

Perceptions of a new and emerging renewable energy technology among teachers and learners: A developed and developing country perspective

Pradipta Halder

School of Forest Sciences, University of Eastern Finland, Joensuu, Finland
pradipta.halder@uef.fi

Abstract

Renewable energy technologies are considered as the most promising alternatives to fossil fuels as they can contribute to climate change mitigation, energy security and sustainable development. Bioenergy is a prominent source of renewable energy, and it can provide numerous socio-economic and environmental benefits if implemented properly. However, perceptions of bioenergy are mixed among its stakeholders. The present study explored bioenergy related perceptions among students and teachers in Finland and India, and also investigated their perceptions of bioenergy related education in school. Total 583 students studying in the 9th and 10 grade levels, and 50 science teachers participated in the study from the two countries. Results showed that the teachers and students perceived quite positively the usefulness of bioenergy in mitigating climate change and reducing the use of fossil fuels. Nevertheless, some contradictions appeared among them related to their perceptions of the impacts of bioenergy production on Earth's biological resources. Both students and teachers perceived school as an important place where students could learn about bioenergy though some discrepancies appeared between them on the possibility of teaching bioenergy in schools.

Keywords: Bioenergy, Perceptions, Students, Teachers

1 INTRODUCTION

Energy production from fossil fuels and use are the two major contributors to the world's greenhouse-gas emissions [1]. Despite this understanding, some studies have predicted a substantial increase in the energy consumption from fossil fuels over the coming decades [2, 3]. Amidst this scenario, a number of countries have placed significant efforts to develop energy from renewable sources (e.g., solar, wind, biomass, and small hydro) in order to address the climate concerns, achieve energy security, and improve their local economies. According to a report by REN 21 [4], renewable energy provided an estimated 19% of the global final energy consumption in 2013, and the report also predicted a positive growth in the renewable energy sector in the coming years. Among various renewable energy sources, biomass is the oldest source of energy used by humans for heating and cooking. Today, the modern bioenergy technologies can serve different purposes such as producing heat, electricity, and liquid fuels (e.g., bioethanol and biodiesel) from various feedstocks (e.g., agriculture, forestry, and municipal organic waste). It has been observed that the perceptions of bioenergy are both positive and negative among its wide range of stakeholders [5]. In one hand, there is a concern among them that the increasing usage of bioenergy in an effort to mitigate

climate change can pose significant risks to the environment and society [6]. On the other hand, many also perceive that the advanced biofuels will be able to address much of the environmental concerns related to the conventional biofuels and also provide an array of socio-economic benefits [7].

It is generally argued that apart from technical and economic factors, bioenergy related developments will be greatly influenced by its stakeholders' awareness of the consequences of using bioenergy as an alternative to fossil fuels [8]. In this context, perceptions of bioenergy among school students and teachers appear to be a key driver for promoting the acceptance of bioenergy in the society. Young students' perceptions and attitudes related to bioenergy could indicate their intentions to use bioenergy in the future as they are the future consumers of different renewable energy options such as biofuels. Along with students, in the present context, the role of teachers who are responsible for delivering science and environmental education in schools has become highly significant. It is because the teachers who are knowledgeable and supportive of the renewable energy technologies can motivate their students to obtaining required knowledge and information regarding these new energy technologies already at an early age [9, 10]. In this direction, a few studies tried to explore perceptions of bioenergy

among school students and teachers, and the results appeared to be mixed. For example, Halder et al. [9, 11] explored ninth grade school students' perceptions of bioenergy from cross-cultural data, and they found that the students had negative perceptions of bioenergy, particularly towards producing energy from forest biomass. However, Kapasaa et al. [12] reported Greek secondary school students' positive perceptions of bioenergy in matters related to limiting the use of fossil fuels and reducing the emission of greenhouse-gases. Among teachers, Zyadin et al. [13] reported that the school teachers in Jordan were undecided on the contentious issue of biofuels vs. food price increase, and they did not perceive production of energy from forest biomass environmentally friendly. Nevertheless, there is no study that have analyzed perceptions of bioenergy among students and teachers from a cross-national viewpoint. The present study aims to address this particular research gap from the perspectives of students and teachers in Finland and India.

