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Practices and perceptions on the development of forest bioenergy in China from participants in national forestry training courses

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ARTICLE INFO

Article history:
Received 16 February 2011
Received in revised form
16 January 2012
Accepted 30 January 2012
Available online 26 February 2012

Keywords:
Professional opinion
Energy policy
Bioenergy development
Professional perceptions
China

ABSTRACT

This study examines forest bioenergy related knowledge, perceptions, attitudes, and behavior amongst participants of national forestry training course in China. The participants are forestry professionals and are senior government officials in this area on a county level; additionally all have been working in the forestry field for more than ten years. Their perceptions and practices are worth examing as they directly influence local and regional decision makers, and could affect the adoption of forest bioenergy in the country. The purpose of this study was able to determine how well the professionals' practices and future preferences concerning the use of forest bioenergy fit together. A thorough assessment was conducted using a questionnaire of 74 professionals in Xiamen and Hangzhou (China). The results revealed that, firstly, their environmental behavior can be classified as being a low carbon lifestyle. Secondly, the professionals think that renewable energy has potential for use in the future, but less potential for forest bioenergy. Thirdly, the professionals' practices and future preferences concerning the use of forest bioenergy do not appear coherent. Fourthly, the professionals feel that the development of forest bioenergy requires increased cooperation between the government and enterprises with respect to the different functions of the forest and its impact on the ecosystem. Finally, the findings indicate that bioenergy related education through different channels has to be improved. The findings create a foundation for further discussions regarding the use of forest as a source of renewable energy, as well as forest management in the country.

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doi:10.1016/j.biombioe.2012.01.050

1. Introduction

China became the world's largest energy user and CO_2 emitting country in 2009 [1]. One related issue is that the country's energy structure is greatly dependent on non-renewable energy sources (77% Coal and 10% oil), with only a small share of commercial energy consumption originating from renewable energy sources [2]. For example, the share of hydropower and wind energy is less than 9%, while commercial bioenergy supplies are less than 0.1% of the total energy consumption in 2008 [2]. China's future economic development, with its forecasted rapid GDP growth, will see the country's energy demand continue to grow [3]. This will have repercussions on many levels, both in China and abroad, underlining the need to examine the multitude of drivers, as well as the implications.

To mitigate the environmental threats, as well as meeting the challenges of energy security, the development of the utilization of renewable energy sources is an imperative. In 2007, China set a target to increase the production of renewable energy: 15% of its total energy demand coming from renewable sources by 2020 [4]. According to the National Development of Reform and Commission (NDRC), China gets 260 ton of coal equivalent electricity and biofuels from renewable energy sources, which is 8% of its primary energy needs by the end of 2010 [5]. In 2010, China invested more in the renewable energy sector than any other country, its commitment also being demonstrated by the total investment being 28% higher than in 2009 [6].

In this study, forest bioenergy refers to energy from woody biomass from fuel-wood forests and shrub forests, forest residues from timber production forests, woody oil plants, SRF (short rotation forest) energy crops, and waste wood from forest industries. Forest bioenergy as a low-carbon energy source has great potential for mitigating climate change [7] and is available on a large scale in China [8], though its potential varies depending on the region. The Chinese government attaches great importance to reforestation/afforestation and forest protection. Afforestation and reforestation has increased on an annual basis since the 1980's. According to the Seventh National Forest Inventory (2004-2008), the forest area covers 20% of the total land area [9]. Following the 2006 reform of forest ownership which aimed to improve the opportunities to produce timber and offer income for rural people [10], forest management and governance has paid more attention to regulatory support by disseminating knowledge for improving the productivity of these forests [11], which includes taking into account its potential role in supplying fuel for bioenergy.

China's forest sector has increasingly emphasized the exploitation of bioenergy since the 1950s [12]. This has been reflected in the State Forestry Administration's (SFA) increased emphasis on research and development (R&D) in bioenergy. The establishment of a multidisciplinary bioenergy R&D center by the ChineseAcademy of Forestry in 2005 underlines this commitment. Additionally a development strategy for China's forest biomass industry was introduced in the 11th (2005-2010) and 12th (2011-2015) Five-Year Plans, and the exploration of forest bioenergy is one of the most important targets of the strategy.

