterprises, institutes, universities. Experts will assess the overall research results by the method of evaluation of technology readiness level. On that basis, the technology mapping group will assess the overall research capacity of enterprises, institutes, universities for each specific technologies and common technologies in the higher layer.

Technology readiness level is used to evaluate R&D activities of the institutes, universities for a specific technology. If a technology has a high readiness level, it means that technology has the short production time. In this case, the cooperative promotion of institutes, universities and enterprises or some forms of commercialization are focused more than

R&D activities in order to continue research on the technology. If the technology readiness level is low for the technologies that has been identified as important, there should be the R&D programs to improve the technology readiness level, such as the program to develop the prototype, improve technology in the actual operating environment and so on.

2.2.5. Step 2.5. Completion of particular technology profile

Completing information in technology profile which was developed in step 1.5. In step 1.5, the fundamental information of technology is analyzed, assessed and updated in technology profile including technology description, technology application into products, fields and information of technology current status in the world. After implementing the step 2.2, 2.3, 2.4, the technology mapping group will supplement the information about technology gap between manufacturing and operating capability, research capability of institutes/universities, enterprises to completion the lower layer of technology profile and calculate the technology gap comparing with the higher layer ones.

2.3. Step 3. Making the summary report

2.3.1. Step 3.1. Summary of results, assessment of current status of industry technology

Aggregation and arrangement of technology by layers; completion of technology profile of each technology; aggregation and identification of the linkages between technology and related products; identification of the owners of the best technology and the national distribution of the owners; implementation of calculating and assessing the technology current status and capacity in layers from the particular to the general; making the summary reports by analyzed from the database system of technology map, showing the results by the various charts and drawings.

2.3.2. Step 3.2. Assessment of trend in research in the world

Bibliometric method

This method is used to analyze and forecast trends in research based on the keyword search of the key technologies in the large database of scientific publications in the world, such as SCOPUS, Springer, ISIKNOWLEDGE. Thanks to that, we can identify and forecast trends in research in the world as well as support the development of the technology lifecycle (along with patent analysis method).

Patent analysis method

Patent analysis method is applied with two main objectives:

- Analysis of development trends of technology in the world and development of technology lifecycle (based on the density of the patents related to technology);
- Overview assessment of basic research capacity, domestic applied research and identification of sectors tending to focus on research (including from the state budget and private).

In addition, international experience shows that, in some specific cases, experts use patent analysis method to develop technology tree in areas without technology tree of specific technology (as in the case of mechanical technology).

Besides the application in technology mapping, patent analysis is also applied to the fields of scientific publications for the development of current status map of national science and technology capacity.

2.3.3. Step 3.3. Identification of challenges and demands of technology innovation

Demand of technological innovation is determined based on three main factors including: the level of product in the potential market segment, the level of importance of technology and technology gaps, demand of technological innovation in enterprises. First, the technology mapping group need to clearly recognize the potential market segments with specific requirements on the level of the product to identify technology needs. It is unreasonable to provide the product level higher than the existing technological capacity which leads to the identification of needs technological innovation not necessary.

The information on technology innovation demand in enterprises is collected from the surveys as well as through the direct exchange, interviews with enterprises. The technology demand should be aggregated and analyzed to identify high-demand technologies in the enterprises. Then, through the evaluation results of the level of importance of technology, technology mapping group will synthesize and make a list of technologies that demand high-tech innovation in the future with information details can.