Finland and India have started adopting different renewable energy technologies to address the challenges of climate change, energy security, and economic development. At present, Finland has an advanced biofuels industry, and a number of research centers in Finland are engaged in developing advanced biofuels from forest biomass. In contrast, although about 70% of the Indians still rely on traditional ways of using biomass for cooking and heating [14], the progress in the modern bioenergy sector has remained sluggish in the country because of several key challenges in the fields of policy, technology, and social acceptance [15, 16]. However, apart from this disparity between the two countries, there is a similarity between them when it comes to renewable energy education in schools. Topics related to different renewable energy sources including bioenergy have been part of the curricula for the high school students in both the countries. This inclusion indicates that students are expected to be aware of bioenergy and other renewable energy sources already before they enter into the higher education arena. At the same time, teachers are expected to deliver relevant education and also motivate their students to become aware of the energy and environmental issues in the contexts of the climate change and sustainable development. Therefore, a cross-national comparison of bioenergy related perceptions among students and teachers between these two countries can provide useful

information to the energy and educational professionals to develop future strategies regarding bioenergy. Based on these discussions, the present study had the following objectives: (1) exploring perceptions of bioenergy among students and teachers in Finland and India; (2) finding out their perceptions of bioenergy related education in schools; and (3) providing some recommendations for implementing energy and environmental education in schools.

2 METHODS

The study was based on surveys, which were conducted in high schools in Finland and India. Six schools participated from Finland, which are located in two cities viz. Joensuu and Savonlinna. In India, two schools were selected from New Delhi, and two from Bengaluru. Mail survey was used in both the countries to collect data from students and teachers. Questionnaires were sent by mail to those schools and after the survey, each school returned the questionnaires also by mail. A self-constructed questionnaire was first designed in English by consulting a few bioenergy and science education experts. The original English version was used for the survey in the Indian schools since the medium of instruction was English in all those four schools. However, the questionnaire was translated into Finnish for the Finnish students and teachers. The translation work was completed by a linguistic expert and two bioenergy researchers validated the translation for its appropriateness for the Finnish participants. The study included only the teachers from those schools who taught subjects such as physics, chemistry, mathematics, and biology. The questionnaire consisted of several sections of which the first section included questions related to the respondents' socio-demographic profiles. The second section consisted of items in statement forms to measure the respondents' knowledge of bioenergy on a True-False scale. The third section included statement-like items on a seven-point Likert-type scale (strongly agree to strongly disagree) that intended to measure the respondents' intentions to use bioenergy. The fourth section was also made up with statement-like items to explore the respondents' concerns over the consequences of energy production from biological materials. The fifth section contained questions to find out the respondents' perceptions of the possibility of bioenergy related education in schools. However, this paper only included the items that measured the respondents' perceptions of

bioenergy from the third and fourth sections, and also the items from the fifth section that measured their perceptions of bioenergy related teaching and learning.

Total 50 science teachers participated in the survey from the two countries (Finland=22, India=28). The mean age of the Finnish science teachers was 48 years (SD=9.85) and that of the Indian science teachers was 35 years (SD=7.75). About 55% and 80% of the science teachers were female in Finland and India, respectively. In addition, about 90% of the Finnish and 60% of the Indian science teachers had a master's degree in a science related subject. The average teaching experience of the Finnish and Indian science teachers was 19 years (SD=8.95), and 8 years (SD=5.81), respectively. There were 402 students studying in the 9th grade level from Finland who participated in the survey, and their mean age was 15.35 years (SD=0.52). From India, 183 students participated who were studying in the 9th and 10th grade levels, and their mean age was 14.14 years (SD=0.89). About 52% and 51% of the Finnish and Indian students were male, respectively. Besides descriptive statistics, non-parametric Mann-Whitney U test was applied to find statistically significant differences in the respondents' perceptions of bioenergy with regard to country and gender.