At the same time, the principle of sustainable development was introduced in China in the late 1980s. In Agenda 21, China's sustainable development strategies and policies were clarified [13]. The strategy for implementing China's Agenda 21 can be categorized into four parts: to coordinate the development of the economy, society, the management of resources and protection of the environment, with the goal of sustainable development. The pursuit of sustainable development includes the development of renewable energies throughout the country. This is reinforced by the fact that as China faces problems of energy security, it is essential that it integrates its energy strategy with environmental, economic, cultural and social aspects for ensuring the country's sustainable development [14].

In this sense, forest biomass is increasingly considered as being a sustainable energy source. However, the use of biomass is questioned by several scientists in different fields. The doubts are related, for example, to the continuing deforestation or peatland conversion to biofuel production resulting in an immediate negative carbon balance, and even the increasing price of food as has been seen as a consequence of the development of biofuels [15,16]. There are numerous possible cultural, economic, environmental and social impacts of the use of different bioenergy fuels and the development of forest bioenergy must be managed in line with the principles of sustainable development. However, the principles are not easily balanced. The realization of this depends on the support and input of all relevant stakeholders' in the decision making process through legislation, certification, and guidelines at different levels [17]. Various benefits may be gained from the participatory process, including the examination of the public's knowledge, perceptions and attitudes, helping to increase the related understanding and acceptance of the bioenergy products in the context of sustainability.

Forestry professionals play an increasingly important role in supporting and guiding various stakeholders, including forest owners, regarding the utilization of forest resources. This includes supporting the government's target of maximizing forest usage, in a sustainable manner. There are, however, numerous obstacles, including institutional, political, technical and financial limitations, regarding the utilization of bioenergy. One hindrance is the lack of public and political support for bioenergy [12,18].

In China the modern methods of using the forest resources for energy production – as opposed to the traditional use of firewood in homes, for example for cooking – are in nascent stages. The whole bioenergy value chain has to be modernized, this includes ecosystem management in conjunction with the cultivation of energy plants [19]. Additionally, because of forest bioenergy's poor economic competitiveness, an important issue is how the consumer markets are supported and guided [7]. In this context, political factors play a crucial role when trying to overcome social barriers to the use of renewable energy. As part of this professionals act as intermediaries in this field, particularly because the energy issues are becoming increasingly complex and challenging.

Professionals working in the field of forestry play a key role in decision making and knowledge dissemination regarding forest management. Forestry professionals combine practical experiences with scientific knowledge when providing information to decision makers, as well as guiding the general public [20,21]. For example, the role of professionals in the practice of sustainable forest management has been understated, and this includes their importance regarding dissemination of knowledge and the acceptance of new technical ideas and programs [22–24]. Stakeholders, such as land owners, need advice from professional experts when making practical decisions in many areas of management, and therefore the importance of the professionals has to be increasingly highlighted [25,26].

The Chinese government modified its agricultural policies and promulgated the "Rural Land Contract Law" in 2002, which mandated that farmland tenure security must be maintained for at least 30 years from 1998 [27]. Subsequently, China has been implementing new forestry reforms with the ambitious aim of significantly changing land ownership [28]. At the same time the country has launched a challenging program regarding renewable energy including bioenergy. As part of this the professionals employed by the SFA have an important role of increasing public receptiveness towards the increased use of forest biomass for energy production. Because of the expert roles of forest professionals, it is necessary to know, regarding the development of the energy sector, how they consider the use of forest bioenergy both for household based energy and for industrial purposes.

Following this context, the aim of this research is to study forest bioenergy related knowledge, perceptions, attitudes, and behavior amongst the national forestry training course participants. The State Academy of Forestry Administration (STAFA) who organizes the courses invited the professionals from the provinces with a high share of plantations, to participate in two training courses during which the survey was carried out providing a basic sample group of respondents for this study. The study aims to offer a basic description dealing with forest bioenergy related thinking of SFA professionals.