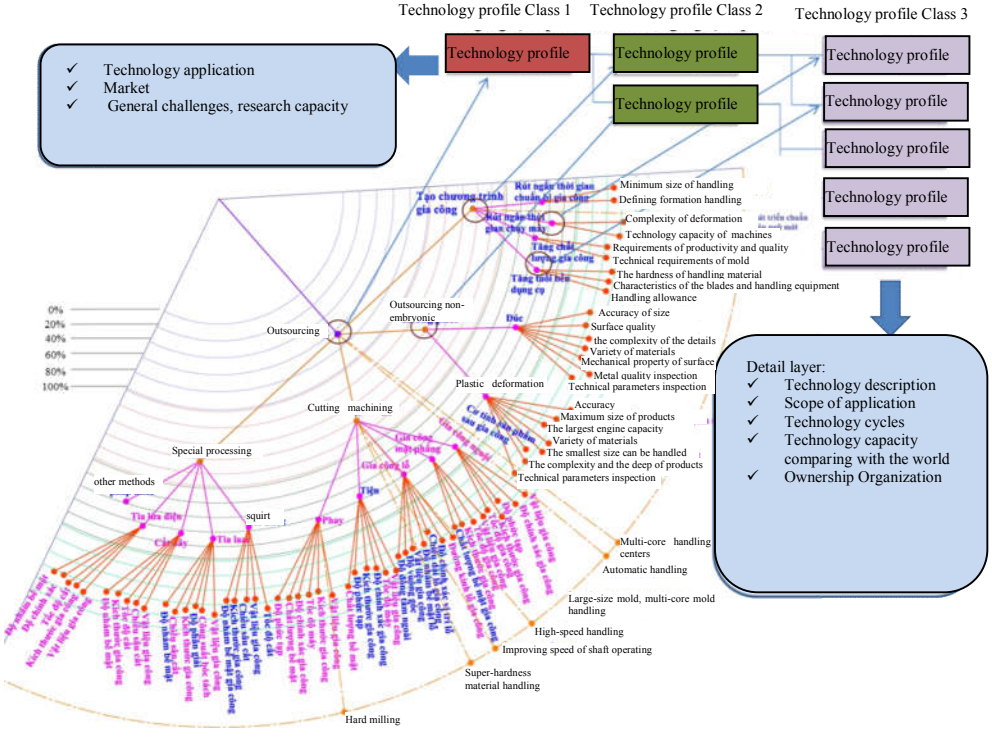
2.3.4. Step 3.4. Making the summary report

After aggregation of results of technology mapping, the next step is completion of the database system and making the detailed assessment report according to main contents.

The basic structure of the summary report on technology mapping should meet the following minimum contents

1. General introduction
2. Technology current status
3. Analysis of relationship between technology and product
4. Development trend
5. Aggregation and demonstration of the result of technology mapping:

According to the Figure 5, technology mapping has provided the needed information for all levels from national to ministries and enterprises. The national level will be interested in information about the general class technology (class 1) as a basis to develop national R&D program. For the ministerial level, the industry would be interested in information about the deeper layer technology (class 2.3) as a basis for determining the tasks of S&T research. Enterprises will focus on the details class technology relating to products of enterprises to research, develop or purchase of technology.



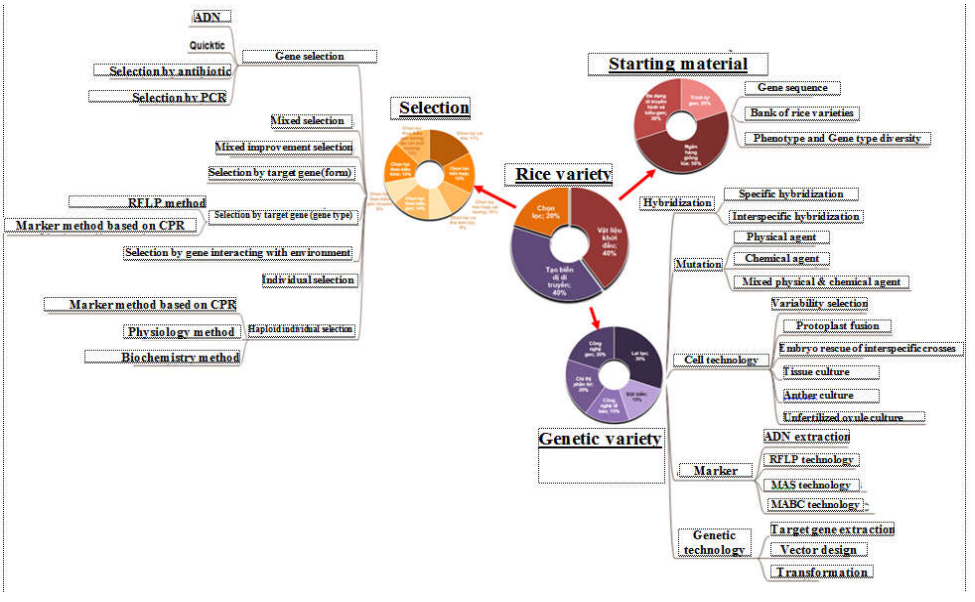
Source: Technology roadmapping in mold manufacturing industry, SATI

