Technology Identification of South-South Cooperation on Climate Change of Developing Countries: A Case of the Countries Along OBOR

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Abstract--**The issue of Climate change has become a corn concern of the humanity. Appropriate technology and partner identification for mitigation and adaptation to climate change is the key to South-South cooperation. There has an urgently needs for technologies in developing countries while lack of information. This paper presents a scientometric analysis of research work to establish evaluation index system of science and technology strength on climate change from two sides of scientific research and technology development through output data in the Science Citation Index Expanded database (DB SCIE) and European Patent Office Worldwide Patent Statistical Database (DB EPO) from 2003 to 2014. Then we evaluate the scientific strength of key requirements fields of developing countries and get a comprehensive grasp of the status quo distribution of world-class technology, world-class organization and world-class professional. We hope the answers can be used to comprehend the scientific research and technology development level on climate change of the world's major countries and China, so as to provide reference for the partner selection of the technology transfer, the technology service and the technology information exchange of developing countries and to provide the theory foundation for the technology cooperation between China and the countries along the OBOR.**

I. INTRODUCTION

Human activities are the main cause of the rising of the atmospheric concentration of greenhouse gases [19]. With the increased understanding to the own problem of human, the issue of Climate change has become a corn concern of the entire human race [2] [23] [11]. In order to achieve more constructive consensus, the UN climate talks had never been stopped since the adoption of the world's first international convention which was aiming to tackle global warming in 1992. Henceforward, the Kyoto Protocol and the Gopenhagen Accord have adopted in 1997 and 2009, slow progress in a hard time. On December12th, 2015, the Paris Agreement was unanimously adopted by Nearly 200 parties of United Nations Framework Convention on Climate Change (UNFCCC) as contained in its objective, mitigation, adaption, vulnerability, Financial, technology, capacity-building, transparency framework and global stocktake. More than ever before, there has been a fundamental shift in the mode of the UN climate talks: emission compulsively with showdown was replaced by the intended nationally determined contributions. To promote cooperation is the theme in the Era of the Global Economic Integration, and strengthening cooperation on climate change technology development and transfer between developed and developing countries is no exception. The drives of the international transfer of climate change technologies came from external factor and internal factor include Intellectual Property regimes, international trade, foreign direct investment and local technological capabilities tend [8]. With the rapid diffusion of mitigation and adaptation technologies, the role of intellectual property rights in the development and transfer of climate change technologies has been a contentious issue in negotiations under the UNFCCC [1]. The traditional North-South paradigm lacked emphasis of developing countries as sources of advanced climate-friendly technologies, so they emphasized developing countries' intellectual property rights policies as barriers to technology transfers. The more extensive paradigm, include South-North and South-South paradigm, focuses on international trade and investment policy [4]. In this paper, we defined a generalized South-South cooperation as the cooperation among developing countries on climate changes primarily, especially the cooperation between China and the developing countries. Developed countries stand in the leading position in current world political and economic order, they assume the main technology of the fight against climate change, so we have not eliminated the cooperation between developing countries and developed countries instead of establishing models of cooperation pattern through South-South cooperation, thus clearing away obstacles for South-North cooperation. Before proposed the conception of this paper, we analyzed the barrier of technology transfer from the technology needs assessment reports for developing country from UNFCCC according to the standpoint of the majority of developing countries. The results show that the main technology transfer barrier include lack of capital investment, market imperfection and market instability, capacity-building, information dissymmetry, law and policy, intellectual property rights, traditional culture and public awareness. We focus on the research of the information dissymmetry, which mainly refers to a lack of mutual understanding of South-South counties. Specifically, the government or the industry of developing countries has no knowledge of which viable and environment-friendly technology at home and abroad can be used in their country. Conversely, the institute and enterprise of developed countries also didn't know much about what main technology the developing countries suit. Policy-makers will likely make poor decisions if developing countries lack of information on the application of technology, application range, technology parameters, technology transfer institutes and the funds come from developed countries and international organization.

China pays a great deal of attention to its cooperation with developing countries in the field of climate change [3]. By executing the strategy of "go global", more and more Chinese companies have an opportunity to participate in the world economy, and Chinese government support and encourage Chinese companies investment in oversea, especially in developing countries. Since 2011, the Chinese juggernaut started sputtering with its overcapacity and high dependence on imported hydrocarbon resources and mineral resources. In order to facilitate the free flow and the optimized distribution of economic factors, China is carrying out the strategy of One Belt, One Road, which stands for the Silk Road Economic Belt and the 21st Century Maritime Silk Road initiatives, called "OBOR" for short, offer opportunities for China and the countries along the route. "One Belt" refers to the Silk Road Economic Belt, which proposed by Chinese President Xi Jinping On September 7, 2013 at Nazarbayev University Astana, Kazakhstan, he is calling for China and Central Asia join hands to build a Silk Road economic belt to boost cooperation. The intention is to help Eurasian countries, especially central Asian countries, to grow rapidly in economy while achieving fast development in China. It is a mutually beneficial and win–win option for central Asia and China [18]. Actually, The Silk Road is an ancient (The original ''Silk Road'' was established over 2100 years ago during the Han Dynasty (206 BC–AD 24)) network of trade and cultural transmission routes that were central to cultural interaction through regions of the Asian continent connecting the West and East by merchants, pilgrims, monks, soldiers, nomads, and urban dwellers from China and India to the Mediterranean Sea during various periods of time. The other part of the plan is the so-called 21st Century Maritime Silk Road, also known as "One Road", which begins in southern China and heads to the Malacca Strait in Southeast Asia. It then goes to include countries such as India and Kenya. The Maritime Silk Road moves on north to enter into the Red Sea and the Mediterranean through Horn of Africa. It meets the land-based Silk Road in Venice.

Trade on the Silk Road was a chief driving factor in the development of the civilizations of China, the Indian subcontinent, Persia, Europe, the Horn of Africa and Arabia, opening long-distance, political and economic relations between the civilizations [13]. Though silk was certainly the major trade item from China, many other goods were traded, and religions, syncretic philosophies, and various technologies, as well as diseases, also travelled along the Silk Routes. In addition to economic trade, the Silk Road served as a means of carrying out cultural trade among the civilizations along its network [14].

The main traders during antiquity were the Chinese, Persians, Somalis, Greeks, Syrians, Romans, Armenians, Indians, and Bactrians, and from the 5th to the 8th century the Sogdians. Following the emergence of Islam, Arab traders became prominent. Nowadays, OBOR is open for cooperation. It covers, but is not limited to, the area of the ancient Silk Road. It is open to all countries, and international and regional organizations for engagement, so that the results of the concerted efforts will benefit wider areas. David Daokui Li et al. (2014) [7] argue that the OBOR in geographically economic sense starts from China on the east end of the Eurasia continent, passes through Central Asia, West Asia, South Asia and some other regions by three lines, approaches the Caspian, Black Sea, Mediterranean Sea and the Arabian Peninsula, and arrives in Europe and North Africa on the west end of Eurasia. In this paper, for research purpose, we define the countries alone the route in geographical point as shown in the following table 1. In country selection, many middle-income, developing countries with a diversified economy based on agriculture, industry, and energy have been involved. Meanwhile, we drawn a picture of the OBOR by refer to Wikipedia (https://en.wikipedia.org/wiki/Silk_Road) and UNFCCC (http://unfccc.int/ttclear/templates/render_cms_page?TNR_cre) show as in figure 1.

The international Technology transfer as a kind of transactions has a major part to play in learning of the advanced technology and promotion of technology capability for developing countries [10]. The overall strategy for OBOR of the implementation in China means that China is vigorously seeking opportunity of cooperation with the developing countries along the OBOR through broad-based international communication. As the largest developing country, China, on the one hand, needs to transfer their advance technology by the method of technology training, technology demonstration, cooperative research, policy advice, technology services and etc., while on the other China also requires to improve the technology level through learn from developed countries. However, the pattern of these different kinds of cooperation is inseparable from teaching and learning for china, but for developing countries as well. In this regard, it is particularly important to select and evaluate partner for developing countries and developed countries. For the developing countries, they urgently need technologies to tackle climate change while lack of related information to cause them unacquainted with the appropriate technology. For the developed countries, they lack of the information of where or who suit their technology though they hold the advanced technology. In brief, the less and incomplete information intermediary institutions is one of the main obstacle to the technology transfer of climate change [16] [5] [21] [26]. Despite plenty of obstacle study on technology transfer, no one has yet been proposed specific measures for information exchange. In this research, for solving the above problems, a technology identification information system was established. First, we identified urgently technologies through analyzed the UNFCCC technology needs assessment reports for developing country along the OBOR and classified it. Then we refined the above-identified technologies for obtained more comprehensive information. Third, we made the paper and patent retrieve strategy of this refined technologies according to the regulations of the DB SCIE and DB EPO and we downloaded the paper and the patent dada from 2003 to 2014 as database for our system. Forth, we bring forwarded the index system for the identification of world-class technologies, world-class professionals and world-class