The overall aim is divided into four specific research questions:

- What types of energy related choices the participants are making in their own everyday lives?
- How well the professionals' practices and future preferences concerning the use of forest bioenergy fit together?
- What is their level of knowledge and what are their sources of information concerning energy, forests and forestry in China?
- How the participants express their perceptions of forests and forestry in China?

2. Material and methods

2.1. The study design

The principal data was collected using a structured questionnaire. The questions were selected on the basis of previous studies regarding public knowledge and attitudes concerning renewable energy issues [29–34]. The questionnaire consisted of five sections:

1. Respondents' social demographic data;
2. Questions about professionals' current energy use practices and their future energy preferences;
3. Questions about professionals' knowledge and sources of information with respect to forests and energy in China;
4. Questions about professionals' perceptions of forests and current forestry issues;
5. Questions about professionals' perceptions of forest bioenergy development in China

The questionnaire was originally written in English and then translated into Chinese. In this study the 5-point Likert scale was applied as an instrument for structuring and analyzing the answers. Attitudes towards forest bioenergy were measured with a 5-point Likert scale: 1 (strongly disagree), 2 (disagree), 3 (not disagree, not agree), 4 (agree), 5 (strongly agree) or from 1 (not important at all) to 5 (very important) [35]. To ensure the validity of the questionnaire and the understanding of the questions, the questions were pre-tested on Chinese students and academics in the field of forestry and bioenergy.

The reliability of the 5-point Likert scale in the questionnaire was tested using the Cronbach's alpha which showed a highly satisfactory level of internal consistency. A reliability coefficient of 0.70 and above is usually considered acceptable and desirable for consistency levels [36,37]. In this study the reliability coefficient was 0.80.

2.2. Participants and the data collection

The survey was conducted in 2010 in the cities of Xiamen (June) and Hangzhou (July), China, with the help of the State Academy of Forestry Administration (STAFA). STAFA is a training institute and provides training opportunities for civil servants and other employees of the SFA, leaders from the counties where the key forestry programs are implemented, local forestry leaders and technicians, as well as managers of large and medium size state forest enterprises [38]. The participants of this study are heads of the bureaus of forestry and county leaders who are responsible for forest programs.

2.3. Data analysis

The analysis for this article was based on descriptive statistics, and the aim was to compare average rating between different statements. The reliability and credibility of the data were checked with SPSS17.0, additionally frequency analysis, mean value were also calculated using the same software.

3. Results

3.1. Social demographic data of the respondents

A total of 120 questionnaires were delivered to the professionals who participated in the training, with 74 of the

participants answering the survey (62% response rate). The participants came from Xinjiang, Chongqing, and some coastal provinces such as Fujian and Zhejiang. The respondents from the two training courses present a reasonable sample which offers opportunities to present a basic description of the topic. Generalization of the description to cover all the professionals of SFA is limited even if the respondents are representing these regions which have large areas of forest plantations, with great potential as sources of fuel. Most of the respondents (92%) were male. A large majority (83.6%) lived in city-areas. All of the respondents lived in an owned apartment (83%), while a few lived in a rented apartment or in an owned single family house.

Most of the respondents were county leaders or directors. The age of the respondents was mainly between 41 and 60 years old (≤45 years old: 26 and gt; 45years old: 46; two of the respondents did not give their age). Tables 1 and 2 show the respondents' educational background and their household income, respectively. Among the respondents, 51% have their education in forestry. Most of the respondents have been working in the field of forestry for more than ten years, and some of them have thirty years experience.

3.2. *Professionals' energy use*

The professionals were asked about their current energy use, as well as thoughts on their likely energy use in the future. Over 95% of the respondents had both heating and air conditioning in their houses. According to the responses they mainly used coal and electricity for space heating. About 30% of the heating electricity was converted from renewable primary sources of energy. Cooling was based on the use of electricity. One third of the respondents expressed that the primary energy for cooling was renewable energy; however, cooking was mainly done by using gas (Table 3).

Half of the respondents answered that they are not able to decide what kind of energy is used at their residence. The energy system is planned and organized by the State Grid Corporation of China (SGCC), and the customers usually are not able to participate in the decision making regarding their electricity supply [39].