3 RESULTS

3.1. Teachers' Perceptions of Bioenergy

Teachers' perceptions of bioenergy were evaluated by six statement-like items (Table 1). More than 80% of the respondents from the both countries appeared to be positive in their perceptions of the usefulness of bioenergy in addressing the threat of climate change (Statement 1), cutting down the dependency on imported fossil fuels (Statement 2), and reducing the use of petrol and diesel in motor vehicles (Statement 3). Furthermore, the majority of the science teachers in both the countries agreed on the notion that energy production from biological materials was necessary for the progress of human society (Statement 4). Nearly 60% of the science teachers in both the countries also agreed to the proposition that the use of biological resources (e.g., wood and agricultural materials) for energy production could diminish their availability for other uses (Statement 5). However, about one-third of the respondents showed their disagreements with that particular proposition. The majority of the science teachers in the two countries

also disagreed with the notion that the use of biological materials for energy production could destroy biological resources on Earth (Statement 6). Statistically significant differences ($U=196.5$, $Z=2.31$, $p=.013$) appeared between the respondents in the two countries only related to the Statement 1. In this aspect, the Indian science teachers appeared to be more positive than their Finnish counterparts. Further analyses were carried out to explore gender differences in the science teachers' perceptions of bioenergy in each country. It revealed statistically significant gender differences among the Indian science teachers related to the Statement 1 ($U=21$, $Z=-2.38$, $p=.027$) and Statement 2 ($U=18$, $Z=-2.58$, $p=.016$). In both the cases, the female science teachers appeared to be more positive than the male science teachers. In case of Finland, a statistically significant gender difference emerged related to the Statement 3 ($U=25$, $Z=-2.43$, $p=.021$) where the male science teachers appeared to be more positive than the female science teachers.

3.2. Students' Perceptions of Bioenergy

Students' perceptions of bioenergy were explored by the same statement-like items (Table 2) that examined the science teachers' perceptions of bioenergy. Much like the science teachers, the majority of the students in both the countries agreed with the propositions under the Statements 1 to 3. However, noticeable differences appeared between the students' perceptions of the consequences of energy production from biological resources, which were mentioned under the Statements 4 to 6. It appeared that a higher proportion of the Indian students were in agreement with those propositions than the Finnish students. In addition, about half of the Finnish students appeared to be undecided on those propositions. Statistically significant differences ($p<.01$) appeared between the Finnish and Indian students' perceptions related to all the statements. In one hand, the Indian students were more positive than the Finnish students towards the usefulness of bioenergy. On the other hand, the Indian students were also more concerned than the Finnish students over the perceived negative impacts of increasing production of energy from biological materials. Statistically significant gender differences ($U=16473$, $Z=-3.29$, $p=.001$) emerged

Table 1. Teachers' perceptions of bioenergy (adapted from Halder et al. [19]).

Statements	Finland (n=22)		India (n=28)	
	Agree (Disagree) (%)	Undecided (%)	Agree (Disagree) (%)	Undecided (%)
1. Use of bioenergy can reduce the threat of global climate change	86 (5)	9	85 (8)	7
2. Domestically produced bioenergy in my country can reduce the dependency on importing energy from other countries	95 (0)	5	93 (4)	3
3. Use of bioenergy as a fuel in motor vehicles can reduce the use of petrol and diesel	95 (0)	5	89 (7)	4
4. Energy production from biological materials is necessary for the progress of human society	77 (18)	5	85 (8)	7
5. Use of wood and agricultural materials for energy production could reduce their availability for other uses	59 (32)	9	56 (28)	16
6. Use of biological materials for energy production could destroy biological resources on Earth	18 (73)	9	27 (62)	11