TABLE 1 THE COUNTRIES ALONE THE ROUTE IN GEOGRAPHICAL POINT

Geographical Position	Countries
East Asia	Mongolia, Malaysia, Indonesia, Myanmar, Thailand, Laos, Cambodia, Viet Nam, Brunei, Philippines
Western Asia	Iran, Iraq, Turkey, Syria, Jordan, Lebanon, Palestine, Saudi Arabia, Yemen, Oman, United Emirates, Qatar, Kuwait, Bahrain, Cyprus, Azerbaijan, Georgia, Armenia
South Asia	India, Pakistan, Bangladesh, Sri Lanka, Maldives, Nepal, Bhutan
Central Asia	Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, Afghanistan, Kyrgyzstan
Eastern Europe	Russia, Ukraine, Greece, Belarus, Poland, Lithuania, Latvia, Czech Republic, Hungary, Croatia, Bosnia Herzegovina, Montenegro, Serbia, Albania, Romania, Bulgaria, Macedonia, Moldova
East African	Kenya, Tanzania, Rwanda, Zambia
North African	Egypt, Sudan

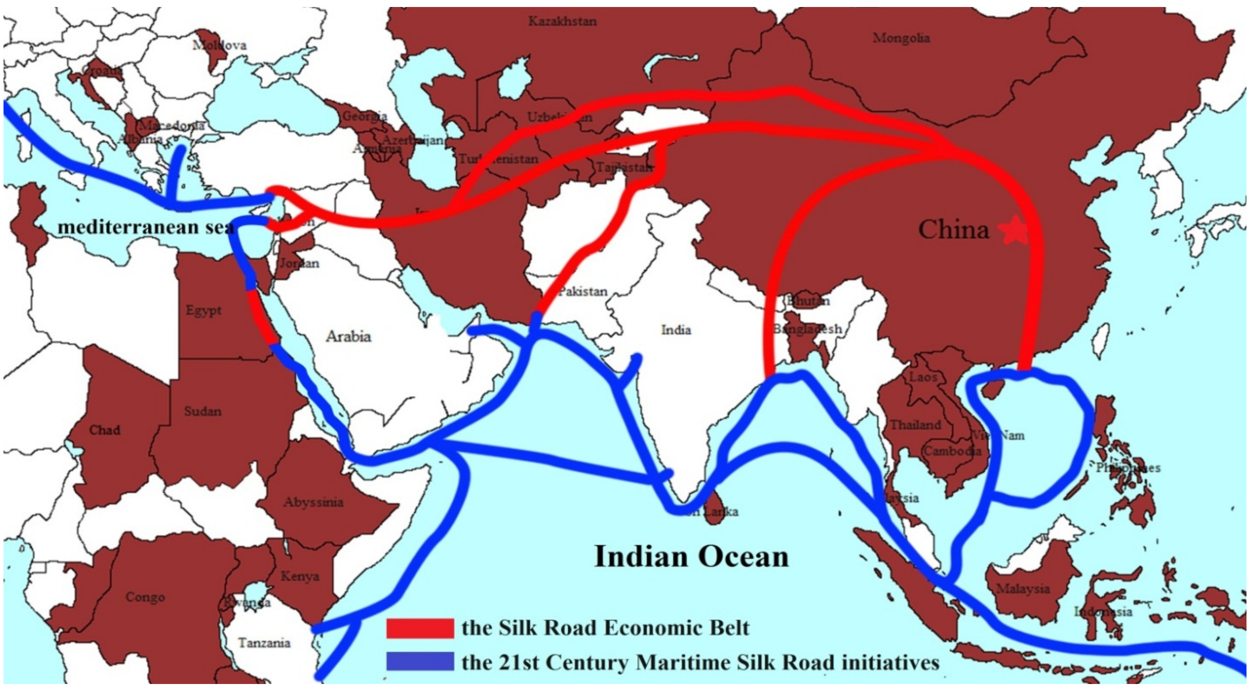

Fig. 1 Maps of the new Silk Road and the countries along the routes. Red line is the Silk Road Economic Belt. Blue line denotes the 21st Century Maritime Silk Road initiatives. The countries marked with wine-colored indicate the UNFCCC Parties that have submitted technology needs assessment reports.

institutes. Meanwhile, we matched the world-class institute with the 2015 European Commission world top 2500 companies for more information about the search of the technology cooperation. For now, this information system is mainly developed for developing countries. In the future we envision that it can be used by developed countries through an interactive system that can achieve the interaction between developing countries and developed countries.

II. THE PRIMARY METHODS AND THE GENERIC TECHNOLOGY NEEDS IDENTIFICATION

A. Literature Analysis

This study focuses on the technology needs assessment reports for developing country from United Nations Framework Convention on Climate Change (UNFCCC) via manual reading, we selected the sector and the technology prioritization for climate change in developing countries involved, and classified them according to the form of table 2 shows.

B. Text Analysis

Text analysis is one of the most commonly used qualitative research methods of data analysis, it is suitable for handle the large number of text information. Due to more and miscellaneous sectors and technologies, this study applies text analysis method to measure the frequency of the technology phrase. In order to enhance its reliability and accuracy, we use two kinds of method for identifying the technology frequency: by manual reading and by machine reading. In the part of manual reading, we read the technology prioritization sentences literally. The words and phrases that represent key technologies are summarized and standardized, and a number of key technology phrases or words are received as the data set. Cleanup, merging and normalize of the above data to complete the coding scheme as stated in Table 2. Each key technology phrases is encoded and made statistics, forms the following table 3. Full disclosure, we invited two PhD students to encode and statistical analysis based on these methods, and checked the results'consistency coefficient (CC) by equations as follows.

$$CC = \frac{2M}{N_1 + N_2}$$

Where N_1, N_2 denote the sample number of this technology that identified by two coders respectively, M denotes the sample number of these technologies that identified by both of two coders (consistent sample number). To ensure the reliability and validity of this research, we asked two coders must know the research fields on climate change, and the analysis results were also verified randomly. As shown by the calculated results, the technology of table 3 list is reliable.

Furthermore, we use the Computer-assistant Content Mining Software (CCMS) developed by Wuhan University of ROST Virtual Learning Group to once again dig out the key technology words in machine reading. CCMS is an easy to use to analysis content of chatting, website, blog and other text information, and the results also can be displayed visually. Finally, the result of machine reading was compared and analyzed to that of manual reading, and then we were concluded key technologies that determines and analysis for the following of the paper, and these technologies will pay an essential role in response to climate change for developing countries.

TABLE 2 THE CODING SCHEME OF PARTS OF THE KEY TECHNOLOGY PHRASES

Range	Key technology phrases	The Synonyms for key technology phrases
1	Power	Hydro power plants, wind power, Large-Scale Heat and Power, renewable energy technology (waste (power generation)), biomass residue based cogeneration combined heat and power.
2	Water	water harvesting techniques, water re-use by agriculture irrigation, waste water treatment, rain water collection from ground water surfaces, rainwater harvesting, Surface runoff water harvesting, Roof rain water harvesting, supply of high guarantee quality water to rural population, construction of local water pipe system, water saving, automating the water distribution, Metering of water for irrigation and watering, water reclamation and reuse, reducing water leakages in water management facilities, Desalination of brackish water, Harvesting runoff water, domestic waste water recycling.
3	Irrigation	sprinkler irrigation, drip irrigation, irrigation and water saving, Metering of water for irrigation and watering, efficient irrigation methods, irrigation and water management, drip irrigation and artificial raining, spray irrigation, Efficient water use irrigation system, Use of treated wastewater in irrigation, Wet and dry irrigation in certain rice growth stages,
4	Waste	waste water treatment, electricity generation (biomass waste water, PV utility and waste landfill), Waste paper recycling, gasification of municipal solid waste for electricity/heat production, waste heat recovery in iron and steel and ferro alloy industries, management of health care waste, conversion of biomass and waste to energy, waste-to-energy, waste minimization technologies, renewable energy technology (waste (power generation)), domestic waste water recycling.
5	Solar	solar powered pump for water supply, solar lanterns, large solar PV, solar CSP, Solar Home Systems and Solar Dryers, solar energy, solar power (photovoltaic), smart grid technology for wind & solar integration with hydro, solar home PV, solar water heater, solar thermal.
6	Efficient	energy efficiency, efficient boilers using dual fuel, energy efficient lamps, high efficient heat, efficient irrigation methods, energy efficient motors, efficient wood stoves, efficient construction technology, Biogas for cooking and electricity and efficient stoves, fuel efficient gasoline powered vehicles, energy efficient lighting, energy efficient appliances, efficient electric motor, efficient lighting.
7	Biomass	improved biomass institutional stoves, biomass gasification, biomass gasifier, biomass waste water, biomass combustion, biomass-steam, biomass in heating plants, biomass in cogeneration plants, biomass energy, biomass residue based cogeneration combined heat and power, conversion of biomass and waste to energy, plant residue or biomass burning.
8	Crop	improved crop species and cultivars and Zero tillage, crop diversification and new varieties, cover crop for soil improvements, integrated crop-small livestock-fish-poultry-vegetable production system, Diversification of crop production, crop diversification and precision farming, double cropping, crop improvement.
9	Warning	Early warning system.
10	Heat	heat waves, high efficient heat, heat production, combined heat and power plants, Use of electric power and heat, waste heat recovery, combined heat and power, heat cogeneration, heat supply, Large-Scale Heat and Power.