Figure 5. Example of developing subclass structure of technology mapping

3. Example in application technology mapping development for rice variety selection in Vietnam

Vietnam's demand of rice variety in 2015 is estimated at 1.2 million tonnes (source: OECD), which accounted for almost 96% pure rice, concentrated mainly in the Mekong Delta. Ability to meet the needs of hybrid rice varieties: 33% of the demand. Remaining imports from China, India. With the import value of approximately $35 million, Vietnam has 17 units selecting major variety, including 6 companies, 11 institutes and universities. There are 263 enterprises manufacturing and trading varieties, including 5 large enterprises account for more than 30% market share of rice in the country.

Vietnam's rice varieties are mainly at level 3 and level 2 without level 1 variety which is equivalent to the main varieties of countries like Jassmine (USA), Honda4 (Japan), Basmati (Indian). Most local varieties (dominant gene can develop brand) are at level 3, which is lower than the rice varieties are being developed on the large scale today. Especially for hybrid rice, Vietnam has made the sterility varieties (TGMS, CMS), but with the insignificant quantity. There is no combination of hybrid rice creating from this sterility varieties using to produce hybrid rice in Vietnam. Vietnam's hybrid rice varieties currently used the sterility varieties such as 32A, T196S, 103S originated from China and 25A, 9A from India.

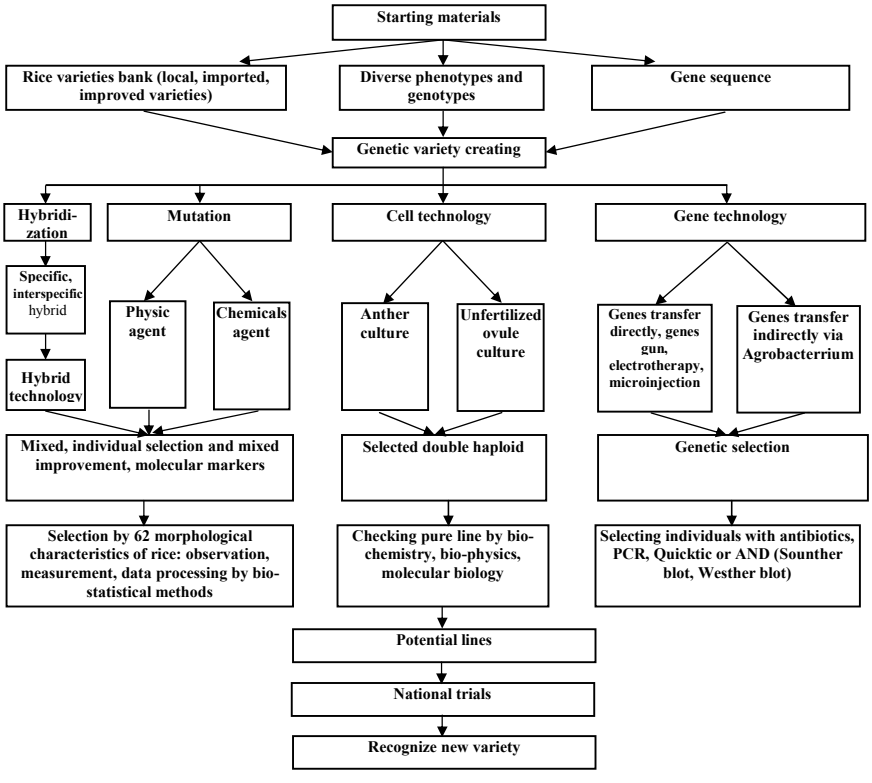


Source: Technology roadmapping in rice variety selection, Vietnam National Seed Joint Stock Company

Figure 6. Component technology in rice variety selection

Technology mapping has assessed 40 major technologies in creating and selecting genetic varieties which can be used as 18 technology combinations (14 combinations are widely used in the world and 4 combinations currently not applicable). Technological capacity in rice variety selection of Vietnam equals 46% of the world in which technology of creating starting materials by 38% the world's, technology of creating genetic variation by 49% of and selection technology by 47.9% compared to the world.