On the basis of the respondents' answers there are clear differences in their future energy preferences. If they had the choice 74% of the respondents would prefer their heating to be generated from renewable energy sources (solar 4%, wind 31%, hydropower 20%, and forest bioenergy 19%). Just under 50% of the respondents prefer liquid biofuels and 22% hydrogen fuel for transportation fuels. A majority of the respondents (59%) prefer cooking energy from renewable energy sources (wind, forest bioenergy, and hydropower), while a quarter of the respondents prefer liquefied natural gas for cooking. The answers dealing with future preferences (the influence of costs not taken into account) showed that the professionals would like to use substantially more renewable energy if it were available.

Table 1 – Respondents' educational background.

Education	Amount	%
Bachelor degree in the university	55	75.3
Master	9	12.3
Polytechnic school	8	11
Doctor	1	1.4
Total	73[a]	

a One of the respondents did not give their education level.

Table 2 – Respondents' household monthly income.

Household income (€)*	Amount of r espondents	%
>8 00	16	21.6
600–799	23	31.1
400–599	21	28.4
≤399	14	18.9
	74	

3.3. *Professionals' environmental behavior*

Of those respondents with a car (33%), 18% had a normal emission car, while 15% had a low emission car. Nearly half of the respondents (43%) stated that they usually walk to work, while 31% go by public transportation, 21% by car and 5% by bicycle.

For investigating the professionals' everyday behavior, it was asked whether they participated in the worldwide activity of the "Earth Hour", when it was last organized (March 26th, 2010). The results showed that about 33% of the respondents participated in the last activity, 39% did not participate because they had never heard of it, while 28% did not participate because they did not care about this activity.

Table 3 – Respondents' answers regarding the main energy sources for different uses.

Sources	Amount	%
Heating		
Coal based electricity and direct coal combustion	33	46.5
Electricity from renewable sources (solar, wind, and hydropower)	17	23.9
Liquefied natural gas	10	14.1
Electricity without defined source	9	12.7
No heat	2	2.8
Total (3 missing)	71	100
Cooling(air conditioning)		
Electricity from renewable sources	23	33.3
Coal based electricity	18	26.1
Electricity without defined source	24	36.2
No cooling	3	4.4
Total (5 missing)	69	100
Cooking		
Liquefied petroleum gas	68	93.2
Electricity from renewable sources	3	4.0
Coal electricity	2	2.8
Total (1 missing)	73	100

3.4. *Professionals' knowledge about forest and energy issues in China*

General questions relating to Chinese forest and energy sectors were addressed to the respondents for studying their level of knowledge. The share of correct answers related to forestry (Q1, 2) was higher than related to energy (Q5, 6) (Table 4). The answers to energy related questions varied, with only 22% of the respondents providing the correct answer regarding the government objectives and targets relating to renewable energy consumption in China in 2020. Mostly the respondents thought that the target was higher than the official target.

3.5. *Professionals' perceptions of forests and current forestry issues*

The professionals were asked to rate the various roles of forest in the society. In addition, they were asked to rate forest management in practice in China (Table 5).

The professionals placed high importance on ecological and environmental values of forests. The most important roles of forests were related to ecological balance, combating desertification, water resources, greenhouse effects, and nature conservation. The means of the Likert scale (1-5) answers for the ecological roles were higher than 4.36. The role of wood production either for industry or bioenergy purposes was seen as less important than the ecological functions of the forest but generally more important (except traditional firewood) than the social roles. Among the social roles the highest score was for recreational roles (4.00). The lowest scores were hunting and game management (2.49).

A similar set of questions from a different contextual point of view were presented to the professionals. The context was actions in forests in practice. The results were very similar with a high level of consistency in the answers. Only pulp wood production (3.68) and saw timber production (3.30) were lower than timber production (4.11) (Table 5A). In the context of actions in forest management, the main emphasis was on ecological balance. On the basis of the respondents answers, environmental, ecological, and sustainability related aspects have a high priority in forest management in practice.

Table 4 – Professionals' responses concerning forest and energy issues in China.