TABLE 3 ENCODING FOR FULL SAMPLE OF TECHNOLOGY AND ITS CONSISTENCY COEFFICIENT

Sectors	SF	Technologies	SN	TF	CC
Renewable energy	64	Biomass energy (biogas et al.)	10	20	0.9756
		Wind power	11	12	0.9898
		Hydro power	11	12	1.0000
		Solar energy photovoltaic	7	9	0.9800
		Solar energy photothermal	4	7	0.9967
		Solar Dryers	2	4	0.9587
Water resource	31	Rain water collection	8	14	1.0000
		Waste water treatment and recycling	5	8	1.0000
		Drinking water intaking	3	4	0.9873
		Drinking water treatment	2	3	1.0000
		Desalination of brackish water	2	2	1.0000
Agriculture	28	Irrigation and water saving agriculture	14	19	0.9981
		Crop breeding	3	4	0.9210
		Substitute of pesticide	2	3	1.0000
		Soil improvement	2	2	0.9877
Waste recycle	13	Waste landfill, reclamation and composting	5	7	1.0000
		Solid waste recycling	4	6	0.9352
Energy-efficient and emission-reduction	13	Energy saving lighting	5	8	0.9721
		Energy conversation for building insulations	2	3	1.0000
		Thermal energy storage	2	2	1.0000
Disaster prevention and reduction	12	Early warming for disaster	9	12	0.9789
Forestry	9	Agro-forestry	3	4	1.0000
		Forest management	3	3	1.0000
		Afforestation and reforestation	2	2	1.0000
Transport	7	New energy transport	3	4	0.9976
		Intelligent transport	3	3	1.0000
Health	7	Health and safety of drinking water	2	3	1.0000
		Antiparasite drugs	2	2	1.0000
		Drugs used to treat infectious disease	2	2	1.0000

SF: the frequency of sector.
TF: the frequency of technology.
SN: sample number which presents the number of countries that mentioned this technology. For example, on the first row and SN column of this table, the number 10 means 10 countries need this technology among 28 surveyed countries.

C. Expert Consultation and Delphi Method

Based on the expert consultation and the report of the Technical Manual of South-South Science and Technology Cooperation on Climate Change, IPC Green Inventory, EST Concordance and the detailed description of technology needs assessment report of the countries alone the route, we provided a break-down and improvement of the technology listed in table 3 as shown in table 4. It should be noted that this classification is merely based on the regional common technology needs of the developing countries along the OBOR.

TABLE 4 SUB-TECHNOLOGIES OF THE COUNTRIES ALONG THE ROUTE FOR CLIMATE CHANGE

Sectors	Technologies	Sub-technologies
Renewable energy	Biomass energy (biogas et al.)	Solid fuel based on animal and plant material
		biodiesel
		Plant oil
		bioethanol
		Extract biofuel from genetically engineered biologics
		biogas/methane
	Wind power	Machine-driven generator
		The structure of wind turbine
		Wind-driven vehicle
		Wind-driven vessel
	Hydro power	The equipment of machines or engines regulate and control
		Hydraulic-driven ocean ship
		Hydro-power Plant
	Solar energy photovoltaic	Photoelectric conversion device
		Solar cell components
		Silicon and monocrystalline silicon
		The regulation of solar cells
		Solar lighting equipment
		Use solar energy to charge the battery
		dye-sensitized solar cells
	Solar energy photothermal	The solar space-heating system
		Solar collector

		Gas Turbine Power Plant with solar energy heat source
		Domestic hot water supply system
	Solar Dryers	Use solar energy to dry materials or objects
Water resource	Rain water collection	Rain water collection
	Waste water treatment and recycling	Waste water management
		Biological sewage treating
		Physical sewage treating
		Chemical sewage treating
	Drinking water intaking	Water taking from underground
		Water taking from ground
		low-temperature distillation film water intaking
		Water taking from the snow or ice
	Drinking water treatment	Physical drinking water treatment
		Biological drinking water treatment
		Chemical drinking water treatment
	Desalination of brackish water	Desalination of brackish water
Agriculture	Irrigation and water saving agriculture	Irrigation canals
		Drip irrigation
		Alternative irrigation
	Crop breeding	Crop breeding (adversity resistance cultivar breeding et al.)
		Cross breeding
	Substitute of pesticide	Substitute of pesticide
	Soil improvement	Soil improvement
Waste recycle	Waste landfill, reclamation and composting	Waste landfill and reclamation
		Use waste material to Produce chemical fertilizers
	Solid waste recycling	Solid waste recycling
Energy-efficient and emission-reduction	Energy saving lighting	light-emitting diodes (LED), Organic light-emitting diodes (OLED), polymer light-emitting diodes (PLED)
	Energy conversation for building insulations	Energy conversation for the door or window
		Energy conversation for the walls
		Energy conversation for the floors
		Energy conversation for the roofs
		Energy conversation for the ceiling
	Thermal energy storage	Thermal energy storage
Disaster prevention and reduction	Early warming for disaster	Early warming for disaster
Forestry	Agro-forestry	Agro-forestry
	Forest management	Forest management
	Afforestation and reforestation	Afforestation and reforestation
Transport	New energy transport	New energy transport
	Intelligent transport	Intelligent transport
Health	Health and safety of drinking water	Health and safety of drinking water
	Antiparasite drugs	Kill the amoebae drugs
		Pneumocystis carinii medication
		Anti-worm medicine
		Against biting insects medicine
		Anti-ectoparasites medicine
	Drugs used to treat infectious disease	Treatment of diseases of digestive system or gastrointestinal
		Antimalarial drugs
		Avian influenza vaccine
		drugs therapy for leprosy

Aiming at the above-mentioned key technologies this paper used a Keywords Improve-query Approach (KIA) to make the retrieval strategy for the related patent data and paper data from the DB SCIE and the DB EPO respectively. KIA is a kind of general methods, which is use keywords to query patent and paper data straightly, and improve keywords according to expert consultation in querying process [24]. In order to improve the accuracy of retrieval, Aroraa et al. [22] proposed a scalable and evolutionary query for nanotechnology tracking. In particular what we should learn from is to interact between keywords and expertise. Also we should establish effective feedback mechanism by Delphi Method. In this paper, we identify the process of retrieval strategy is shown in Figure 2. It is also worth noting that we adopted a Keywords-IPC method in the patent search process. We look for and identify IPC of every technology from IPC Green Inventory and EST Concordance.

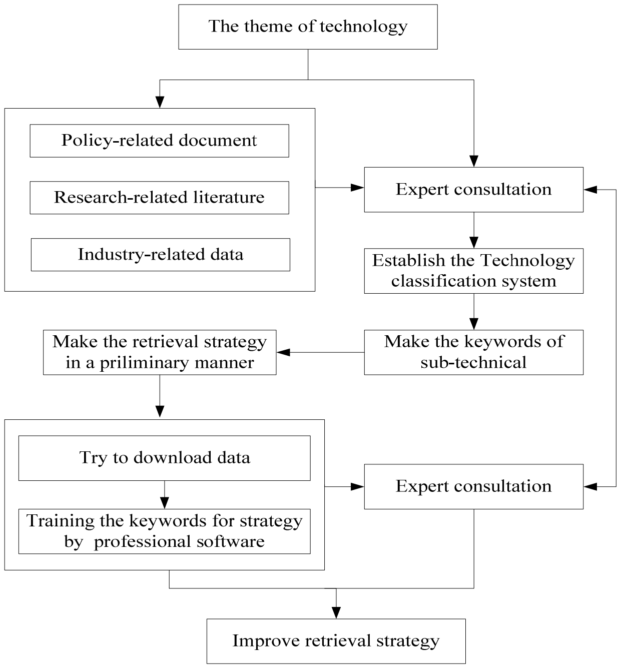

Fig. 2 The process of the retrieval strategy making

D. Bibliometric

In this paper we used an advanced bibliometric [29] to measure the evaluation index of academic journal publications and patent-based data relating to these technologies. This approach has widely been utilized in the impact evaluation of R&D and public policies in the area of innovative research especially in recognition of the existing technologies and forecast of the emerging technologies [15]. In this study, the times cited, author' institute, the publications, subjects, key words, references, collaborations cluster analysis of the papers and patents were deeply examined [20]. In some publishing files of this technology identification information system, the Vantage Point (VP) data mining tool, developed by professor Alan Port at Georgia Institute of Technology, as well as the social network analysis tools of UciNet and NetDraw were employed to analyze the paper and patent data for data processing and knowledge mapping. This bibliometric study specifically related to the 3 assessment aspects, namely, world-class technologies, world-class institutes and world-class professionals.