Noteworthy that technology of creating starting materials of Vietnam only reached 38% comparing to the world because the assessing technology of morphological and genotype diversity account for 30% (Vietnam only assesses morphological and about 10% of the genotype diversity) and genome sequencing technology takes only 10% compared to the world (Vietnam decoded 36 new local varieties but have accessed this technology). Meanwhile, most of the senior professionals in the rice sector recognize the significant importance of technology of creating starting materials for the development of the rice variety selection in Vietnam.

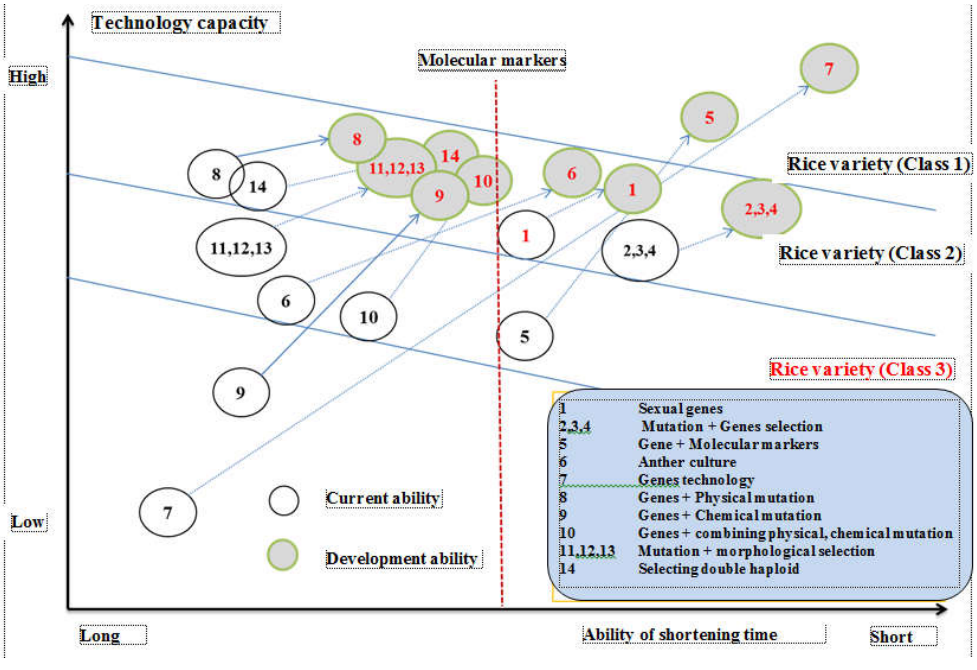


Source: Technology roadmapping in rice variety selection, Vietnam National Seed Joint Stock Company

Figure 7. Process of rice variety according to technology combinations

Although the genetic variation technology accounts for 49% compared to the world, but the new technologies such as genetic technology takes only 18% compared to the world and cannot come up with GM varieties which have ability to commercialization.

Technology mapping analyzes technological capability, technology trends for current 14 technology combinations is being widely used in the world in which Vietnam mastered only 5 combinations based on traditional technologies. Based on evaluation of the technological capacity of component technologies in Vietnam and growing trend in the world, technology mapping analyzed and proposed 5 combinations which need to preferential develop (7 combinations can be used to develop level 2 and level 1 rice varieties) include: sexual hybridization + selective genotyping, physics mutation + genotype selection, m***arker assisted*** hybridization (MAS, MABC), anther culture and genetic technology.