Questions	% answering correctly
1. What has been the general trend for imported forest wood products in China during the last ten years?	88.7
2. What is the current forest coverage in China approximately?	87.8
3. What is the most commonly used type of bioenergy in China?	78.9
4. What was the share (%) of imported oil of total oil consumption in China in 2009?	60.6
5. What is the current share of commercial forest bioenergy in total energy consumption in China?	58.8
6. What share will renewable energy contribute to the total energy consumption according to Medium and Long-Term Development Plan for Renewable Energy in China in 2020?	22.1

Table 5 – The rankings regarding the professionals' perceptions (A) on roles of the forests in the society and (B) on actions emphasized on forest management in practice in China (1 = not important at all to 5 = very important).

A. roles of forests	Mean
Maintaining the ecological balance	4.86
The containment of soil desertification	4.73
Protecting water resources	4.53
Mitigating the greenhouse effect	4.51
Nature conservation	4.47
Timber production	4.11
Beauty of landscape for amenity values	4.36
Provide raw materials for bioenergy production	4.07
Recreational function	4.00
Employment in timber production	3.30
Non-wood forest products (e.g. berries and mushrooms)	3.22
Hunting and game management	2.49
Providing firewood	2.90
B. actions in Forest management in practice	**Mean**
Sustainable forest management	4.59
Mitigation of climate change	4.54
Nature conservation	4.53
Forest carbon sinks	4.38
Forest tenure reform	4.24
Nature tourism	4.03
Recreational use of forests	3.93
Forest bioenergy development	3.97
Forest certification	3.95
Pulp wood production	3.68
Saw timber production	3.30

3.6. *Attitudes and perceptions regarding forest bioenergy development in China*

In order to determine the professionals' attitudes and perceptions towards forest bioenergy, they were asked to indicate how much they agree with the statements concerning forest bioenergy development in China (Table 6).

The respondent's perceptions of development issues clearly favored nature conservation and ecological management compared to forest bioenergy. Forest bioenergy seems not to be a very high priority for the respondents, though there are doubts dealing with its importance.

The professionals highlighted the importance of the government's actions in the development of the forest bioenergy industry. They also strongly agreed that forest bioenergy and sustainable forest management should be jointly promoted and forest biomass should play a multi-functional role in the society. The respondents agreed that forest bioenergy could mitigate the climate change.

The professionals' were also asked about their likely future behavior concerning the use of forest bioenergy. According to their responses, they agreed that they would

Table 6 – Professionals' perceptions of development issues regarding forest bioenergy (fbe) in China (1 = strongly disagree to 5 = strongly agree).

Statements	Mean value
Wood-energy production should be part of sustainable forest management practice in China.	4.23
It is an exact time to take forest based environmental issues more into consideration when developing the economy in China.	4.19
The Chinese government should provide financial support for FBE development.	4.14
The Chinese government should play a supervisory role in the developing stage of FBE industry.	4.08
There are technical barriers, such as low conversion efficiency due to immature lignin-cellulose decomposition technology.	3.93
Increasing the share of FBE can reduce CO_2 emissions.	3.89
There are abundant unused barren hills and wasteland.	3.81
Low environmental awareness of the general public is an obstacle for developing forest bioenergy in China.	3.70
There is a lack of national standards for FBE products.	3.68
The development of FBE can reduce China's reliance on imported oil.	3.64
FBE is equally discussed issue in media in China with other renewable energies such as solar, wind energy, oil bearing crops.	3.40
Different stakeholders' investments have not been successful during the last ten years.	3.37
Lack of recognition of the potential of FBE among professional foresters.	3.34
There are insufficient wood resources for energy production in China.	3.18
Use of forest biomass for energy can cause overuse of forest resources.	2.84
The development of forest bioenergy is determined by the oil price.	2.74
Forest bioenergy production is conflicting with food production in China.	2.31
Bio-fuels will replace fossil fuels in the next ten years.	2.21
Wood resources should be used in wood industry instead of energy production.	2.11
The development of forest bioenergy is determined by the pulp and paper industry.	2.08

like to disseminate the forest bioenergy knowledge among their family members and friends (4.01) and learn more about forest bioenergy (4.00). The respondents disagreed with the statement that they have received enough information and knowledge about forest bioenergy (2.44). The respondents agreed that they are happy to convince forest owners to develop energy forest (such as wood oil plantations) (3.39).