III. THE TECHNOLOGY SUPPLIES IDENTIFICATION

A. Construction of database platform for science and technology on climate change

As previously mentioned each sub-technology and its retrieval strategy making, we identified and downloaded 532,584 publications in the DB SCIE as well as 494,016 patent applications in the DB EPO for the period 2003 to 2014. The number of each technology as indicated in appendix A. The reason for chose the DB SCIE is that it has more than thirty million scientific publications in peer-reviews journals, and it also is an international multidisciplinary database includes articles, reviews, letters, proceeding paper, and etc.[27]. We chose the DB EPO, because this database contains a worldwide share of patent applications provided by 90 patent offices around the world [9]. To be clear, we used those papers data and talents date for monitoring the worldwide frontiers science, technology and enterprise so that we can identify the world-class technologies, professional and institutes to provide sufficient technical information for developing countries along the OBOR on climate change. Base on the above download data and conception, we established the database of paper and talent, and meanwhile, we downloaded the 2015 European Commission (http://iri.jrc.ec.europa.eu/home) R&D scoreboard: R&D ranking of the world top 2500 companies, and set up an enterprise database for the matching between the patent applicants in the patent database and the companies in the ranking to discover more information about the company of interest to developing countries. We also created a network database using the network resources include the detail of authors, patent applicants, inventors and institutes. Feature extraction is a concept for computer vision and image processing, it refers to using a computer to extract image information and identify whether each image point belonging to the same image [6]. The result of using this method is that image points are divided into different subsets. This study used feature extraction method to clean, processing, integrate data in data warehouse. At this point, we established four databases, and they are both certainly independent and closely relative. Together they combined to give the more objectify data support on the technology identification. The paper then focuses on the study of mathematical and theory model of analysis and assessment for technology data mining and analysis. The result of data mining can be realized visualization through GIS system. The processes of constructing the database and identifying the technology as illustrated in Figure 3 following.

B. Establishment of technology identification index system

Technology identification index system offers a foundation for the dada mining and analysis. In this section, we created the multi-sub-item indexes of scientific frontier, technology frontier and the top world companies concerning the quantity, citation, quality and etc. based on the above data warehouse system, as shown in figure 4. Specifically, in scientific frontier, this paper identified world-class professionals, world-class institutes and research hotspot with the number of papers, the number of references, papers citation, high cited paper in recent year and the number of patents possessed as indices, and we measured the top talents or institutes by the evaluation indexes of the number of authors or institutes theses published (the number of papers), the total citation of authors or institutes theses published (papers citation), the average citation of authors or institutes theses published (cites per paper) and the ownership of

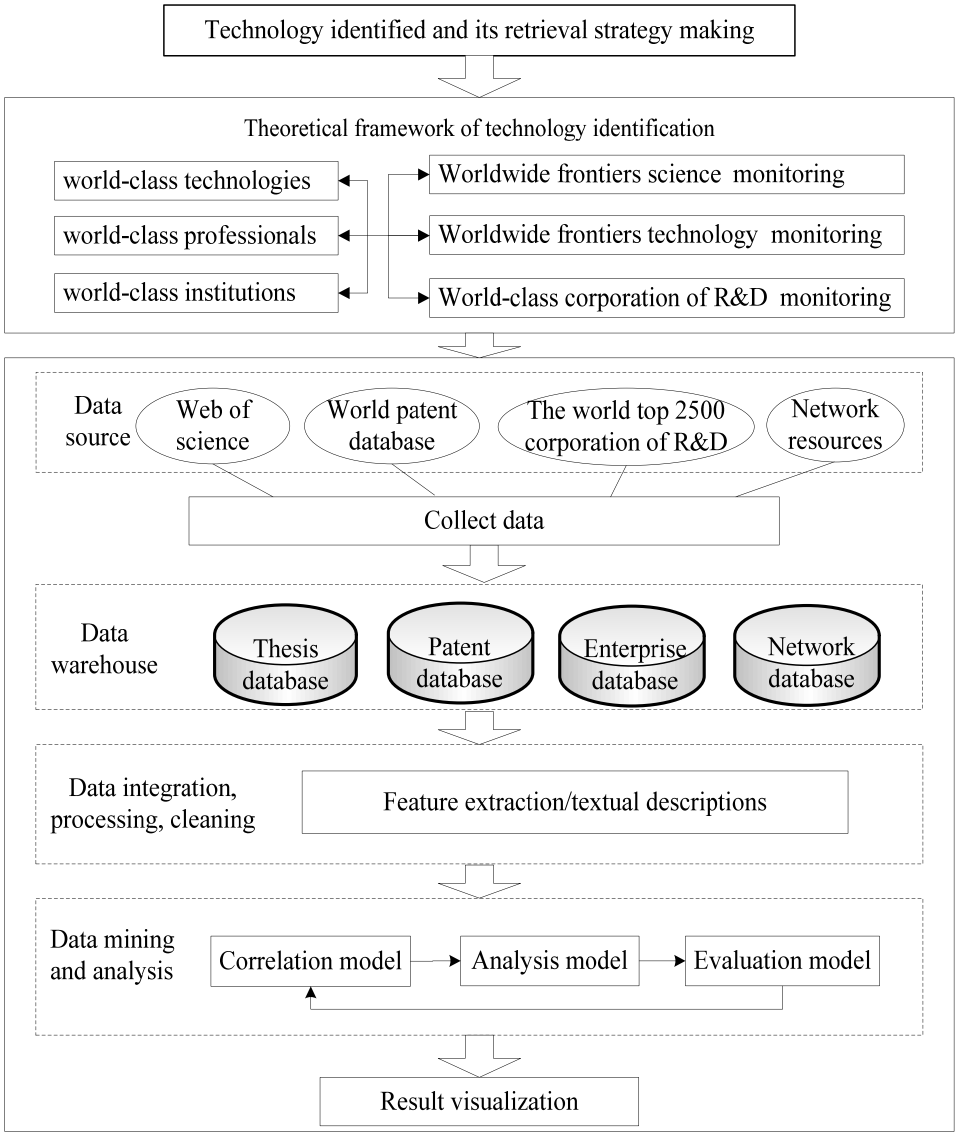

Fig.3 The process of construct database and data mining for science and technology on climate change

authors or institutes patents Authorized (the number of patents possessed) and identified the research hotspot through learning the topic of high cited paper in recent year. In terms of the evaluation indexes above, a large scale of bibliometric study was made from many aspects as amount and citation. Meanwhile, a method of evaluate professionals and institutes called NSP designed by Marek Kosmulski in 2011 has been applied in this paper. The NSP devote into evaluate author's academic level also reflect the quantity of author's publications and citations. Marek Kosmulski proposed 'successful paper' as the number of references greater than the number of citations, and expressed by formula as follows:

$$\begin{cases} s=1 \\ s=0 \end{cases} \; when \; \begin{matrix} TC > NR \\ TC \le NR \end{matrix}$$

Where S denotes the score of one paper, its value of 1 means this paper is successful paper, and 0 is not. TC and NR denote the quantity of references and citation respectively. Furthermore, Marek Kosmulski brings forward an evaluation index for one's academic level based on the number of successful papers [17], its computation formula is as follows:

$$NSP = \sum_{i=1}^{n} s_i$$

Where S_i denotes the score of one's i th paper. The practical meaning of the above formula is the total successful paper of one's publications. Similarly, the celebrated H index proposed by Hirsch and Jorge E also is a method of calculate the number of one's highly impact papers that its citations reached H [12]. Using these two methods, we designed the application and identified the world-class professionals and institutes in our information system.

In technology frontier, in order to identify the world-class technologies, institutes and professionals we referred to the indicator system for patent evaluation of CHI Research, Inc. CHI is famous the world for its intellectual property consultation. We selected the indexes of patents citation, cites per patent, science linkage, technology strength and current impact index from CHI to evaluate the world-class technologies. Patents citation is an important index which concerning the times of an early patent cited by the later patents. This citation means the significant breakthrough of a technology. We are generally interested in total citations of one's patent applications (TCP) during a certain period. Cites per patent (CPP) is not concerned the highly cited patent but evaluated the importance and popularity of patents applications from institute or individual in a certain period. The formula for calculating the CPP is shown below.

$$CPP = \frac{TCP}{N}$$

TCP: the total citations of one's patent applications during a certain period, *N*: the total number of one's patent applications during the same period. Science linkage (SL) is a measurement of correlation degree between science and technology through calculating the number of a patent cites scientific literature. Higher values of SL indicate a closely linkage between science and technology and also express the patent technology is closer to the scientific frontier. Current impact index (CII) is a reflection of patent impact and portfolio quality of institute for the past 5 years. The computing process of CII in this paper is to count the sum of patent and its citations of the whole dataset and one institute in a technical field for the past 5 years respectively in the first place, and then if NPW is short for the number of patent of the whole dataset in a technical field for the past 5years, NPO is short for the number of patent of one institute in the same field for the same period, NCW is short for the total number of citation of the whole dataset in the same field for the same period and NCO is short for the total number of citation of one institute in the same technical field for the same period, we will get the following formula for calculating the CII.

$$CII = \frac{NCO / NPO}{NCW / NPW}$$

Another technology evaluating indicator based on CII is known as technology strength (TS), which reflected the overall quality of technology innovation, and it is defined as follows.

$$TS = NPC \times CII$$

Where *NPC* denotes the number of patents of an institute within the current year.