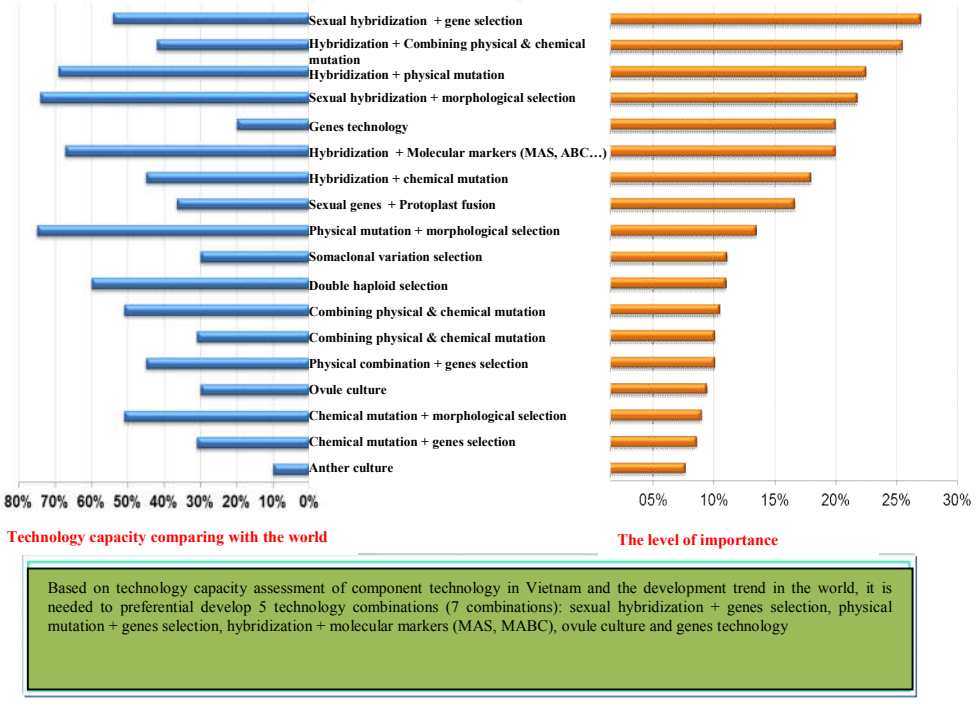


Source: Technology roadmapping in rice variety selection, Vietnam National Seed Joint Stock Company

Figure 8. Response capacity of technology combination according to rice variety levels

The results of technology mapping proposed technology roadmap with specific goals, such as developing 2-3 indigenous aromatic rice varieties to increase productivity up 6- 7 tonnes/ha without changing existing features

(from level 3 to level 2); Selecting rice varieties (level 2) which can export 600-800USD/tonne with specific features include: productivity of spring crop is 7-8 tonnes /ha, 6 tonnes/ha in crop, grain length > 7mm, amylose content <20%; Selecting varieties (level 2) can respond to climate change include: salinity tolerant rice varieties up to 8 per thousand, productivity 6-7 tonnes/ha, drought-resistant rice varieties from 15-20 days, yield 5-6 tonnes/ha, submergence-tolerant rice varieties from 7-12 days, yield 6-7 tonnes/ha; selecting Japonica (level 2): productivity 7-8 tonnes/ha, rounded grains, clear, amylose <18%, disease resistance, fragrant; Choosing varieties with high productivity from 9 tons or more for the super rice.



Source: Technology roadmapping in rice variety selection, Vietnam National Seed Joint Stock Company

Figure 9. Current capacity and importance level of technology combinations

On that basis of analyzing, we selected 11 primary technologies in 5 technology combinations to develop priorities in the period to 2035. Technology mapping proposed to focus on 6national R&D program, 9 ministerial R&D programs and new investment for 6 infrastructures to develop commercial varieties level 2 and level 1.

Conclusion

Methodology of technology maps at all levels including 3 main steps: Develop structure of technology map and evaluate technologies with applications/products; surveys, reviews the current state of technology, technology capabilities and prepare report. In particular, investigations and surveys to collect data on the current state of technology requires time and large-scale and should be detailed the implementation plan. In paper also proposes a specific method can be used to create technology map such as technology tree, assess technology gap, assess technology readiness level base on international experience. This methodology has been applied in a number of technology maps for products (technological map of molding, rice, vaccines) and technology fields (stem cell technology, genetic engineering) and in accordance with the assessment of technological capacity of Vietnam./.

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