Concerning the possible information sources regarding forest bioenergy, the professionals were asked to evaluate the importance of the possible information sources with regards to their influence on the public's opinions regarding forest bioenergy. Clearly the most appreciated source was television (4.45). The internet was second (4.30), followed by newspapers and magazines (4.08), professional training program (4.06), books (3.80), radio (3.79), and higher education (3.68).

4. Discussion

4.1. *Professionals' current energy practices and their environmental behavior*

Currently, the energy use practices are mainly based on non-renewable energy which corresponds with the current national energy structure. According to the responses bout 24% of the professional's domestic heating and 33% of their air conditioning come from renewable energy. It is somewhat higher compared with the national renewable energy consumption share in 2008 and may reflect a relatively common fact that consumers in many countries knower not knowledgeable regarding the source of their energy. However, the professionals are from Xinjiang, Chongqing, Fujian, and Zhejiang, which have better opportunities to develop wind, solar, and hydropower than other cities in China [40], and therefore the renewable energy consumption may be higher than the national average. The current energy use does not necessarily reflect the professionals' preferences of energy usage, since Chinese residents in most of cases have very limited opportunities to choose the energy source, and this seems to restrict the ability of the consumers to pressure for the increased use of renewable.

A large share of the respondents gave their priority to environmentally sound behavior related to low carbon living. Results from a previous study about public environmental awareness and preference of residents in Ningbo city, China, were similar in terms that people want to share environmental responsibility. According to the professionals' perceptions of the role of forest, a great majority of the respondents was clearly interested in environmental issues, including ecologically sustainable energy (Table 5). The public information on environmental issues is presented by news media and this influences both opinion formation and current practices. In this sense, increasing environmental awareness is a good basis for meeting the challenges of carbon emission mitigation in China [41].

According to the results, the public's awareness of alternative energy options is increasing, possibly due to the active policy of the government and increasing access to various sources of information, especially the Internet [33]. A more thorough study of these perceptions could include methods based in willingness to pay (WTP), as economic factors can become very restricting, limiting the choice of renewable energy for heating, regardless of the environmental values of the consumer. In China, this requires detailed cost information including dealing with subsidies and investments in renewable energies.

4.2. *Professionals' knowledge and perceptions on the meaning of forests*

According to the results from the questions, which covered a limited area of forestry, the professionals seemed to have fairly good general knowledge regarding Chinese forests and related energy issues. However, a notable exception was the lack of familiarity with the Medium and Long-Term Development Plan for Renewable Energy in the country [4].

The number of correct answers with regard to current commercial forest bioenergy use was somewhat higher than the correct answers with regards to government plans. More than half of the respondents chose a higher target than the real target issued by NDRC in 2007. For boosting the development of renewable energy, the NDRC and renewable energy enterprises have tried to propose a more demanding target than the one set by NDRC in 2007 [42].

The respondents felt the ecological function of the Chinese forests to be very important. Forestry education and planning in China are strongly oriented towards ecological aspects. Therefore, the social dimension needs to be further integrated into forestry education. The forestry professionals who are working at the provincial forestry bureau (PFB) contribute to policy making and policy implementation (also technology and information dissemination). In China, the PFBs are responsible for making the ecological forestry planning for the regions and for organizing and advising afforestation, reforestation, and forest resources management locally. Supervisory and coordinating roles of the PFB are important in their work. Their educational background is relatively diverse which may show that leadership is the elementary part of their work, with great influence in the implementation of forest policy.

Depending on the national forest policies the attitudes in this respect may vary greatly in different countries. For instance in Sweden a survey showed that the forest officers felt that timber production is the most important function in practice [43]. Perhaps the reasons for this are the traditional forest industry combined with very effective silviculture and management, the large forest area which allows both timber production and nature conservation and relatively low population density in the most forested regions of the country. In China the National Forest Conservation Program (NFCP), introduced following the devastating floods of 1998, emphasized environmental and ecological dimensions in forest management [44]. In addition, under the collective forest tenure reform, the ecological, economic, and social roles of the forest are increasingly prioritized since 2003.