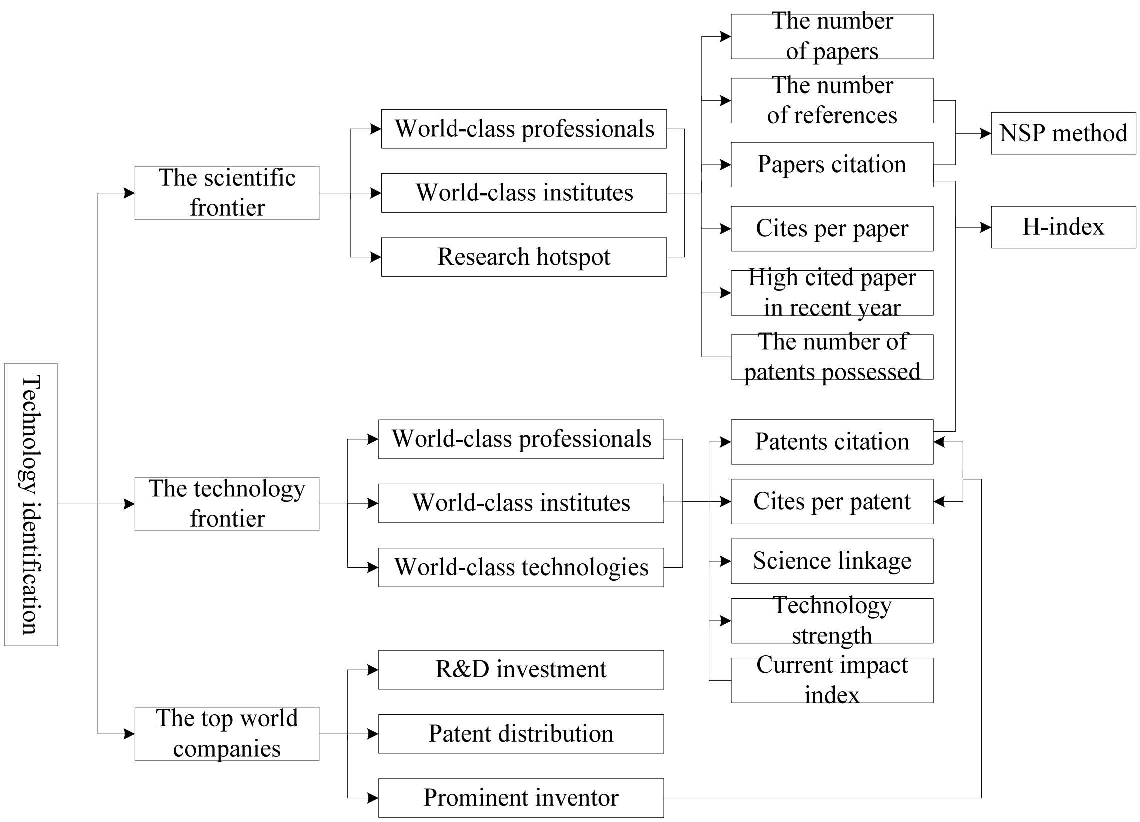

Fig. 4 The framework of technology identification index system

In the part of the top world companies' identification, we matched the world top 2500 companies in enterprise database with the patent applicants in patent database for us to identify the top word companies and obtain its further information include R&D investment, patent distribution and etc. According to the matching results, we also analyzed the quality of patents possessed by companies by the evaluation indexes of patents citation and cites per patent.

C. Development of technology identification information system

We developed the technology identification information system (TIIS) on climate change on the basis of the aforementioned databases and index system and made the identification algorithm for our system by analyzed the above-mentioned indicator and its calculating formula. As required by the identification algorithm, we accomplished the complement of the abbreviation for the name of institute or company by network search firstly, and then searched the information of technology R&D institute or company as much as possible and add them into network database, pave the way for the details of the following technology holders. After further data processing, we wrote the program to realize identification algorithm for developing system based on browser/Server (B/S) structure. The system has designed 9 technology fields contains renewable energy, agriculture, forestry, waste recycle, water resources, resources and environmental, Energy-efficient and emission-reduction, Disaster prevention and reduction and health by literature reference. Each field involves several subfields of developing countries all concerned. In our research, we focus on technology identification of south-south cooperation on climate change for developing countries along the OBOR. On the TIIS design, we were just concerned the approaches and its accuracy on identification of a practicable technology from global technology resources rather than which country is in our border delineation.

As a part of TIIS, we also developed an extended module allows analysis of geographical distribution of GIS monitor for world-class technology, professionals, and institute. It makes the identification results more visible from the overall respective. The development of TIIS has been achieved and its successful debugging through stand-alone contributed to the analysis below. What follows is to put more potential user in complete on-line testing and improving.

On the application of TIIS, we designed many function for technology, institutes and researcher identification. For example, TIIS provide fuzzy retrieval function for users who just make an exploratory finding through keyword retrieval on technology identification. And it also can achieve the accurate search if a user interested in a particular technology so that they can obtain more about this technology information. In addition, TIIS can send a request for technical assistance to other users.

IV. THE RESULTS ANALYSIS OF TECHNOLOGY IDENTIFICATION IN PARTIAL TECHNOLOGY FIELDS

In this section, we made a list of the identification results in partial technology fields to show the output of TIIS. The following Tables show a sample on world-class technologies, world-class institutes and world-class technologies for different technologies. As illustrated in figure 5, the TIIS can also analyze the geographic information of the technologies, institutes and professionals. Because of the length of this paper, we analyzed results through run the TIIS instead of listed all identification results. As an Chinese user of TIIS, The result show that the world-class technologies are mostly located in Europe and United States and other developed countries such as Japan, Singapore, Korea and etc. In the field of individual technology, China is second only to the United States, overtaking even US, and rivals with US in transferring technologies to developing countries. In the transport sector, the development of the new and renewable energy, as well as new energy vehicles is one of China's key measures to tackle climate change. Meanwhile, China is vigorously developing and marketing high-speed railway, and the technology level in this filed is a commanding lead. We noticed that China has retained close cooperation with US, Germany and Japan. With the more and more communications between Taiwan and Mainland, Taiwan's patenting activity, technology cooperation and technology transfer in Mainland become frequently and flourish [28][25]. We found that the science or technology cooperation between developing countries along OBOR and developed countries for its technology protection and intellectual property right.

TABLE 5 THE TOP 10 PROFESSIONALS OF THE BIOGAS SCIENCE ORDER BY CITES PER PAPER

rank	Professionals	Institutes	Counties /Regions	papers	Total cited	Cites per paper
1	Degreve, Jan	Katholieke Univ Leuven	Belgium	7	388	55.4
2	Delgenes, JP	INRA	France	9	469	52.1
3	Karimi, Keikhosro	Univ Boras	Sweden	9	424	47.1
4	Angelidaki, I	Tech Univ Denmark	Denmark	14	657	46.9
5	Kaparaju, Prasad	Tech Univ Denmark	Denmark	6	268	44.7
6	Kennedy, KJ	Univ Ottawa	Canada	5	209	41.8
7	Appels, Lise	Katholieke Univ Leuven	Belgium	11	428	38.9
8	Dewil, Raf	Katholieke Univ Leuven	Belgium	11	428	38.9
9	Hartmann, H	Tech Univ Denmark	Denmark	6	227	37.8
10	Murphy, JD	Cork Inst Technol	Ireland	6	226	37.7

TABLE 6 THE TOP 10 INSTITUTES OF THE WIND POWER (MACHINE-DRIVEN GENERATOR) TECHNOLOGY ORDER BY THE NUMBER OF PATENTS

rank	Applicant	Patents	Total cited	Cites per patent
1	WILIC SARL	63	798	12.7
2	SIEMENS AG	134	357	2.7
3	GEN ELECTRIC	77	286	3.7
4	MITSUBISHI HEAVY IND LTD	38	130	3.4
5	VESTAS WIND SYS AS	45	129	2.9
6	NORTHERN POWER SYSTEMS INC	15	115	7.7
7	LIGHTSAIL ENERGY INC	3	103	34.3
8	SWAY AS	6	81	13.5
9	AIRGENESIS LLC	3	78	26
10	IND METALURGICAS PESCARMONA S A I C Y F	3	75	25

TABLE 7 THE TOP 10 TECHNOLOGIES OF THE HYDRO-POWER PLANT TECHNOLOGY ORDER BY THE TOTAL CITED

rank	Patent number	First applicant	First inventor	Total cited
1	US7105939B2	MOTION CHARGE INC	BEDNYAK VLADIMIR	44
2	US7492054B2	CATLIN C S	CATLIN CHRISTOPHER S	25
3	US6857266B2	WAVEBOB LTD	DICK WILLIAM	19
4	US7224080B2	SCHLUMBERGER TECHNOLOGY CORP	SMEDSTAD ERIC	17
5	US7728454B1	ANDERSON WINFIELD SCOTT	ANDERSON JR WINFIELD SCOTT	17
6	US7012340B2	UNIV KUN SHAN	YI JWO-HWU	17
7	US7877994B2	OCEAN POWER TECHNOLOGIES INC	BULL DIANA	16
8	US7851936B2	ANADARKO PETROLEUM CORP	BOLIN WILLIAM D	15
9	US6695536B2	SANCHEZ GOMEZ GINES	SANCHEZ GOMEZ GINES	14
10	US6568878B2	US NAVY	WOODALL ROBERT	13