Table 2. Students' perceptions of bioenergy

Statements	Finland (n=402)		India (n=183)	
	Agree (Disagree) (%)	Undecided (%)	Agree (Disagree) (%)	Undecided (%)
1. Use of bioenergy can reduce the threat of global climate change	76 (3)	21	86 (7)	7
2. Domestically produced bioenergy in my country can reduce the dependency on importing energy from other countries	62 (5)	33	80 (9)	11
3. Use of bioenergy as a fuel in motor vehicles can reduce the use of petrol and diesel	71 (4)	25	85 (6)	9
4. Energy production from biological materials is necessary for the progress of human society	46 (10)	44	73 (8)	19
5. Use of wood and agricultural materials for energy production could reduce their availability for other uses	37 (12)	51	70 (10)	20
6. Use of biological materials for energy production could destroy biological resources on Earth	24 (22)	54	44 (27)	29

among the Finnish students related to their perceptions of the usefulness of bioenergy in mitigating climate change (Statement 1). In this context, the female students in Finland appeared to be more positive about bioenergy than the male students.

3.3 Perceptions of bioenergy education among teachers and students

Almost all the science teachers from Finland and India agreed on that their students should be aware of bioenergy. However, much differences appeared in

their perceptions regarding the inclusion of bioenergy as a topic in their school curricula. In this case, although all the Finnish science teachers appeared to be aware of the inclusion of bioenergy as a topic in the Finnish school curricula, about one-third of the Indian science teachers did not appear to be aware of that in the context of the Indian school curricula. Furthermore, all the Finnish science teachers perceived that it would be possible to teach students about bioenergy in schools; however, only about half of the Indian science teachers agreed on that possibility. It appeared that the science teachers in both the countries considered school as the most prominent place where their students could learn about bioenergy.

In case of the students, they were asked to inform whether they perceived the need for obtaining more information on bioenergy. About 90% of the Indian students agreed on that notion compared to only half of the Finnish students who did so. Considerable differences appeared in their perceptions of bioenergy as part of their school curricula. Only about half of the Indian students agreed that bioenergy was included in their school curricula, whereas the majority of the Finnish students disagreed. The majority of the Indian students perceived that it would be possible for the teachers to teach bioenergy in school. However, only about one-third of the Finnish respondents perceived that possibility, whereas the majority of them remained undecided on that notion.

4 CONCLUSIONS

The study aimed to explore perceptions of bioenergy among school students and teachers in Finland and India. Although the study findings cannot be generalized due to its small sample size, it can provide some new insights as similar studies are limited. The students in both the countries showed quite positive perceptions of the stated benefits of using bioenergy. However, it appeared that they were also concerned over the probable negative impacts of the increasing use of bioenergy on biological resources. In general, the teachers from both the countries appeared to be quite positive about bioenergy. Nevertheless, much uncertainties also emerged among them in matters related to the impacts of bioenergy production on biological resources. In a way, these findings corresponded to the general perceptions of bioenergy among public and experts [5]. Some gender-related differences

appeared among the students and teachers concerning their perceptions of bioenergy. This also corresponded with the previous findings on gender differences in energy and environmental perceptions among people [17, 18]. Although there were not much differences between the teachers from the two countries in their perceptions of bioenergy, such differences were significant between the students. It indicated that factors such as socio-economic conditions, media coverage of environmental issues, and school context could be powerful determinants of students' perceptions of bioenergy across countries. However, this aspect needs further investigation in order to arrive at any conclusion. The study was also able to generate useful information about bioenergy related teaching and learning in schools in these two countries. It showed that there were differences among the teachers and students about the possibility of teaching bioenergy in schools, although both considered school as an important place where the students could learn about bioenergy. Therefore, it is important that renewable energy related topics should be taught with considerable efforts by the teachers in schools. Not only class-room based teaching and learning, teachers should also be motivated to perform extra-curricular tasks to raise their students' knowledge and awareness of the impending energy issues in the current context of climate change and sustainable development. It is also important that the policy makers provide necessary resources to schools so that the teachers can develop their capacity to teach the complex energy related topics to their students.

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