The Chinese professionals felt that sustainable forest management, mitigation of climate change, and nature conservation are the most important issues regarding forest management. This is a fair reflection of the general forest policy in China. The priorities of the NFCP were to restore natural forests in ecologically sensitive areas and to plant forests for soil and water protection [44,45]. Even if, on the basis of the results, one-third of the respondents were not very interested in general aspects of environmental and ecological sustainability or the development of renewable energy, they greatly valued forest protection and ecologically oriented forest management (Tables 5 and 6).

The professionals felt that timber production is one important ideal role of the forest. However, the professionals claimed that saw or pulp timber production is comparatively not important regarding the current forest management aims in China. The implications of the NFCP imply that the guideline on Chinese forest development is undergoing dramatic change, from timber-producing orientation towards ecological function orientation China. It places potentially significant barriers in the development of the bioenergy industry based on the use of forest biomass due to limited raw material supply [46], as well as impacting overseas as China would source its timber products from countries such as Indonesia. Nowadays, the forest policy is increasingly focusing not only protection but also on gaining economic benefits through sustainable forest management [10].

4.3. *Professionals' perceptions on forest bioenergy development in China*

The professionals clearly agreed that wood energy conversion, such as extracting biofuels from oil plants, should be part of sustainable forest management practices in China. However, their attitude towards forest bioenergy development seemed to be more skeptical than towards forest protection and ecologically oriented forest management. It is because bioenergy related targets set by NDRC are demanding and the professionals do not have relevant knowledge and experience dealing with bioenergy.

The professionals felt that forest biomass used as a renewable energy source can contribute to climate mitigation and can have significant impacts on the forest ecosystems in a positive way, if sustainably management. From this perspective, the use of forest biomass for energy is generally acknowledged as being in agreement with the principles of sustainable development [47]. The factors include cultivation of energy plants, forest bioenergy industrialization, and forest bioenergy research as well as the formulation and implementation of policies encouraging bioenergy development [17]. All of these highlight the relevance of understanding the perceptions of foresters that will play a key role in all stages. The professionals also suggest that great effort should be made in dealing with the relationship between biomass utilization and ecosystem conservation and in dealing with the relationship between the government and enterprises, which corresponds with the findings of the study of Bai et al. [48].

With regards to the development of forest bioenergy, the professionals felt that the Chinese government plays the central role in financial policy and technical support. This strong government role was also found in a previous research in a survey of Chinese academic experts' (working in Universities and research institutes) on forest bioenergy [34]. This is also a reflection of the central role that the State plays, compared to the market, regarding renewable energy options. However, there is some feeling that large scale enterprises holding financial and technical advantages have an important role in the exploration and development of forest bioenergy [49]. Additionally previous research regarding the weaknesses and threats facing the bioenergy industry in China highlighted similar issues as found in our research including limited raw material supply [46] and technological development [46,50].

The results show that the professionals oriented positively towards the use of renewable energy in general and specifically towards the increasing possibilities of utilizing wind power and hydropower. They also viewed forest bioenergy positively but without great enthusiasm, and it was less valued than wind and hydropower. Similar opinions have

been found in the review by Tan et al. [51]. Other studies have showed the lower public awareness of bioenergy when compared to solar, wind, and hydropower [37]. A study of Chinese bioenergy academic experts' views on the development of forest bioenergy in China [34] was promising, although stressed the fact that the development of forest bioenergy is in early stages and that there are many uncertainties in its development. This early development of bioenergy uses can explain the lack of awareness and information about bioenergy, and emphasises the needs of further research, concerning for instance, cost comparisons between forest bioenergy amd wind energy, solar power, hydropower, as well as evaluations of the ecological, economic, social and cultural effects of different energy types. Finally, according to the professionals' future expectations, we can draw a conclusion that bioenergy, especially forest bioenergy related information and knowledge, should be extended to the public by different education means. Zhang et al. [46] also concluded that significant research and education is needed in China on the issues related to bioenergy.