TABLE 8 THE TOP 10 R&D COMPANIES OF THE SOLAR ENERGY PHOTOVOLTAIC TECHNOLOGY ORDER BY THE TOTAL CITED AND THE NUMBER OF PATENTS

rank	Company names	Countries/Regions	patents	Total cited	Cites per patent
1	Sharp	Japan	227	920	4.1
2	Mitsubishi	Japan	221	495	2.2
3	Kyocera	Japan	189	338	1.8
4	Sanyo Electric	Japan	131	541	4.1
5	SUMCO	Japan	129	217	1.7
6	LG	South Korea	124	308	2.5
7	CANON	Japan	108	1564	14.5
8	TOSHIBA	Japan	73	101	1.4
9	HITACHI	Japan	71	243	3.4
10	Mitsubishi Heavy	Japan	62	110	1.8

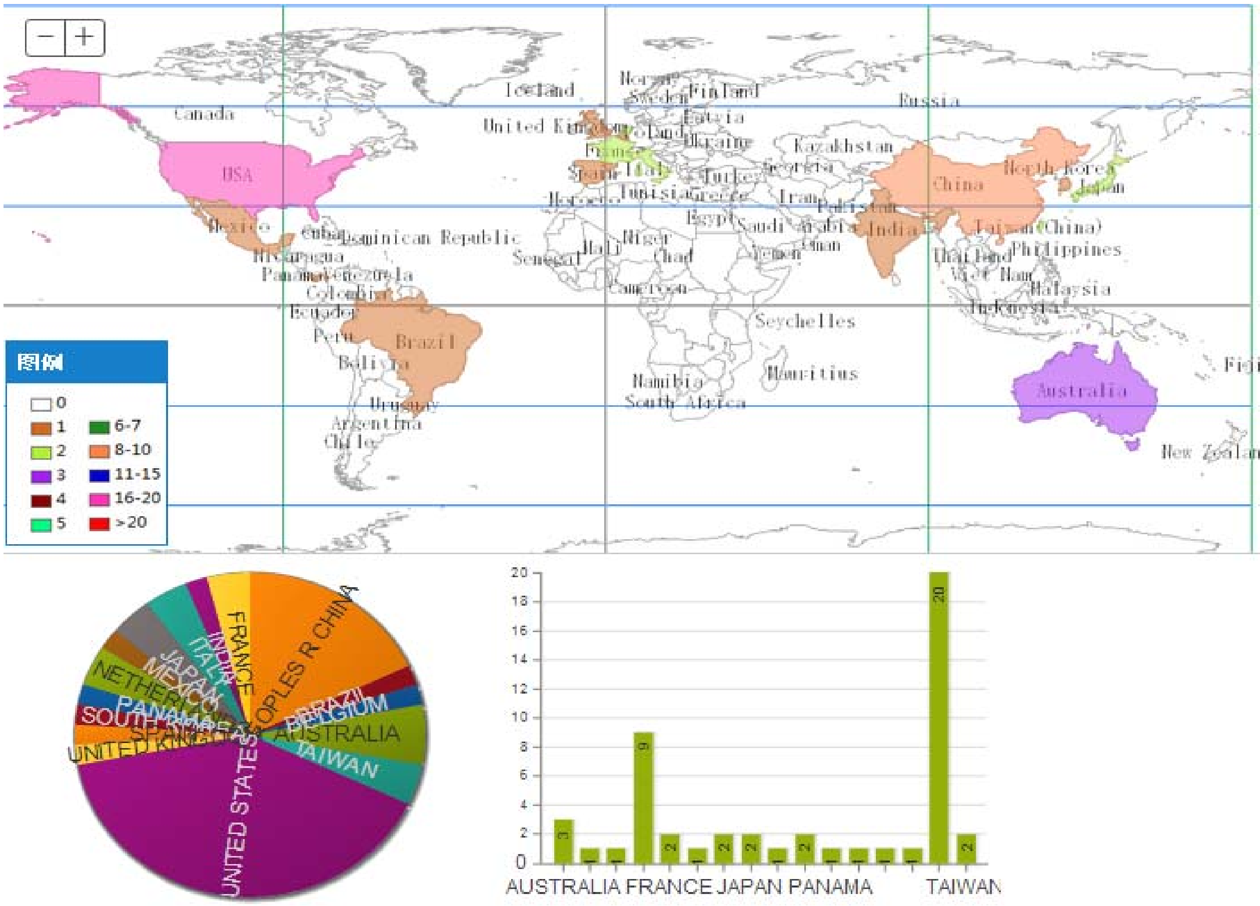

Fig. 5 The geographical distribution and the statistical analysis of the top 50 institutes of rain water collection science order by number of papers.

V. CONCLUSIONS

Technology is a critical support for response to the climate change. For developing countries, the technology laggard and the technology lacking are the main obstacles to tackle the climate change. For developed countries, they are a group that is holding advanced technologies for coping with the climate change headwinds as insufficient funds, concerns about intellectual property protection, asymmetric information and etc. The developing countries are not getting help with a gesture of "whatever" could not reach agreement with developed countries on the support of finance, technology and other aspect. In our research we focused on contribution to remove obstacles for South-South cooperation on climate change by solving merely an aspect of technology transfer barriers. In order to combine with Chinese foreign strategy of "OBOR", we selected the developing counties along the OBOR as sample to analyzed the technology of they need and to identify the suppliers and partner of this technology. And then considered the dissymmetry of information, we developed a technology identification information system (TIIS) aimed at establishing a platform for information sharing between developing countries and developed countries. Actually, the TIIS now provides a valid channel of technology identification for developing countries, and we envision that the TIIS web site can be deployed on the home page of United Nations Environment Programme (UNEP) with its gradually improvement in the future. Because our data is downloaded from the DB SCIE and the DB EPO, in the world-wide range, we can hardly ensure data integrity. Thus, we also hope that if the TIIS can be widely applied in the technology identification on climate change, within the scope of intellectual property rights, the world's major patent office can provide effective data to support TIIS implementation.

The results of technology identification shows that Europe and United States are the technology leader, and China has become one of the leading nations in a few technologies filed. Developing countries should to strengthen cooperation with technology leader on climate change and both are in short supply right now. We also found that the technology leader implement the technology protection polices in science and technology cooperation with developing countries. The developing countries should build their own capacity and continuously seek the technology cooperation partner to achieve rapid development.

The "OBOR" as a national strategy with the arrival of the economy enters a "new normal" will pay an important role in technology transfer between China and the countries along the route. Though China has the ability to transfer their technology to the developing countries to tackle climate change in some fields, it will lead to fierce competition with other technology leaders. In order to avoid malignant competition, we proposed that China and other developing countries should to enhance information exchange with the developed countries to settle differences. The technology identification will also be beneficial to the overproduction shift to developing countries along the OBOR from China.

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APPENDIX A

See Table 9

TABLE 9 THE DISTRIBUTION OF THE TECHNOLOGY TOPICS DOWNLOADED

No.	Technologies	NPPs*	NPTs*	No.	Technologies	NPPs	NPTs
1	Biomass energy (biogas et al.)	53654 (10.1%)	23712 (4.8%)	16	Waste landfill, reclamation and composting	15700 (2.9%)	5809 (1.2%)
2	Wind power	75411 (14.2%)	24484 (5.0%)	17	Solid waste recycling	27197 (5.1%)	46950 (9.5%)
3	Hydro power	21843 (4.1%)	4560 (0.9%)	18	Energy saving lighting	31082 (5.8%)	7285 (1.5%)
4	Solar energy photovoltaic	34793 (6.5%)	51584 (10.4%)	19	Energy conversation for building insulations	3466 (0.7%)	11597 (2.3%)
5	Solar energy photothermal	3814 (0.7%)	47249 (9.6%)	20	Thermal energy storage	9319 (1.7%)	7973 (1.6%)
6	Solar Dryers	518 (0.1%)	303 (0.1%)	21	Early warming for disaster	31632 (5.9%)	2077 (0.4%)
7	Rain water collection	16295 (3.1%)	2195 (0.4%)	22	Agro-forestry	240 (0.05%)	150 (0.03%)
8	Waste water treatment and recycling	27718 (5.2%)	144282 (29.2%)	23	Forest management	2069 (0.4%)	619 (0.13%)
9	Drinking water intaking	3979 (0.7%)	1494 (0.3%)	24	Afforestation and reforestation	5510 (1.0%)	432 (0.09%)
10	Drinking water treatment	13560 (2.5%)	42304 (8.6%)	25	New energy transport	10341 (1.9%)	3748 (0.8%)
11	Desalination of brackish water	3862 (0.7%)	8391 (1.7%)	26	Intelligent transport	2017 (0.4%)	1605 (0.3%)
12	Irrigation and water saving agriculture	14143 (2.7%)	8140 (1.6%)	27	Health and safety of drinking water	15023 (2.8%)	1209 (0.2%)
13	Crop breeding	21963 (4.1%)	19740 (4.0%)	28	Antiparasite drugs	14667 (2.8%)	3152 (0.6%)
14	Substitute of pesticide	32543 (6.1%)	1399 (0.3%)	29	Drugs used to treat infectious disease	24220 (4.5%)	17632 (3.6%)
15	Soil improvement	16005 (3.0%)	3941 (0.8%)	532584 in total of papers, 494016 in total of patents.			

* NPPs, NPTs means the number of papers and patents downloaded related to this technology theme respectively.

APPENDIX B

See Table 10

TABLE 10 THE KEY DOMAINS OF TECHNOLOGY NEEDS OF THE DEVELOPING COUNTRIES ALONG OBOR

Geographical Position	Countries	Type of country	Strategies	Key domains of technology needs
East Asia	Mongolia	Land-locked country, Medium-to high-income country	Mitigation	**The Energy Industries Subsector:** large hydro power plants, wind turbines and pulverized coal combustion technologies. **The Residential And Commercial Subsector:** efficient lighting (Compact Fluorescent Lighting, LED) and improved insulation of panel apartment buildings.
			Adaptation	**Arable Farming:** System of wheat intensification (SWI), Vegetable production system (VPS) with drip irrigation, Potato seed production system(PSPS). **Animal Husbandry:** Seasonal to Inter-annual Prediction and Livestock Early Warning system (SPLEWS), High quality livestock (HQL) through selective breeding and animal disease management, Sustainable Pasture Management (SPM).
	Indonesia	Low-and middle-incom e country	Mitigation	**The Forestry Sector:** technology of measurement and monitoring of carbon sequestration on and emission, peat re-mapping and water management. **The Energy Sector:** photovoltaic industry, Improvement of public transport (MRT and BRT) and efficient electric motor (motor drive). **The Waste Sector:** mechanical-biological treatment, in-vessel composting technology, and low-solid anaerobic digestion.

			Adaptation	**The Food Security Sector:** crops (rice) tolerance to drought and flood, technology for mariculture development, cattle meat development. **The Water Resource Sector:** a rain harvesting technology, domestic waste water recycling, modeling of water resources projection.
	Thailand	Medium-to high-income country	Mitigation	**The Energy Sector:** energy supply (smart grid), renewable energy technology (solar thermal, Solar photo-voltaics (PV), waste (power generation)), second and third generation of biofuels, energy efficiency improvement (Lighting system, fuel combustion in industry sector), carbon capture and storage (CCS).
			Adaptation	**Agriculture Sector:** climate forecast and early warning systems, crop improvement, precision farming practices, post-harvest technology, animal nutrition and feed technology. **Water Resource Management Sector:** environmental observation, weather and hydrological modeling, flood and drought risk management, operation of water infrastructures, community water resource management, integrated urban water resource management, early warning systems.
	Laos	Land-locked country, least developed country	Mitigation	**The Forestry Sector:** effective protection and protected area, optimal agro-forestry, optimal plantation, sustainable community forest management. **The Agriculture Sector:** organic farming, biogas digester, feeds improvement, agriculture residue to energy.
			Adaptation	**The Water Sector:** early warning system, disaster impact reduction fund, river basin or watershed management, irrigation, water supply system. **The Agriculture Sector:** livestock disease prevention and control, agricultural development subsidy mechanism, climate resilient rural infrastructure, crop diversification.
	Cambodia	Least developed country	Mitigation	**The Transport Sector:** energy efficient urban mass transport, vehicle emission standards. **The Energy Sector:** energy efficient lighting, energy efficient appliances.
			Adaptation	**The Water Sector:** household safe water supply (rainwater harvesting from rooftops, wells for domestic water supply), community water supply (small reservoirs, small dams and micro-catchments). **The Coastal Zone Sector:** mangrove management.
	Viet Nam	Low-and middle-incom e country	Mitigation	**The Energy Sector:** Wind power technology, Energy-saving compact fluorescent lamps, Large-Scale Heat and Power (Cogeneration), Bus rapid transit. **The Agriculture Sector:** Biogas, Nutrition improvement through controlled fodder supplements, Wet and dry irrigation in certain rice growth stages. **The Land Use, Land-Use Change And Forestry (LULUCF) Sector:** Sustainable forest management, Afforestation and reforestation, Rehabilitation of mangrove.
			Adaptation	**The Agriculture Sector:** Plant Genetic/Breeding, Rice to upland grain, Triple cropping to double cropping + shrimp/fish/poultry crop. **The LULUCF Sector:** Plant Science/ Genetics, Agro-forestry. **The Coastal Zone Sector:** Sea-dyke, Coastal wetland Rehabilitation. **The Water Sector:** Rooftop rainfall harvesting for household usages, Harvesting runoff water, Integrated River Basin Management.
Western Asia	Iran	Medium-to high-income country	Mitigation	**The Transport Sector:** Road transport including light duty vehicles and public passenger buses, Rail transport, which is a suitable substitution for road transport, Air transport that due to some political problems has old vessels, Marine transport that is active in goods transport or oil. **The Industry Sector:** clean technologies, pollution control technologies, energy consumption optimization technologies, waste minimization technologies, fuel substitution technologies. **The Oil, Gas And Petrochemical Sector:** Light ends upgrading, Heavy products upgrading, Incorporation of FCC unit in refineries, Utility and hydrogen development.
			Adaptation	**The Water Sector:** Hydro power plants, Underground dam type hydroelectric power plant, Desalination of brackish water, Wastewater Treatment. **The Agriculture Sector:** rice cultivation,

				plant residue or biomass burning, carbon sequestration.
	Jordan	Low-and middle-income country	Mitigation	**The Energy Sector:** methods of saving in consumption of fuel and energy, energy consumption saving. **The Heating Sector:** types of heating used at the establishment, heating dissipation.
			Adaptation	**The Training Sector:** Employees of training needs. The Transport Sector.
	Lebanon	Low-and middle-income country	Mitigation	**The Energy Sector:** wind power, photovoltaic cells, hydropower, biomass, or waste-to-energy. **The Transport Sector:** bus technologies, fuel efficient gasoline powered vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, battery electric vehicles, natural gas vehicles.
			Adaptation	**The Water Sector:** Rainwater harvesting from hill lakes or earth lakes, Rainwater harvesting from ground or roads, Rainwater harvesting from greenhouse tops, Efficient water use irrigation system, Water users' association, Soilless agriculture, Use of treated wastewater in irrigation, Early warning system for water supply management (river flow) through snowpack monitoring. **The Agriculture Sector:** conservation agriculture, risk coping production systems, selection of adapted varieties and rootstocks, integrated pest management, integrated production and protection for greenhouses, early warning system - information and communication technologies, index insurance.
	Azerbaijan	Medium-to high-income country	Mitigation	**Alternative Energy Sources Sector:** grid-connected wind power, passive solar energy (hot water) and solar photovoltaic (electricity), small hydro-powers on mountain rivers. **Commercial And Residential Sector:** High efficiency lighting systems, Heating pumps, Biogas for cooking and electricity and efficient stoves.
			Adaptation	**The Water Sector:** rainwater collection from ground surfaces—small reservoirs and micro-catchments, Flood warning, water reclamation and reuse, reducing water leakages in water management facilities. **The Agriculture Sector:** optimizing of location and structure of agricultural lands with introduction of crop species resistant to expected climate changes, enhance the application of windbreaks, application of water saving technologies, such as drop or spray irrigation, at irrigated lands, application of conservative agricultural technologies.
	Georgia	Low-and middle-income country	Mitigation	**Energy Sector:** energy consumption in residential and office buildings, various technologies in public and individual transport systems, renewable Energy supply (solar water heater, efficient wood stoves, efficient construction technology).
			Adaptation	**The Black Sea Coastal Zone:** Creation of artificial underwater reef, Decentralised early warning systems, Beach nourishment (Artificial piling of inert material). **The Agriculture Sector:** wind-breakers, drip irrigation and artificial raining, USLE methodology. **Nature Disaster:** protective measures against extreme events-phyto-melioration, cleaning and levelling of riverbeds, mapping of climate change related extreme geological processes and providing long-term forecast of their development.
	Armenia	Low-and middle-income country	Mitigation	**The Energy Sector:** Renewable sources of energy, Electricity and heat cogeneration, electricity production, heat supply, gas supply, wastes,.
			Adaptation	The Water Sector, The Agriculture Sector (Application of water saving technologies in crop production), Natural ecosystems, population's health.
South Asia	India	Low-and middle-income country	Mitigation	
			Adaptation	
	Pakistan	Low-and middle-income country	Mitigation	
			Adaptation	
	Bangladesh	Least developed country	Mitigation	**The Energy Sector:** natural gas combined cycle, solar home PV, advanced combustion turbine, integrated gasification combined cycle single/double unit, Advanced Pulverized Coal single/double unit.
			Adaptation	**The Water Sector:** rehabilitation of existing embankments/ dykes and dredging, tidal barriers (sluice gates), tidal river management including computer simulation of tidal flow, comprehensive