According to the professionals' responses, it is clear that there is a lack of technical standards and guidelines for forest bioenergy production. In addition, an incentive mechanism has to be established in the initial stage of the industrialization, following other countries' initiatives. For example, the Swedish incentive mechanism is an example in promoting the development of short rotation forest to some extent [52]. In the USA, the State governments have announced incentives to encourage forest bioenergy development, and this incentive mechanism is expected to give impetus to its development [53]. Therefore, forest bioenergy's development will be partly reliant on the support and subsidies from governments, not only in China but also in other countries [54].

4.4. *Limitations and future research*

Our results show that the professionals' assessment can be incorporated into the current and forthcoming forest bioenergy development and its related policies and regulations. However, it must be taken into account that the findings from this research are limited, as only 74 participants from four provinces in China were included in the study. This has implications regarding the generalization of the results [55], although the samples were chosen by stratified random sampling taking into account the realities of survey studies in a large country as China in order to get the richest information. In this sense, the study has the features of a case study, such as intensive investigations of particular individuals and groups, and therefore the findings are a valid starting point for further discussion of bioenergy development and provide a look at professionals' perspectives using a method that provides both qualitative and quantitative information.

It is important to examine the public's perceptions, attitudes and knowledge about bioenergy throughout the whole policy process, including design and implementation. However, this type of study has not been conducted in China and it had a pioneering character. When we start looking for renewable energy implementation and especially biomass production and biomass energy in China, there might be clear differences between the public awareness related to the various benefits (environmental, social and economic) and the acceptance of the use of bioenergy. It is a problem, which cannot be solved easily. Usually the first step involves a public survey in order to determine the current situation among the selected population. The main results of this study describing the current situation may support the development of process towards the acceptance of bioenergy. Further research is required for determining which factors affect the professionals' different perceptions of. This is important with regards to the achievement of renewable energy goals.

5. Conclusions

The professionals in the field of forestry, who responded to the questions in this survey, currently mainly use non-renewable energy sources in their own everyday practices. Their environmental perceptions show that a majority would like to increase their consideration of low carbon living. The attitudes of these professionals are positive towards renewable energy in general, but less positive towards forest bioenergy. Therefore, the professionals' practices and future preferences concerning the use of forest bioenergy are not compatible. The professionals feel that the future development in the implementation of forest bioenergy requires cooperation between the government and enterprises. Social, economic, and ecological functions must be coordinated in the energy political issues, as together these dimensions greatly influence forest utilization. The impacts of energy policy on the ecosystem must be carefully considered when developing the means of using forest bioenergy. Finally, the findings also indicate that bioenergy related education through different channels have to be implemented and improved in China so that the development of knowledge meets the demands of everyday practices.

Acknowledgements

Financial support for this study was provided by the China Scholarship Council, China, and the School of Forest Sciences, University of Eastern Finland, Finland. We thank Ms Dongfang Zhang who is working in the State Academy of Forestry Administration for her help in conducting the survey. We also grateful to all the participants for their cooperation and completing the survey.

Appendix

Questions measuring your knowledge concerning forest and energy issues in China. Please give the answer you think is right (√ shows the right answer).

What is the current forest coverage in China approximately?

A ☐ 10% B ☐ 14% C ☐ 18% √ ☐ 22.

What was the share (%) of imported oil of total oil consumption in China in 2009?

A ☐ about 30% B ☐ about 40% √ ☐ about 50% D ☐ > 60%

What is the share of commercial forest bioenergy in total energy consumption in China currently?

A ☐ 20–30% B ☐ 10–15% C ☐ 5–9% √ ☐ <3%

What share will renewable energy contribute to the total energy consumption according to Medium and Long-Term Development Plan for Renewable Energy in China in 2020?

A ☐ 10% √ ☐ 15% C ☐ 20% D ☐ 30%

What has been the general trend of imported forest wood products in China during the last ten years?

√ ☐ increasing B ☐ no change C ☐ decreasing.

What is the most commonly used type of bioenergy in China?

√ ☐ Biogas B ☐ Liquid biofuels C ☐ Forest bioenergy based electricity.

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