				disaster management incorporating early warning systems and involving community, monitoring of sea level rise, tidal fluctuation, salinity intrusion, sedimentation and coastal erosion, Urban Infrastructure development. **The Agriculture Sector:** development of salinity-tolerant rice varieties, development of drought-tolerant rice varieties, development of short-maturing rice varieties, training on improved farming practices for crops, irrigation and water management, soil fertility management.
	Sri Lanka	Medium-to high-income country	Mitigation	**The Energy Sector:** conversion of biomass and waste to energy, smart grid technology for wind & solar integration with hydro, building management systems. **The Transport Sector:** integration of non-motorized transport methods in colombo along with regularized public transport system, promote carpooling and park-and-ride systems during rush hours and on roads with heavy volumes of vehicles, electrification of the existing railway system. **The Industry Sector:** energy efficient motors, variable speed drivers for motors, biomass residue based cogeneration combined heat and power (CHP).
			Adaptation	**The Food Sector:** culture-based fisheries, sustainable land management, crop diversification and precision farming. **The Health Sector:** early warning systems and net-working for information exchange on extreme events and other climate change related events, transfer of knowledge and skills to health personnel, management of health care waste. **The Water Sector:** restoration of minor tank net works, rainwater harvesting from rooftops, boreholes/tube wells as a drought intervention for domestic water supply. **The Coastal Sector:** sand dune rehabilitation, restoration of mangroves, restoration of coral reefs by transplanting corals. **The Biodiversity Sector:** restoration of degraded areas inside and outside the protected area network to enhance resilience, increasing connectivity through corridors, landscape/matrix improvement and management.
	Bhutan	Least developed country	Mitigation	**The Solid Waste Disposal On Land Sector:** composting. **The Transport Sector:** intelligent transport system. **The Manufacturing Industries And Construction Sector:** waste heat recovery in iron and steel and ferro alloy industries.
			Adaptation	**The Water Sector:** micro/mini hydro power, efficient irrigation methods, solar power (photovoltaic). **The Agriculture Sector:** agro-forestry, development of drought resistant and pest resistant varieties of crops, sloping agriculture land technology. **The Natural Disasters and Infrastructure Sector:** real-time weather stations and weather forecasting (multi-range), climate resilient roads, community based early warning systems
Central Asia	Kazakhstan	Land-locked country, Medium-to high-income country	Mitigation	**The Energy Sector:** Pulverized Coal Combustion with higher efficiency, Small hydropower. **The Industry Sector:** cement production (energy efficiency and saving, change from wet to dry production technology).
			Adaptation	**The Agriculture Sector:** Transhumance system (southern part of the republic), Grazing and stabling system on an industrial basis (all regions), No-Till, Diversification of crop production. **The Water Sector:** Technology of extreme events prevention, Metering of water for irrigation and watering, Technology of drip irrigation.
	Turkmenistan	Medium-to high-income country	Mitigation	**The Energy Sector:** Electric and thermal energy production, Transmission and distribution of electric and thermal energy, Mining, transportation and storing of natural, casing-head gases, petroleum, Oil and natural gas refining, Building materials production, Motor transport, Railway transport, Air transport. Use of electric power and heat, Alternative sources of energy (sun, wind)
			Adaptation	**Industry:** Mineral fertilizers production, Cement production, planting of forests.
	Tajikistan	Land-locked country, Low-and	Mitigation	**The Energy Sector:** energy efficiency and energy saving, electric power production and consumption, thermal power production and consumption, small hydropower energy, solar energy, wind energy,

		middle-income country		biomass energy. **The Industry Sector:** aluminum production, chemical industry, building material production. **The Agriculture Sector:** cattle breeding, rice cultivation on irrigated fields.
			Adaptation	**The Water Sector:** automating the water distribution and con-sumption system, based on the geoinformation system, increasing the irrigation system efficiency and introducing new methods of irrigation and water saving. **The Agriculture Sector:** updating the agricultural material and techno- logical base, Providing scientific and technological facilities for agriculture, including a long-term prognos-tication. **The Transport Sector:** monitoring of dangerous geological and hydro meteorological phenomena at dangerous road cuts, constructing new highly effective protective installations (anti-avalanche, anti-mudflow, slope-fortifying).
Eastern Europe	Croatia	Medium-to high-income country	Mitigation	**The Energy Sector:** wind power plants, biomass in heating plants, insulation improvement and energy efficiency in buildings and construction, biomass in cogeneration plants, increase in biodiesel use.
			Adaptation	——
	Moldova	Medium-to high-income country	Mitigation	**The Electricity Supply Sector:** combined heat and power plants based on internal combustion engines of at most 500 kw. **The Heat Supply Sector:** gasification of municipal solid waste for electricity/heat production. **The Transport Sector:** hybrid electric vehicles. **The Residential And Administrative Sector:** energy efficient lamps, high efficient heat, ventilation and air-conditioning system. **The Agriculture Sector:** The No-Till and Mini-Till soil cultivation system with preliminary positive recovery of the post-arable layer and use of vetch as intermediary crop for green fertilizer, Classic tillage. Including a vetch field (two yields per year), as a "green fertilizer field" into a 5 fields crop rotation.
			Adaptation	**The Agriculture Sector:** conservation system of soil tillage without herbicides for winter wheat, applying of 50 t/ha of manure with bedding to agricultural soils once per five years, vetch field as green fertilizer into 5 year crop rotation. **The Human Health Sector:** supply of high guarantee quality water to rural population, construction of local water pipe system (aqueducts), provisional posts of emergency care and prompt rehabilitation during critical periods of heat waves.
	Albania	Low-and middle-income country	Mitigation	**The Energy Sector:** hydro power plants, thermal power plants, solar energy, power transmission system. **The Agriculture Sector:** Low cost bio-digesters for the manure processing, Use of urea molasses blocks as a supplement in the diet of ruminants. **The Waste Category:** construction of sanitary landfills with recovery gas system, construction of MSW incinerator with energy utilization.
			Adaptation	The water sector, the health sector, the forestry sector, the fishery sector.
East African	Kenya	Low-and middle-income country	Mitigation	**The Energy Sector:** Solar Home Systems and Solar Dryers. **The Waste Management Sector:** methane capture from landfills, Waste paper recycling.
			Adaptation	**The Water Sector:** Surface runoff water harvesting, Roof rain water harvesting. **The Agriculture Sector:** Drought Tolerant Sorghum Variety, Drip Irrigation.
	Tanzania	Least developed countries	Mitigation	
			Adaptation	
	Rwanda	Land-locked country, Least developed countries	Mitigation	**The Energy Sector:** small hydropower, kivu methane-based CCGT, geothermal, biomass-steam, large solar PV, peat-based IGCC, solar CSP, pumped storage hydro, biodiesel (engine internal combustion), wind power, enhanced coal /peat-bed methane, biogas for thermal applications.
			Adaptation	**The Agriculture Sector:** seed and grain storage, agro forestry, radical terraces, drip irrigation, rainwater harvesting, integrated fertilizers and pesticide management, biotechnology for CC adaptation of crops, sprinkler irrigation.

	Zambia	Land-locked country, Low-and middle-income country	Mitigation	**The Energy Sector:** biofuels, charcoal production, energy efficiency, electricity generation(biomass combustion, geothermal, wind energy, biomass waste water, PV utility and waste landfill), improved cooking and heating and lighting devices (improved charcoal stoves, improved biomass institutional stoves, improved firewood stoves, biogas for cooking, and solar lanterns), off grid (small hydros, biomass gasifier, biogas digester, and small wind turbine). **The Agriculture Sector:** conservation tillage, development of green manure and cover crop for soil improvements, and control of weeds. **The Land Use Change And Forestry Sector:** afforestation and reforestation, improved biomass institutional stoves, improved charcoal stove, biomass gasification, retort kiln and metal kiln.
			Adaptation	**The Water Sector:** rain water collection from ground water surfaces (small reservoirs and micro-catchments), improving the resilience of protected wells to flooding (Building a Concrete Apron/Collar on the well), Borehole/ tubewell with overhead tank and a solar powered pump for water supply. **The Agriculture And Food Security Sector:** conservation farming with faidherbia albida (musangu tree), integrated crop-small livestock-fish-poultry-vegetable production system, crop diversification and new varieties (promotion of drought-tolerant and early maturing food crops/varieties).
North African	Egypt	Medium-to high-income country	Mitigation	**The Coastal Zones Sector:** **The Water Sector:** water re-use by agriculture irrigation, waste water treatment. **The Land Use And Land Change Sector:**
			Adaptation	——
	Sudan	Least developed countries	Mitigation	**The AFOLU Sector/Livestock Subsector:** the use of improved stoves. **The Energy Sector:** mass transportation, electricity production and consumption, compact fluorescent lamp. **The Industry Sector:** efficient boilers using dual fuel.
			Adaptation	**The Agriculture Sector:** improved crop species and cultivars and Zero tillage. **The Water Sector:** early warning system and water harvesting techniques.